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ORIGINAL ARTICLE

Severe maternal morbidity and postpartum mental health-related outcomes in Sweden: a population-based matched-cohort study

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Abstract

We examined whether women experiencing severe maternal morbidity (SMM) are more likely to be treated for a psychiatric illness or be prescribed psychotropic medications in the postpartum year than mothers who did not experience SMM. We also examine the relationship between SMM and specific mental health-related outcomes, and the relationship between specific SMM diagnoses/procedures and postpartum mental-health-related outcomes. The national registers in Sweden were used to create a population-based matched cohort. Every delivery with SMM between July 1, 2006, and December 31, 2012 ($n = 8558$), was matched with two deliveries without SMM ($n = 17{,}116$). Conditional logistic regression models assessed the relationship between SMM and postpartum mental health-related outcomes. Women who experienced SMM had significantly greater odds of being treated for a psychiatric disorder (aOR 1.22; 95% CI 1.03–1.45) and being prescribed psychotropic medications (aOR 1.40; 95% CI 1.24–1.58) in the postpartum year. Specifically, they had significantly greater odds of being treated for neuroses (aOR 1.35; 95% CI 1.09–1.69) and having a prescription for anxiolytics/hypnotics (aOR 1.36; 95% CI 1.18–1.58) or antidepressants (aOR 1.35; 95% CI 1.17–1.55). Women who were diagnosed with shock or uterine rupture/obstetric laparotomy during delivery had the greatest odds of postpartum mental health-related outcomes. This study identified mothers with SMM as a group at high risk for postpartum mental illness. Postpartum mental health services should be provided to ensure the well-being of these high-risk mothers.

Keywords National registry data · Psychiatric treatment · Psychotropic medication · Severe maternal morbidity

Introduction

Severe maternal morbidity (SMM), sometimes referred to as a near miss for maternal mortality, includes conditions resulting from labor and delivery that have unintended short-term or long-term consequences for a woman's health (American College of Obstetricians and Gynecologists et al. 2016). Without medical intervention, most women experiencing SMM would have died (Meikle et al. 2009). However, these complications often result in long hospital stays, emotional distress, interfere with bonding between mother and child, and may result in mother being at higher risk for postpartum mental illness (Filippi et al. 2007; Gray et al. 2012; Norhayati et al. 2015). Research examining the mental health of women after having SMM is inconsistent. Several studies have found that experiences of SMM were associated with post-traumatic stress disorder symptoms and depression in the first 2 months postpartum, whereas others have found no associations between SMM and postpartum depression (Warner et al. 1996;

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Filippi et al. 2007; Blom et al. 2010; Furuta et al. 2014). One of the challenges in examining the relationship between SMM and postpartum psychiatric outcomes is that both SMM and postpartum mental health encompass a range of conditions. Although rates of SMM have been increasing over the past decade (particularly due to blood transfusions), SMM is still quite rare, occurring in approximately 1% of births (Centers for Disease Control and Prevention 2017; Lazariu et al. 2017). Large populations are required to detect associations between different SMM diagnoses and different mental health-related outcomes.

The objective of this study is to examine whether women with SMM are at higher risk of postpartum mental health-related outcomes. Specifically, we examine (1) whether women experience SMM at greater risk of being treated for a psychiatric condition or to be prescribed psychotropic drugs in the year following childbirth, (2) whether SMM associated more strongly with treatment for specific types of psychiatric conditions or specific types of psychotropic prescriptions, and (3) whether the risk of postpartum mental health-related outcomes differ for specific SMM diagnoses/procedures. This population-based matched-cohort study using the linked national registry data provides insight into the relationship between SMM and postpartum mental health in the Swedish population.

Methods and materials

Setting and data

Sweden—a northern European country—has approximately 10 million residents, with all residents having access to universal healthcare coverage (Statistics Sweden 2017; Sweden Institute 2018). Study data were provided by national registers held by the Swedish National Board of Health and Welfare (the Medical Birth Register, the Hospital Discharge Register, Prescribed Drug Register), the National Council for Crime Prevention (the National Register of Criminal Convictions), and Statistics Sweden (Longitudinal Integrated Database for Health Insurance and Labor Market Studies (LISA by Swedish acronym)). These de-identified registries were linked at the individual level using a unique personal identification number. This study is restricted to a matched subcohort.

Exposures and outcomes

SMM is identified in the obstetric delivery record, defined by ICD-10 diagnosis codes and Nordic medical procedure codes during the delivery hospitalization. SMM includes blood transfusions, organ failure, sepsis, shock, cerebrovascular diseases, cardiovascular diseases, severe pre-eclampsia and eclampsia, and uterine rupture and obstetric laparotomy (Wahlberg et al. 2013; Centers for Disease Control and Prevention 2017). The specific conditions and their corresponding diagnosis and procedure codes can be found in Supplementary Table 1.

Two indicators of severe mental health conditions are examined: postpartum psychiatric treatments and psychotropic prescriptions. Information on postpartum psychiatric treatments is obtained through the inpatient psychiatric hospitalizations and psychiatric outpatient clinics in the community outside of hospitals using ICD-10 codes; this information is found in the Hospital Discharge Register. Postpartum psychiatric treatment is defined as an inpatient hospitalization or outpatient treatment where the primary or contributing diagnosis was listed as ICD-10 code F00-F99 (Lindstrom et al. 2009). Three common psychiatric disorders are examined individually: mood (affective) disorders (including severe depressive, manic and bipolar forms, and a range of severe, moderate, and mild depressive disorders; ICD-10 codes F30-F39), neuroses (including phobic, panic, and obsessive-compulsive disorders; ICD-10 codes F40-F49), and behavioral disorders (including eating, sleep, and stress disorders; ICD-10 codes F50-F59) (Wing 1994).

Psychotropic prescriptions are identified through the Prescribed Drug Register using Anatomical Therapeutic Chemical (ATC) codes. Postpartum psychotropic medication is defined as at least one dispensed neuroleptics (ATC code N05A), antidepressants (ATC code N06A), or anxiolytics/hypnotics (ATC codes N05B and N05C) prescription in the year after the woman was discharged from her delivery hospitalization (Brendler-Lindqvist et al. 2014).

Covariates

A series of covariates are included to reduce bias due to confounding. Covariates were selected based on predictors of SMM and postpartum mental illness, and availability of data in the registries. First, we control for the year of the index delivery (1997–1999; 2000–2002; 2003–2005; 2006–2008; 2009–2012). Mother's country of origin has been identified as risk factor for SMM; we define mother's country of origin being Sweden, Europe outside of Sweden, and outside of Europe (Urquia et al. 2017). Sociodemographic characteristics of women in the year of the index delivery (associated with both SMM and postpartum mental illness) are also included: age (< 25, 25–34, 35+), level of education (< 10 years, 10–11 years, 12–13 years 14 years), location (metropolitan area, smaller city, rural), employment status, social welfare receipt, living with the child's biological father, and the number of previous live births (0, 1, 2+) (Beck 2001; Gray et al. 2012). We also account for whether women had a previous cesarean section, which has also been identified as a risk factor for SMM (Goffman et al. 2007). Characteristics during the pregnancy included smoking during pregnancy, and whether the

birth was a multiple pregnancy (e.g., twin pregnancy) (Pallasmaa et al. 2008; Gray et al. 2012). Finally, we adjusted for substance misuse, psychiatric treatment, and prescriptions for psychotropic medications in the year before the delivery, which are both indicators of mental illness (Beck 2001; Munk-Olsen et al. 2011; Forray 2016). Psychiatric treatment is defined as at least one inpatient hospitalization or outpatient treatment in the year before the delivery with an ICD-9 diagnosis of 290–319 or ICD-10 diagnosis of F00–F99 (ICD-9 codes used before 1997, ICD-10 codes used in 1997 and later) (Lindstrom et al. 2009). Substance misuse is defined as at least one inpatient hospitalization or outpatient treatment with alcohol or drug misuse as a main or contributory diagnosis (ICD-9 codes 292, 304, 965.0, 968.5, 969.6, 969.7, 291, 303, 305.0, 357.5, 425.5, 535.3, 571.0–571.3, E86.0, E98.0; ICD-10 codes F10, G62.1, I42.6, K70.0, K70.1, K70.9, K29.20, K29.21, K70.30, F11-F19, T40.0-T40.4, T40.6-T40.9, T41.3, T43.6), or at least one conviction of an alcohol- or drug-related crime in the year before the delivery (Hjern et al. 2004). Psychotropic prescriptions in the year before the index delivery (defined as at least one dispensed prescription of neuroleptics, antidepressants, or anxiolytics/hypnotics) (Brendler-Lindqvist et al. 2014).

Cohort formation

The study cohort formation process began with all deliveries resulting in live births in Sweden between July 1, 2006, and December 31, 2012 ($n = 699{,}236$). The start date was selected to ensure complete prescription data for each mother from 1 year before her index delivery to 1 year after her index delivery (prescription data becomes available in Sweden in July 2005). The end date was selected as the last date of information for at least 1 year after childbirth (data on inpatient hospitalizations, outpatient treatments, and prescriptions are available in Sweden up to 2013). Deliveries with missing information on covariates were removed. Of the remaining 696,159 deliveries, SMM was identified in 9350 (1.3%). Since the exposure in this study (SMM) is rare, we used a matched cohort design to account for potential confounding and minimize variability (Brazauskas and Logan 2016). Each delivery with SMM (group 1) was matched with two deliveries without SMM (group 2) using exact matching; matching was done on all covariates listed above. We selected two deliveries without SMM to increase sample size and minimize mean squared error (Austin 2010; Song and Chung 2010). For women with multiple deliveries in the study period, each delivery was included in the cohort; however, deliveries with SMM were never matched with deliveries without SMM for the same mother. Our final cohort consisted of 8558 deliveries with SMM and 17,116 deliveries without SMM (Fig. 1).

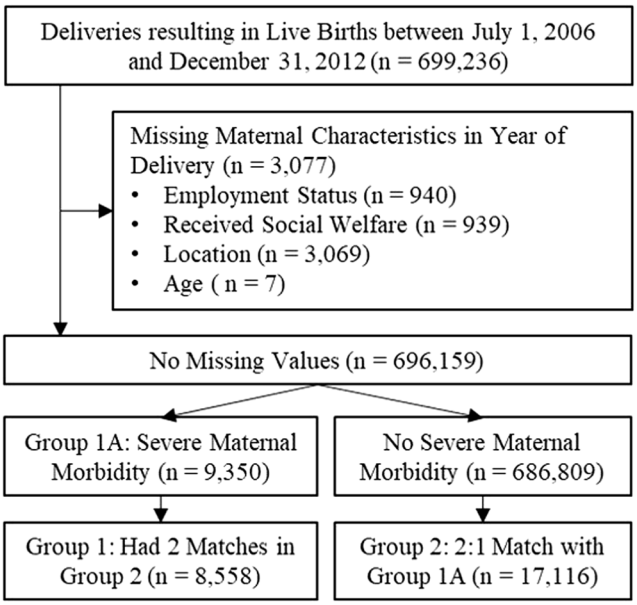

Fig. 1 Cohort selection

Statistical analyses

Conditional logistic regression analysis of the matched cohort examined the relationships between SMM and postpartum mental health-related outcomes. The first analysis examined the relationship between SMM and mental health-related outcomes (overall and specific treatments and diagnoses), and the second analysis examined the relationship between specific SMM diagnoses/procedures and psychiatric treatment/psychotropic prescriptions. All data management, programming, and analyses were performed using SAS® version 9.4.

Results

The cohort consisted of 25,674 deliveries in Sweden between July 1, 2006, and December 31, 2012, of which 8558 had SMM. Since women without SMM were matched on characteristics of women with SMM, the characteristics of the women in the matched cohorts reflect those of the women who experienced SMM and not women in the general population. Most women in the cohorts were between 25 and 34 years old, lived with the father of the child, were born in Sweden, had more than 11 years of education, lived in a metropolitan area, and were employed and not receiving social welfare (such as income and housing supports) in the year of their index delivery (Table 1).

The first analysis examined the association between SMM and postpartum psychiatric treatment/psychotropic medication. We found that women with SMM at delivery had greater odds of being treated for a psychiatric disorder in the year postpartum than women without SMM (OR 1.22; CI 1.03–1.45) (Table 2). Specifically, in deliveries with SMM, the odds

Table 1 Characteristics of women before index delivery, by SMM, Sweden, 2006–2012

Variables	SMM ($n = 8558$)	No SMM ($n = 17,116$)
Year of index delivery		
2006	366 (4.3%)	732 (4.3%)
2007	1166 (13.6%)	2332 (13.6%)
2008	1277 (14.9%)	2554 (14.9%)
2009	1352 (15.8%)	2704 (15.8%)
2010	1562 (18.3%)	3124 (18.3%)
2011	1628 (19.0%)	3256 (19.0%)
2012	1207 (14.1%)	2414 (14.1%)
Mother's country of birth		
Sweden	6588 (77.0%)	13,176 (77.0%)
Europe, outside of Sweden	422 (4.9%)	844 (4.9%)
Outside of Europe	1548 (18.1%)	3096 (18.1%)
Characteristics of women in year of index delivery		
Age		
< 25 years	1097 (12.8%)	2194 (12.8%)
25–34 years	5363 (62.7%)	10,726 (62.7%)
≥ 35 years	2098 (24.5%)	4196 (24.5%)
Living with father of child	7684 (89.8%)	15,368 (89.8%)
Education		
≤ 9 years	991 (11.6%)	1982 (11.6%)
10–11 years	630 (7.4%)	1260 (7.4%)
12–13 years	3516 (41.1%)	7032 (41.1%)
14+ years	3421 (40.0%)	6842 (40.0%)
Residency		
Metropolitan area	4100 (47.9%)	8200 (47.9%)
Smaller city	3466 (40.5%)	6932 (40.5%)
Rural	992 (11.6%)	1984 (11.6%)
Unemployed	1975 (23.1%)	3950 (23.1%)
Received social welfare	594 (6.9%)	1188 (6.9%)
Number of previous live births		
0	4720 (55.2%)	9440 (55.2%)
1	2601 (30.4%)	5202 (30.4%)
2+	1237 (14.5%)	2474 (14.5%)
Previous cesarean section	1341 (15.7%)	2682 (15.7%)
Pregnancy variables		
Multiple pregnancy	555 (6.5%)	1110 (6.5%)
Smoking during pregnancy	329 (3.8%)	658 (3.8%)
Characteristics in the year before the index delivery		
Psychiatric treatment	152 (1.8%)	304 (1.8%)
Prescription for psychotropic medication	447 (5.2%)	894 (5.2%)
Substance misuse	< 5[a]	[a]

[a] Suppressed to maintain confidentiality

of treatment for neuroses were 1.35 times greater (CI 1.09–1.69). Deliveries with and without SMM were equally likely to be followed by a treatment for mood disorders or behavioral disorders. The odds of having a postpartum psychotropic prescription were 1.44 times greater among women who had SMM at delivery (95% CI 1.24–1.58). Specifically, in deliveries with SMM, the odds of having a prescription for anxiolytics or hypnotics was 1.36 times greater (CI 1.18–1.58) and the odds of having a prescription for antidepressants was 1.35 times greater (CI 1.17–1.55). The odds of being prescribed a

Table 2 Prevalence and odds ratios for psychiatric treatment and psychotropic prescriptions in the first year postpartum, Sweden, 2006–2012

	SMM ($n = 8558$)	No SMM ($n = 17,116$)	Odds ratio (95% confidence interval)
Treatment for any psychiatric disorder	240 (2.9%)	424 (2.5%)	1.22 (1.03–1.45)
Treatment for specific psychiatric disorders			
Mood disorders	103 (1.2%)	208 (1.2%)	0.99 (0.76–1.28)
Neuroses	141 (1.7%)	214 (1.3%)	1.35 (1.09–1.69)
Behavioral disorders	23 (0.3%)	41 (0.2%)	1.12 (0.67–1.87)
Prescription for any psychotropic medication	619 (7.2%)	973 (5.7%)	1.40 (1.24–1.58)
Prescription for specific psychotropic medication			
Neuroleptics	20 (0.2%)	41 (0.2%)	0.98 (0.57–1.68)
Antidepressants	447 (5.2%)	722 (4.2%)	1.35 (1.17–1.55)
Anxiolytics/hypnotics	315 (3.7%)	474 (2.8%)	1.36 (1.18–1.58)

neuroleptic did not differ for women with and without SMM at delivery.

Specific SMM diagnoses/procedures

Next, we examined whether specific SMM diagnoses or procedures led to higher risk of psychiatric treatment and psychotropic prescriptions. The most common SMM diagnosis/procedure in our cohorts was blood transfusion (80%), and the least common SMM diagnosis was sepsis (< 1%) (Table 3). Women who were diagnosed with shock or uterine rupture/obstetric laparotomy during delivery were significantly more likely to have a postpartum psychiatric treatments and postpartum psychotropic prescription than their matches who did not have a SMM diagnosis/procedure. Women who had a blood transfusion, cerebrovascular disease, or cardiovascular disease had higher odds of having a postpartum psychotropic prescription but not a postpartum psychiatric treatment. Organ failure, severe pre-eclampsia, eclampsia, and sepsis did not result in greater odds of postpartum psychiatric treatment or psychotropic prescriptions.

Sensitivity analysis

In our primary analysis, psychiatric treatments were defined as having an inpatient or outpatient treatment where the primary or a contributing diagnosis was a psychiatric disorder. Women with SMM will likely continue to use specialized care after their deliveries, which increases their surveillance and may increase their likelihood of having a complimentary psychiatric diagnosis registered. To address this potential bias, a sensitivity analysis was conducted where the psychiatric treatments were defined using only the primary diagnosis.

When we defined postpartum psychiatric treatment using only the primary diagnosis, 2.3% of women with SMM had a treatment (compared to 2.9% of women with SMM using the original definition). The percent of women without SMM who had postpartum psychiatric treatment also decreased slightly using only primary diagnosis (2.5% using all diagnoses, 2.0% using only primary diagnosis). Using only primary diagnoses resulted in women with and without SMM to have equal odds of being treated for psychiatric treatments; however, women with shock and uterine rupture/obstetric laparotomy had

Table 3 Frequencies of specific SMM diagnoses/procedures among women with SMM, and odds ratios for any psychiatric treatment and any psychotropic prescriptions in the first year postpartum for each SMM diagnoses/procedure, Sweden, 2006–2012

SMM diagnosis/procedure	*N* (% of SMM)	Psychiatric treatment Odds ratio (95% confidence interval)	Psychotropic prescriptions Odds ratio (95% confidence interval)
Blood transfusion	6866 (80.2%)	1.07 (0.87–1.31)	1.27 (1.11–1.46)
Organ failure	82 (1.0%)	1.48 (0.44–4.95)	0.77 (0.22–2.68)
Shock	183 (2.1%)	28.53 (3.76–215.46)	3.03 (1.38–6.64)
Cerebrovascular diseases	61 (0.7%)	0.67 (0.07–6.41)	4.32 (1.35–13.81)
Cardiovascular diseases	151 (1.8%)	2.21 (0.92–5.31)	4.00 (1.90–8.41)
Severe pre-eclampsia, eclampsia	708 (8.3%)	1.43 (0.82–2.48)	1.47 (0.98–2.19)
Uterine rupture, obstetric laparotomy	724 (8.5%	2.85 (1.62–5.02)	1.94 (1.28–2.94)
Sepsis	34 (0.4%)	[a]	6.61 (0.72–60.86)

[a] Model did not converge

significantly greater odds of being treated for a psychiatric disorder (see Supplementary Tables 2 and 3).

Conclusion

To our knowledge, this is the first population-based study to examine the relationship between SMM and postpartum mental health-related outcomes. We found that women who experienced SMM during the delivery of their child had significantly greater odd of being treated for a psychiatric condition and to be prescribed psychotropic medication in the year after giving birth. However, when we examined specific psychiatric treatments and psychotropic prescriptions, we saw differences in their relationship with SMM. Women with SMM during delivery had greater odds of being treated for neuroses, but not mood disorders or behavioral disorders, and had greater odds of being prescribed anxiolytics/hypnotics and antidepressants, but not neuroleptics. SMM encompasses a range of diagnoses and procedures, and not each diagnosis/procedure was associated with an increased risk of postpartum mental health-related outcomes. While all SMM diagnoses except organ failure, sepsis, severe pre-eclampsia, and eclampsia resulted in either higher psychiatric treatments or psychotropic prescriptions, uterine rupture/obstetric laparotomy and shock resulted in both greater psychiatric treatment and psychotropic prescription use. Thus, while there is a relationship between SMM and postpartum mental health-related outcomes, many nuances exist.

Independently, SMM and postpartum mental illness each have significant implications for the health and well-being of both mother and child. Our findings indicate that women with SMM are at an increased risk for postpartum mental illness, resulting in increased challenges for both women and their children. Postpartum mental illness can affect mother-child bonding and affect a mother's ability to parent, and has been associated with behavioral and cognitive development in offspring (Beck 2001; Field 2010). Nearly half of SMM cases have been deemed preventable, with the source of prevention being provider factors in the majority of these case (Geller et al. 2004). Improved maternal health services can reduce the risk of SMM, which in turn could have the potential to reduce postpartum mental illness in this group of high-risk women. Additionally, since mental illness is a leading cause of maternal death, clinical practice improvement for maternal morbidity, and mortality should include mental illness (Easter et al. 2018). While the effectiveness of many interventions to reduce postpartum mental illness is questionable, several studies examining home visiting programs have shown improved parent-infant interactions, improved maternal mental health, and maternal well-being (Escobar et al. 2001; Shaw et al. 2006; Chartier et al. 2017). While SMM is relatively rare, and often preventable, when it does occur, patient care should offer services and information to women with SMM during hospitalization and after discharge from hospital to aid in recovery and prevent subsequent psychiatric disorders (Filippi et al. 2007). Women with SMM often do not receive adequate information about their illness; it has been recommended that following an SMM event, women should be debriefed by their clinician before discharge, offered social support and/or mental health services, and have a follow-up appointment arranged with a clinical specialist team (Furniss et al. 2018). These measures could better identify changes to a woman's mental health, and appropriate services could be provided potentially preventing hospitalization for mental illness.

The national registry data in Sweden have some significant strengths, including large sample sizes (close to 700,000 deliveries), which allows us to examine rare outcomes such as SMM, and linkages across many databases (including information on births, hospitalizations, prescribed drugs, criminal convictions, and receipt of social welfare), which allows for the inclusion on many potential confounders. The primary limitation of this study concerns the availability and reliability of variables. The use of ICD codes to define mental illness leads to results with high specificity but low sensitivity (Fiest et al. 2014). Additionally, while we can account for inpatient psychiatric hospitalizations, outpatient psychiatric treatment, and psychiatric pharmaceutical prescriptions, we do not have any information on mental health treatments in primary care, nor do we have information on actual medication intake. This means that we are likely underestimating the incidence of psychiatric illness both before and after the delivery, and only capturing more severe forms of mental illness. It is possible that there is no difference in the overall prevalence of mental illness for women who do and do not have SMM, just a difference in prevalence of severe mental illness. While we account for psychiatric treatment and prescriptions of psychotropic medications in the year before the delivery, we do not know whether mothers had a mental health condition before this time period that potentially re-emerged after the delivery. We also do not know whether the mental health of women with pre-existing mental illness deteriorated after a delivery with SMM, resulting in a hospitalization. While the population-based cohorts did allow us to examine nuances in the relationship between SMM and postpartum psychiatric treatment, we did not have a large enough sample size to examine specific conditions. For example, previous studies have identified a relationship between SMM and post-traumatic stress disorder (PTSD), but we did not have enough cases of PTSD in our cohort to examine this relationship (Furuta et al. 2014). While the large sample size allowed us to examine different SMM events, given how rare each specific event is, diagnoses were grouped together. This is a limitation, as our definition of shock included a range of outcomes, including hemorrhagic shock, septic shock, or cardiogenic shock, each of which has a different etiology, and have

different clinical implications. Larger sample sizes are required to understand the relationship between specific SMM events and postpartum mental illness. Finally, the rate of SMM was slightly lower in Sweden (134 per 10,000 deliveries) than in the USA (144 per 10,000 deliveries in 2014) and Canada (154 per 10,000 deliveries in 2010) (Public Health Agency of Canada 2013; Centers for Disease Control and Prevention 2017); however, this study should be replicated in other settings to assess generalizability, particularly in settings without universal healthcare. Given the universal coverage and strong social safety net in Sweden, the risk of mental illness following SMM may be lower in this setting; however, rates of mental health treatment and medication may be lower in a setting without universal coverage because women with mental health consequences of SMM may not be getting the care they need.

Women experiencing SMM, particularly organ failure, shock, cerebrovascular diseases, and cardiovascular diseases, are at greater risk of postpartum mental illness requiring treatment and psychotropic medications. Women experiencing SMM are closely monitored to ensure their physical health stabilizes. This study indicates that mental health should also be monitored, and mental health services should be provided to ensure better outcomes for these high-risk women.

Author contributions EW conceived of the presented idea, conducted the analysis, and drafted the manuscript. SLC, MLU, CL, and AH made important intellectual contributions on severe maternal morbidity, reviewed the manuscript, and provided significant feedback. AH obtained the data. All authors discussed the results and contributed to the final manuscript.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The Regional Ethics Committee in Stockholm approved this study (dnr: 2010/5:1); all data was anonymized and therefore did not require informed consent.

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