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Postpartum Psychiatric Outcomes following
Severe Maternal Morbidity at an Urban Safety-Net Hospital

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Objective: To estimate the risk of hospitalization with a mental health disorder in the first postpartum year among patients with and without severe maternal morbidity (SMM) at a large, safety-net institution in Atlanta, Georgia.

Methods: In this population cohort study of majority publicly insured racial and ethnic minority patients, we examined all liveborn deliveries at Grady Memorial Hospital in Atlanta between January 1, 2013 and December 31, 2018. The exposure of interest was SMM at or within 42 days of delivery. The outcome of interest was hospitalization with a psychiatric diagnosis in the year following delivery, identified using International Classification of Disease codes. We used inverse probability of treatment weighting based on propensity scores to adjust for index delivery characteristics, demographics, and medical, psychiatric, and obstetric history. We fit a log binomial model with generalized estimating equations to calculate adjusted risk ratios (aRRs) and 95% confidence intervals (CIs) for the association between SMM and risk of postpartum hospitalization with a psychiatric diagnosis.

Results: Among 16,984 deliveries, the overall rates of SMM and postpartum hospitalization with a mental health disorder, respectively, were 6.77% (n = 1149) and 0.68% (n = 115). The most common psychiatric diagnosis was non-psychotic mood disorders (with SMM 0.48%, n = 5; without SMM 0.37% n = 59). After adjusting for baseline differences, 1.12% of deliveries with SMM had a postpartum readmission within one year, compared to 0.65% (n = 102) of deliveries without SMM [aRR 1.65, 95% CI (0.94–2.90)].

Conclusion: Deliveries with SMM had higher rates of postpartum admission with psychiatric illness in the first postpartum year than deliveries without SMM. Patients who experience SMM at or within 42 days of delivery may benefit from enhanced psychosocial support in the critical first year following delivery.

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Introduction: The peripartum period presents a well-known elevated risk of new onset or worsening psychiatric illness, such as depression or anxiety.[1-3] Following a full-term, uncomplicated delivery, 2-6% of women experience post-traumatic stress disorder (PTSD).[1,4] Rates of severe maternal morbidity (SMM) in the United States (US) have risen to affect more than 50,000 patients annually.[5-7] These life-threatening conditions may portend significant psychological consequences, but current literature on mental health outcomes following a difficult delivery is scant and yields conflicting results.[8-11] Findings from a recent population-level study suggest a two-fold higher risk of psychiatric illness at postpartum inpatient or emergency department encounters among US deliveries with SMM in the year following delivery hospitalization compared to those without SMM.[12]

Both SMM and mental health disorders disproportionately affect racial and ethnic minority patients.[13-15] Racial/ethnic minority, low-income and Medicaid-enrolled patients are less likely to utilize mental health services during the perinatal period, further exacerbating these disparities.[8,16,17] Given the disproportionate burden of both SMM and perinatal mental health disorders in medically underserved populations, we aimed to estimate the effect of SMM on postpartum psychiatric morbidity in the year following delivery in one such population. At Grady Memorial Hospital, a large safety-net institution in Atlanta, Georgia, we hypothesized that patients who experienced SMM at or within 42 days of delivery would have a higher risk of hospitalization with a new psychiatric diagnosis in the year following index delivery than those without SMM.

Methods: The data for this study were derived from the Grady Obstetrics and Gynecology Outcomes (GOGO) database, which is composed of real-time, prospectively collected electronic health record (EHR) data for all women who delivered at Grady Memorial

Hospital from 2011 onward. Grady Memorial Hospital is part of Grady Health System, which partners with Emory University School of Medicine and Morehouse School of Medicine. Information on demographics, medical history, diagnoses and procedures, medications, treatment plans, immunizations, vital signs, and laboratory test results are captured electronically and updated monthly. The authors had full access to the GOGO database. We restricted the study population to live deliveries to one or more fetuses after 20 weeks of gestation from January 1, 2013 to December 31, 2018 (Figure 1); pregnancies of multiple gestation in which one or more fetus was stillborn were excluded. The Joint Commission definition was used to track delivery admissions.[18] This study was approved by the Emory University Institutional Review Board.

The objective of this study was to estimate the association between SMM and postpartum psychiatric morbidity using a population-based sample. In order to examine risk beyond the traditional six weeks postpartum, we followed patients for 12 months following delivery.[2,12,19] The exposure of interest was SMM at or within 42 days of index delivery. The Centers for Disease Control and Prevention (CDC) defines SMM using 21 International Classification of Disease (ICD) codes (Appendix 1).[6] In a study of California hospitals, the CDC definition of SMM had a sensitivity of 0.77 and positive predictive value of 0.44.[20]

The outcome was any hospitalization at Grady Memorial Hospital with a psychiatric diagnosis in the year following index delivery (Appendix 2). Psychiatric diagnoses at delivery hospitalization were considered pre-existing psychiatric history and were not included in the outcome variable. We adapted composite indicators for psychiatric morbidity, substance use disorders, and chronic medical conditions based on pre-existing literature using ICD-9-CM and ICD-10-CM codes (Appendices 2-3).[8,12,21] A positive psychiatric history was defined as any

hospitalization at Grady Memorial Hospital in the two years preceding index delivery with at least one ICD-9-CM or ICD-10-CM code in the psychiatric morbidity composite (Appendix 2). Pre-existing medical comorbidities and substance use history were defined as an admission to Grady Memorial Hospital in the two years prior to index delivery with a medical or substance use diagnostic code included in the composite list (Appendices 2-3).[12,21]

We collected information on the following baseline variables of interest: maternal characteristics at delivery admission (age, self-reported race/ethnicity, insurance status), index delivery characteristics (year, parity, multiple gestation, preterm birth, cesarean section, gestational diabetes, placenta previa, pre-eclampsia or gestational hypertension without severe features), psychiatric history in the two years preceding index delivery (psychotic, mood, and anxiety disorders; PTSD and acute stress reaction; suicide attempt), substance use disorder history in the two years prior to index delivery, (alcohol and/or other substances), medical comorbidities (chronic lung, kidney, cardiovascular, endocrine, and autoimmune diseases; HIV; obesity; sickle cell anemia), and obstetric history (preterm birth, cesarean section) (Appendices 2-4). Each of these covariates may be independently associated with SMM, postpartum psychiatric morbidity, or both, and were thus included in the propensity score model to adjust for possible confounding (Table 1).[19,22-24]

To account for possible confounding, we used inverse probability of treatment weighting based on a propensity score model.[25,26] We first defined a set of potential confounders *a priori* to create propensity scores using a logistic model; the outcome was SMM (Appendix 1) and the predictors were psychiatric history, chronic comorbidities, obstetric history and index delivery characteristics (Appendices 2-4). Based on the propensity score, we then used inverse probability of treatment weighting to create weighted exposure groups (with and without SMM). To assess

balance across our two exposure groups, we compared the standardized mean differences in each variable of interest before and after weighting. We accepted <10% difference between exposure groups for each predictor included in the propensity score model (Table 1).[26] We then fit binomial log models incorporating inverse probability of treatment weights to estimate risk ratios (aRRs) and 95% confidence intervals (CIs) for associations between SMM and postpartum admission with a psychiatric diagnosis. We included generalized estimating equations in the final outcome model to account for repeated observations from patients with more than one delivery during the study period.

We conducted several sensitivity analyses. To evaluate the effect of including patients with a non-psychiatric chief complaint, we defined the outcome as having a primary psychiatric diagnosis only. To assess loss to follow-up, we performed time-based sensitivity analyses with outcome data at 30 and 90 days postpartum. Because the majority of SMM diagnoses are attributed to blood transfusion, which may include just a single unit of blood and contribute to false positives, we excluded deliveries for which blood transfusion was the only SMM indicator from the exposed group.[20] To evaluate effect modification by pre-existing psychiatric history, we created a second propensity score model excluding psychiatric history; in the final outcome model, we included an interaction term for psychiatric history and SMM (Table 2). We performed a complete case analysis. Data were missing for <5% of all variables. All statistical analyses were conducted using Statistical Analysis Software (SAS Institute Inc., Cary, NC), version 9.4.

Results: We identified a total of 16,984 liveborn deliveries from January 1, 2013 to December 31, 2018 at Grady Memorial Hospital (Figure 1). The prevalence of SMM at or within 42 days of index delivery was 6.8% (Table 1). Overall, 2.7% of deliveries were to women with

existing psychiatric history (had been admitted to Grady Memorial Hospital with a psychiatric indicator in the two years prior to index delivery). The study sample was composed of 69.7% non-Hispanic Black and 22.5% Hispanic patients, and 88.0% of patients were publicly insured. The most common medical comorbidities were asthma (10.3%), obesity (9.6%), and chronic hypertension (4.6%). Before weighting, the most common pre-existing psychiatric diagnosis was non-psychotic mood disorder (1.1% of total study population, 1.0% of patients without SMM, 3.0% of patients with SMM). Overall, 1.1% of patients had a history of substance use or disorder. Before weighting, 2.4% (n = 386) of patients without SMM had a history of psychiatric diagnosis, compared to 6.9% (n = 79) of those with SMM. The most common pre-delivery psychiatric diagnoses were non-psychotic mood disorders (0.4% with SMM, 0.5% without SMM) and non-psychotic anxiety disorders (0.24% with SMM, 0.15% without SMM), and PTSD or acute stress disorder/reaction (0.05% without SMM, 0.26% with SMM).

After adjusting for baseline differences, the overall rate of postpartum admission with any psychiatric diagnosis was 0.7% (Table 2). The adjusted samples were balanced across all covariates (all standardized mean differences <10%). The risk of postpartum psychiatric hospitalization in the year following delivery was elevated for deliveries with SMM (1.1%, n = 13) as compared to those without SMM (0.7%, n = 102) [aRR 1.65, 95% CI (0.94, 2.90)]. The most common psychiatric diagnoses for deliveries with and without SMM, respectively, were non-psychotic mood disorders such as depression (0.5% and 0.4%), non-psychotic anxiety disorders (0.2% and 0.2%), and PTSD or acute stress disorder/reaction (0.3% and 0.1%). For deliveries with and without SMM, respectively, 0.1% and 0.2% were admitted with substance use disorders in the year following delivery.

When we restricted the outcome variable to primary psychiatric diagnosis only, the association weakened [aRR 1.27, 95% CI (0.32, 5.07)]. When deliveries for which blood transfusion was the only SMM indicator were excluded, the association strengthened [aRR 2.22, 95% CI (1.06, 4.68)]. When we restricted the outcome follow-up period to 30 and 90 days following delivery, respectively, we saw a slight decrease in effect size from an aRR of 2.09 (95% CI 0.82 – 5.33) to 1.74 (95% CI 0.69 – 4.39). There was no evidence of effect modification by psychiatric history.

Discussion: In this population, we found an elevated risk of hospitalization with a new psychiatric diagnosis in the year following deliveries with SMM. Our findings fill an important knowledge gap regarding two sets of conditions – SMM and postpartum psychiatric illness – that disproportionately affect minority and medically underserved patients. Approximately 14% of postpartum patients in the US are diagnosed with a new onset major depressive episode and 10% with a new onset anxiety disorder.[9,27] Race/ethnicity has been shown to significantly predict differences in risk of perinatal mood disorders in the US, which may in part be attributed to the chronic physiologic stress of experiencing structural racism.[16,17] Non-Hispanic Black, Indigenous, and Hispanic patients suffer disproportionately from disruptions in health coverage, which may delay or prevent care-seeking for mental health problems.[28,29] One report found lower baseline rates of psychiatric illness among racial/ethnic minority women but higher case morbidity when these conditions were present, possibly reflecting reduced screening, diagnosis and referral for treatment in these populations.[15,30] The weakened association seen when we restricted the outcome to primary diagnosis may reflect clinicians' bias to list medical, rather than co-existing psychiatric, diagnoses as the primary reason for hospitalization, highlighting the need for increased attention to postpartum mental health outcomes.

In our study, 6.8% of patients experienced SMM, which is more than 4 times higher than national estimates from 2015 (1.5%).[5,31,32] Given that our study population is disproportionately affected by social and structural factors that are associated with adverse maternal outcomes, this disparity is not unexpected.[29] Notably, Georgia ranks 40th out of 50 states for access to mental health care and resources and 49th out of 50 states for maternal mortality, suggesting that our study population in particular faces substantial barriers to comprehensive healthcare including mental health screening and support across the life course.[33]

Strengths of this study include the use of inverse probability of treatment weighting to balance baseline differences across exposure groups. The inclusion of women with pre-existing mental health disorders, excluded in previous literature, allowed us to evaluate for effect modification by psychiatric history.[10-12,34,35] Current guidelines recommend screening for depression at the first postpartum visit, often occurring within six weeks of delivery; consequently, patients presenting with symptoms up to 12 months following delivery may be missed.[36] We built upon the sparse literature surrounding more long-term outcomes in the by following patients through the extended postpartum year. Our single-center study design ensured uniformity of postpartum mental health management. Finally, existing data varies broadly by definitions of SMM and postpartum psychiatric illness. By employing previously established indicator lists for both sets of diagnoses, this study expands upon existing work and allows for future replication.[6,12,20]

Our findings should be interpreted in light of several limitations, including the omission of outpatient data and visits outside the Grady Health System. According to the World Health Organization, 35-50% of patients suffering from severe mental disorders have not seen a professional in the past year; our data may represent patients who sought and were able to access

care.[37] As with all administrative datasets, ours was subject to possible misclassification bias and coding errors, particularly in the transition between ICD-9-CM and ICD-10-CM systems. Women who experience SMM often have more frequent postpartum follow-up, possibly leading to overdiagnosis in the exposed group and biasing our results away from the null. Additionally, validity studies for source data on inpatient mental health are sparse; administrative data for psychiatric outcomes may be more reliable for certain diagnoses, such as schizophrenia, than others, like anxiety disorders.[38] Another limitation was attrition; in many states, including Georgia, women may lose Medicaid coverage sixty days after delivery, possibly leading to loss to follow up.[39,40] However, our time-based sensitivity analyses at 30 and 90 days postpartum suggest only modest attrition throughout the extended postpartum period. This study may not be generalizable to the broader US population or globally, given differences in healthcare systems and clinical practice patterns. Finally, we acknowledge that observational data is subject to unmeasured confounding.

Our findings reinforce existing calls for enhanced coordination of mental healthcare in the first postpartum year, particularly following adverse obstetric events.[41,42] Anticipatory guidance and connection to appropriate resources should begin in the antenatal period and continue throughout pregnancy; continuity of care should be prioritized via communication with primary, family and mental health care providers.[43,44] In line with recent guidelines emphasizing the "fourth trimester," obstetrician-gynecologists should address women's physical, social and mental wellbeing at the comprehensive postpartum visit and throughout the extended postpartum period, especially among medically underserved populations.[44]

Table 1. Demographic and clinical characteristics of study population before inverse probability of treatment weighting (IPTW).

Covariate	Total study population N = 16,984	Without SMM N = 15,835 (93.2)	With SMM N = 1149 (6.8)	Standardized mean difference (%) before IPTW*
Year of Index Delivery				
2013	2847 (16.8)	2668 (16.9)	179 (15.6)	-3.5
2014	2989 (17.6)	2853 (18.0)	136 (11.8)	**-17.5**
2015	1974 (17.5)	2773 (17.5)	201 (17.5)	0.0
2016	2992 (17.6)	2766 (17.5)	226 (19.7)	5.7
2017	2637 (15.5)	2436 (15.4)	201 (17.5)	5.7
2018	2545 (15.0)	2339 (14.8)	206 (17.9)	8.4
Age at Delivery (years)				
<18	1846 (11.0)	1722 (10.9)	124 (10.8)	-0.3
18 – 34	12,735 (75.0)	11,891 (75.1)	844 (73.5)	-3.7
35 – 39	1892 (11.0)	1752 (11.1)	140 (12.2)	3.4
40+	511 (3.0)	470 (3.0)	41 (3.6)	3.4
Parity				
0	5425 (32.1)	5009 (31.8)	416 (36.0)	8.9
1	4206 (24.9)	3966 (25.2)	240 (21.1)	-9.7
≥2	7276 (43.0)	6792 (43.1)	484 (42.5)	-1.2
Obstetric History				
Cesarean history	3381 (19.9)	3044 (19.2)	337 (29.3)	**23.7**
Preterm birth history	2209 (13.0)	2037 (12.9)	172 (15.1)	6.3
Index Delivery				
Multiple gestation	313 (1.8)	250 (1.6)	63 (5.5)	**21.2**
Preterm (<37 weeks)	4209 (24.8)	3785 (23.9)	424 (36.9)	**28.6**
Mode: Cesarean section	4851 (28.6)	4218 (26.6)	633 (55.1)	**60.6**
Gestational diabetes mellitus	1025 (6.0)	954 (6.0)	71 (6.2)	**22.2**
Placenta previa	117 (0.7)	76 (0.48)	41 (3.6)	0.8
Mild hypertensive disorder of pregnancy†	2879 (17.0)	2614 (16.5)	265 (23.1)	**16.6**
Maternal Comorbidities				
Asthma	1741 (10.3)	1592 (10.1)	149 (13.0)	9.1
Cardiac valvular disease	44 (0.3)	34 (0.2)	10 (0.9)	9.0
Chronic congestive heart failure	30 (0.18)	8 (0.1)	22 (1.9)	**18.2**
Chronic hypertension	773 (4.6)	669 (4.2)	104 (9.1)	**19.8**

Chronic kidney disease	87 (0.5)	44 (0.3)	43 (3.7)	**24.7**
Congenital heart disease	19 (0.1)	18 (0.1)	1 (0.1)	-0.6
Human immunodeficiency virus (HIV)	301 (1.8)	273 (1.7)	28 (2.4)	4.9
Ischemic heart disease	23 (0.1)	13 (0.1)	10 (0.9)	**11.5**
Obesity	1629 (9.6)	1436 (9.1)	193 (16.8)	**58.3**
Pre-existing diabetes mellitus	412 (2.4)	357 (2.3)	55 (4.8)	**13.5**
Pulmonary hypertension	18 (0.1)	9 (0.1)	9 (0.8)	**40.7**
Sickle cell disease	110 (0.7)	55 (0.4)	55 (4.8)	**28.4**
Systemic lupus erythematous	36 (0.2)	24 (0.2)	12 (1.0)	**11.6**
<u>Psychiatric History</u>				
Any psychiatric history	465 (2.7)	386 (2.4)	79 (6.9)	**21.5**
Psychotic disorder	122 (0.7)	108 (0.7)	14 (1.2)	3.8
Mood disorder	190 (1.1)	157 (1.0)	33 (2.9)	9.5
Anxiety disorder	62 (0.4)	49 (0.3)	13 (1.1)	9.5
PTSD, acute stress reaction, and/or adjustment disorder	38 (0.2)	34 (0.2)	4 (0.4)	2.7
Suicide attempt	0 (0.0)	0 (0.0)	0 (0.0)	0.0
<u>Substance Use History</u>				
Alcohol use/disorder	32 (0.2)	25 (0.2)	7 (0.6)	7.3
Other drug use/disorder	181 (1.1)	147 (0.9)	34 (3.0)	**15.0**
<u>Race/Ethnicity</u>				
White, non-Hispanic	426 (2.5)	395 (2.5)	31 (2.7)	1.3
Black, non-Hispanic	11,775 (69.7)	10,933 (69.4)	842 (73.9)	**10.0**
Asian	373 (2.3)	351 (2.2)	22 (1.9)	-2.1
American Indian/ Hawaiian Native	347 (2.1)	325 (2.1)	22 (1.9)	-1.4
Hispanic	3800 (22.5)	3594 (22.8)	206 (18.1)	**-11.7**

Multiple/Other, non-Hispanic	179 (1.1)	162 (1.0)	17 (1.5)	4.5
Insurance Type‡				
Private	902 (5.3)	827 (5.2)	75 (6.5)	5.5
Public	14,854 (87.5)	13,846 (87.4)	1008 (87.7)	0.9
Uninsured/Other	1228 (7.2)	1162 (7.3)	66 (5.7)	-6.5

SMM, severe maternal morbidity. IPTW, inverse probability of treatment weighting.
Data are N (%). Data were missing for <5% of all variables. Percentages represent the number of deliveries within that classification of a given variable and may not sum to 100% due to rounding. For corresponding ICD-9 and ICD-10 Codes, see Appendices 1-4.
Maternal comorbidities modified from Bateman et. al.'s maternal comorbidity index.[21]
*Standardized mean difference (SMD) between SMM and non-SMM exposure groups before IPTW using propensity scoring. **Bolded values** indicate >10% SMD between exposure groups before weighting.
†Includes mild/unspecified pre-eclampsia or gestational hypertension; excludes chronic hypertension or eclampsia.
‡Insurance type at index delivery hospitalization.

Table 2. Final outcomes before and after adjusting by inverse probability of treatment weighting.

	Before weighting			After weighting		
Outcome Variable	Total study population (n = 16,984)	Without SMM	With SMM	Total study population (n = 16,842.4)	Without SMM	With SMM
Any psychiatric diagnosis	157 (0.9)	123 (0.8)	33 (2.9)	114.7 (0.7)	101.9 (0.7)	12.8 (1.1)
Psychotic disorder	23 (0.1)	20 (0.1)	3 (0.3)	21.9 (0.1)	20.8 (0.1)	1.2 (0.1)
Mood disorder	67 (0.4)	52 (0.3)	15 (1.3)	64.2 (0.3)	58.7 (0.4)	5.4 (0.5)
Anxiety disorder	23 (0.14)	20 (0.1)	3 (0.3)	28.2 (0.2)	26.1 (0.2)	2.2 (0.2)
PTSD, acute stress reaction, adjustment disorder	11 (0.1)	7 (0.0)*	4 (0.4)	10.8 (0.1)	7.5 (0.1)	3.3 (0.3)
Suicide attempt	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Alcohol use/disorder	10 (0.1)	9 (0.1)	1 (0.1)	9.7 (0.1)	9.1 (0.1)	0.6 (0.1)
Other drug use/disorder	40 (0.2)	36 (0.2)	4 (0.4)	38.9 (0.2)	38.3 (0.2)	0.6 (0.1)

Data are N(%). Percentages represent the number of deliveries within that classification of given outcome variable and may not sum to 100% due to rounding.
*Value = 0.04

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