

Severe Maternal Morbidity During Delivery Hospitalizations

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ABSTRACT

Introduction: Severe maternal morbidities include 25 complications resulting from, or exacerbated by, pregnancy. Nationally, in the last decade, these rates have doubled.

Objective: This study describes trends in the rates of severe maternal morbidities at the time of hospitalization for delivery among different groups of Wisconsin women.

Methods: Hospital discharge data and ICD-9-CM diagnosis and procedure codes were used to identify delivery hospitalizations and rates of severe maternal morbidity among Wisconsin women from 2000 to 2014. Subsequent analyses focused on recent years (2010-2014). Rates of severe maternal morbidity were calculated per 10,000 delivery hospitalizations for all 25 severe maternal morbidity conditions as well as 24 conditions (excluding blood transfusions). Rates and rate ratios were calculated overall and for racial/ethnic groups, age groups, public health region of residence, and hospital payer. Median hospital length of stay and median hospital charges were compared for delivery hospitalizations with increasing severe maternal morbidities.

Results: Severe maternal morbidity rates increased 104% from 2000 to 2014 (*P* for trend <0.01). After excluding blood transfusions, rates increased 15% (*P* for trend <0.05). From 2010 to 2014, overall rates were stable over time, but varied by maternal age, race/ethnicity, payer, and public health region of residence. Median hospital charges and length of stay increased as the number of morbidities increased.

Conclusions: Monitoring severe maternal morbidities adds valuable information to understanding perinatal health and obstetric complications in order to identify opportunities for prevention of severe morbidities and improvements in the quality of maternity care.

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INTRODUCTION

Considerable progress has been made in the United States to reduce pregnancy-related deaths.¹ This is reflected in Wisconsin, where maternal mortality remains below the national average (16.0 per 100,000 live births) at 5.9 deaths per 100,000 live births.² Though maternal deaths are relatively rare, it is estimated that for each death another 50 women experience serious complications related to pregnancy.³ While maternal deaths traditionally have been the key indicator for maternal outcomes, the prevalence of serious pregnancy complications—or severe maternal morbidities—can provide a more comprehensive picture of perinatal health issues when examined along with maternal deaths.^{3,4}

Nationally, there are efforts to expand maternal health surveillance beyond maternal death to severe maternal morbidity, which may have both short- and long-term consequences for childbearing women.⁵ Included in these efforts is the development of a standardized measure that utilizes diagnostic codes

from hospital data to identify delivery hospitalizations with at least 1 of 25 severe conditions.³⁻⁵ These conditions often are associated with long hospital stays and high medical costs at the time of delivery and, for some women, well into the postpartum period.⁴

In the past decade, reported severe maternal morbidity nationally has increased from 79 to 163 per 10,000 delivery hospitalizations—a 106% increase—suggesting a need to improve the quality of maternal care and identify high-risk women for targeted interventions in the perinatal period.^{4,6} Estimating severe maternal

morbidity at the state level is an important extension of this work, since state health departments are well-positioned to share the information with multiple partners who work closely with and within health-care systems. To date, statewide surveillance of severe maternal morbidity has not been put into practice in Wisconsin, but may offer insights for identifying opportunities to prevent maternal deaths and address quality in perinatal care.³ This analysis utilizes the standardized measure for severe maternal morbidity to describe temporal trends and identify groups at increased risk in Wisconsin.

METHODS

Wisconsin's hospital discharge data was used to identify delivery hospitalizations to Wisconsin women from 2000 to 2014.

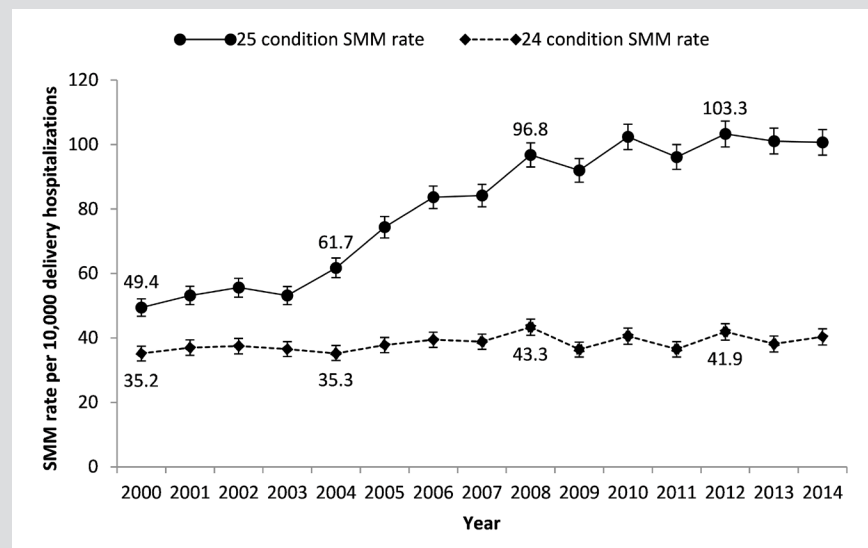
This data contains hospital admission and discharge encounters in Wisconsin facilities regardless of payer. In addition, delivery hospitalizations for Wisconsin residents in Minnesota facilities were included, as approximately 1,200 Wisconsin resident births (2%) and as many as 98% of births to women residing in some western Wisconsin counties occur in Minnesota facilities. Any hospitalizations of out-of-state residents in Wisconsin facilities were excluded from analysis. Delivery hospitalizations were identified with pregnancy-related International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes using methods previously described by Kuklina and colleagues.⁶

To identify delivery hospitalizations with severe maternal morbidity, 25 conditions present at the time of delivery hospitalization among Wisconsin residents were identified with ICD-9-CM diagnosis and procedure codes using methods described by Callaghan and colleagues.⁴ A severity recalculation was applied to account for implausibly short length of hospital stay, such that delivery hospitalizations identified by diagnosis codes were reclassified as non-severe maternal morbidity delivery hospitalizations if the length of stay was less than the 90th percentile.⁴

The severe maternal morbidity rate was calculated as the number of delivery hospitalizations with at least 1 condition per 10,000 delivery hospitalizations, and the Cochran-Armitage test for linear trend was used to examine changes from 2000 to 2014. To statistically test apparent stabilization in more recent years, Joinpoint software was used to identify the best fit line for trends, including detection of any changes in the slope of the trend line over time.⁷

To provide a more detailed look at trends and disparities in recent years, delivery hospitalizations from 2010 to 2014 were the

Figure. Severe Maternal Morbidity Rate, Wisconsin 2000-2014



Abbreviation: SMM, severe maternal morbidities.

focus of subsequent analyses. Rates were calculated separately for each condition as well as hospital stay payer (private, Medicaid, and other—eg, all other payers including Medicare, other governmental payer, self-pay, or unknown), age categories (less than 20 years, 20-24 years, 25-29 years, 30-34 years, 35-39 years, and 40 or more years), race/ethnicity (Hispanic, non-Hispanic white, non-Hispanic black, non-Hispanic American Indian/Alaska Native, non-Hispanic Asian/Pacific Islander, and non-Hispanic other), delivery type (vaginal, primary cesarean, and repeat cesarean) and public health region of residence (western, northern, northeastern, southeastern, and southern). Crude rate ratios were calculated to compare rates within these categories.

Delivery hospitalizations with severe maternal morbidity were categorized as having 0, 1, 2, or 3 or more conditions. In addition, median hospital length of stay and median total hospital charges for delivery hospitalizations with no severe maternal morbidity were compared to delivery hospitalizations across these categories. The Wilcoxon Rank Sum test was used to compare median length of stay and charges for each category compared to the category with fewer severe maternal morbidities as the comparison group (eg, 1 vs 0, 2 vs 1, and 3+ vs 2).

Two severe maternal morbidity rates were calculated across all analyses: (1) a morbidity rate including all 25 conditions, and (2) a 24-condition morbidity rate excluding blood transfusion. The 25-condition rate usually is dominated by transfusion as the leading severe maternal morbidity condition, so an examination of the 24-condition rate allows for an assessment of trends and other findings independent of the impact of transfusion.⁵ This comparison is valuable, as hospital discharge data does not include information about the number of units of blood transfused, and transfusions of less than 4 units may inappropriately classify delivery

hospitalizations as those with severe maternal morbidity. *P*-values of less than 0.05 were interpreted as statistically significant for all comparisons and statistical tests. All statistical analyses were conducted in SAS version 9.4 (SAS Institute, Cary, North Carolina) and Joinpoint version 4.3.1.0.

RESULTS

A total of 995,179 delivery hospitalizations occurred among Wisconsin women between 2000 and 2014. Of those, 7,999 were identified with severe maternal morbidity (overall rate=80.4 per 10,000 delivery hospitalizations, 95% CI=78.6, 82.2), but 1,894 (19.1%) were reclassified as non-severe maternal morbidity hospitalizations due to length of stay less than the 90th percentile. The severe maternal morbidity rate increased 103.6% between 2000 and 2014 (*P* for trend <0.01; see Figure), and we identified 1 point where the slope of the trend line changed significantly. While the rate increased from 2000 to 2007 (*P*<.01), there was no significant change from 2008 to 2014 (*P*=0.14). After removing blood transfusions, there were 3,812 delivery hospitalizations with severe maternal morbidity from 2000 to 2014 (overall rate=38.3, 95% CI=37.1, 39.5), with a 14.7% increase during this time period (*P* for trend=0.04). No changes in the slope of the trend line were identified.

From 2010 to 2014, there were 320,745 delivery hospitalizations. Of those, 3,229 were identified with severe maternal morbidity (rate=100.7, 95% CI=97.2, 104.1), and 572 (15.0%) were reclassified as non-severe maternal morbidity hospitalizations due to length of stay less than the 90th percentile. This rate remained stable during the time period (*P* for trend=0.90).

After removing blood transfusions (24-condition rate), there were 1,266 delivery hospitalizations with severe maternal morbidity (rate=39.5, 95% CI=37.3, 41.7), a rate that remained virtually stable (percent decrease=0.6%, *P* for trend=0.88).

Table 1 shows the number and rate of each condition, ordered by highest rate. Among delivery hospitalizations with severe maternal morbidity, 12.8% (n=414) had more than 1 condition. Both hospital charges and length of stay increased significantly with each additional severe maternal morbidity for the 25-condition

Table 1. Severe Maternal Morbidity Rates by Condition for Delivery Hospitalizations, 2010–2014

Condition	No.	Delivery Hospitalizations	
		Rate Per 10,000	95% CI
Blood transfusion	2,214	69.0	66.2, 71.9
Operations on heart, pericardium, and other vessels ^a	271	8.4	7.4, 9.5
Hysterectomy	245	7.6	6.7, 8.6
Disseminated intravascular coagulation	221	6.9	6.0, 7.8
Heart failure during procedure or surgery	147	4.6	3.8, 5.3
Acute renal failure	130	4.1	3.4, 4.7
Adult respiratory distress syndrome	122	3.8	3.1, 4.5
Ventilation	99	3.1	2.5, 3.7
Eclampsia	85	2.7	2.1, 3.2
Shock	81	2.5	2.0, 3.1
Sepsis	62	1.9	1.5, 2.4
Puerperal cerebrovascular disorders	35	1.1	0.7, 1.5
Cardio monitoring	28	0.9	0.5, 1.2
Pulmonary edema	27	0.8	0.5, 1.2
Thrombotic embolism	27	0.8	0.5, 1.2
Sickle cell anemia with crisis	18	0.6	0.3, 0.8
Internal injuries of thorax, abdomen and pelvis	14	0.4	0.2, 0.7
Amniotic fluid embolism	12	0.4	0.2, 0.6
Cardiac arrest or ventricular fibrillation	12	0.4	0.2, 0.6
Conversion of cardiac rhythm	12	0.4	0.2, 0.6
Severe anesthesia complications	11	0.3	0.1, 0.5
Intracranial injuries	5	b	b
Acute myocardial infarction	4	b	b
Aneurysm	1	b	b
Temporary tracheostomy	1	b	b

^aCategory has been renamed to clarify the inclusion of operations on other vessels.

^bRates and CIs not calculated for severe maternal morbidity with fewer than 10 events.

Table 2. Median and Range of Length of Hospital Stay and Hospital Charges by Number of Severe Maternal Morbidities Among Delivery Hospitalizations, Wisconsin, 2010-2014

	25-Condition SMM		24-Condition SMM	
	LOS (Days)	Hospital Charges	LOS (Days)	Hospital Charges
0 SMM	2	\$8,954	2	\$8,983
1 SMM	3 ^a	\$18,891 ^a	4 ^a	\$23,619 ^a
2 SMM	5 ^b	\$34,975 ^b	6 ^b	\$52,426 ^b
3+ SMM	6 ^c	\$68,895 ^c	7	\$78,874 ^c

Abbreviations: SMM, severe maternal morbidity; LOS, length of hospital stay.

^aSignificantly different from 0 SMM, *P*<0.01.

^bSignificantly different from 1 SMM, *P*<0.01.

^cSignificantly different from 2 SMM, *P*<0.01.

analysis (*P*<0.01 for each comparison), and results were similar for the 24-condition analysis with the exception of 3+ vs 2 conditions (Table 2). Table 3 shows rates and rate ratios by demographic and geographic subgroups. We observed disparities by age, race, payer, mode of delivery, and region.

DISCUSSION

Our observations for the most commonly documented severe maternal morbidity conditions and increasing trend over time

Table 3. Severe Maternal Morbidity Rate by Demographics, Payer, and Public Health Region of Residence, Wisconsin, 2010-2014

	25-Condition SMM			24-Condition SMM		
	Delivery With SMM	Rate Per 10,000 Delivery (Hospitalizations (95% CI))	Rate Ratio (95% CI)	Delivery With SMM	Rate Per 10,000 Delivery Hospitalizations (95% CI)	Rate Ratio (95% CI)
Age						
< 20	290	139.6 (123.6, 155.7)	1.6 (1.4, 1.9)	79	38.0 (29.6, 46.4)	1.2 (0.9, 1.5)
20-24	670	98.8 (91.3, 106.2)	1.2 (1.0, 1.3)	190	28.0 (24.0, 32.0)	0.9 (0.7, 1.0)
25-29	866	85.4 (79.7, 91.1)	Reference	332	32.7 (29.2, 36.3)	Reference
30-34	833	93.3 (87.0, 99.7)	1.1 (1.0, 1.2)	366	41.0 (36.8, 45.2)	1.3 (1.1, 1.5)
35-39	443	128.4 (116.5, 140.4)	1.5 (1.3, 1.7)	227	65.8 (57.2, 74.4)	2.0 (1.7, 2.4)
40+	127	181.4 (149.8, 212.9)	2.1 (1.8, 2.6)	72	102.8 (79.1, 126.6)	3.1 (2.4, 4.1)
Race/ethnicity ^a						
Non-Hispanic white	1,922	86.2 (82.3, 90.0)	Reference	775	34.7 (32.3, 37.2)	Reference
Non-Hispanic black	476	148.0 (134.7, 161.3)	1.7 (1.6, 1.9)	197	61.3 (52.7, 69.8)	1.8 (1.5, 2.1)
Hispanic	347	126.3 (113.0, 139.6)	1.5 (1.3, 1.6)	116	42.2 (34.5, 49.9)	1.2 (1.0, 1.5)
Non-Hispanic Asian/Pacific Islander	172	135.7 (115.4, 156.0)	1.6 (1.3, 1.8)	61	48.1 (36.0, 60.2)	1.4 (1.1, 1.8)
Non-Hispanic American Indian/Alaska Native	56	158.9 (117.3, 200.5)	1.8 (1.4, 2.4)	14	39.7 (18.9, 60.5)	1.1 (0.7, 1.9)
Non-Hispanic Other	29	100.5 (63.9, 137.1)	1.2 (0.8, 1.7)	16	55.5 (28.3, 82.6)	1.6 (1.0, 2.6)
Payer						
Private	1,551	85.1 (80.9, 89.3)	Reference	652	35.8 (33.0, 38.5)	Reference
Medicaid	1,548	120.9 (114.9, 126.9)	1.4 (1.3, 1.5)	543	42.4 (38.8, 46.0)	1.2 (1.1, 1.3)
Other	130	125.8 (104.2, 147.4)	1.5 (1.2, 1.8)	71	68.7 (52.7, 84.7)	1.9 (1.5, 2.5)
Public health region of residence						
Western	310	75.3 (66.9, 83.7)	Reference	131	31.8 (26.4, 37.3)	Reference
Northeastern	663	98.2 (90.7, 105.7)	1.3 (1.1, 1.5)	202	29.9 (25.8, 34.0)	0.9 (0.8, 1.2)
Northern	271	113.9 (100.3, 127.4)	1.5 (1.3, 1.8)	94	39.5 (31.5, 47.5)	1.2 (1.0, 1.7)
Southeastern	1,259	101.7 (96.1, 107.4)	1.4 (1.2, 1.5)	538	43.5 (39.8, 47.2)	1.4 (1.1, 1.7)
Southern	726	112.8 (104.6, 121.0)	1.5 (1.3, 1.7)	301	46.8 (41.5, 52.0)	1.5 (1.2, 1.8)
Delivery type						
Vaginal	606	57.9 (54.9, 61.0)	Reference	306	17.2 (15.6, 18.9)	Reference
Primary cesarean	1,250	273.4 (258.6, 288.9)	4.7 (4.4, 5.1)	553	121.0 (111.2, 131.4)	7.0 (6.2, 8.0)
Repeat cesarean	1,373	159.6 (147.3, 172.7)	2.8 (2.5, 3.0)	407	80.6 (71.9, 90.0)	4.7 (4.0, 5.4)

Abbreviations: SMM, severe maternal morbidity.

Bold type indicates a statistically significant difference from a ratio of 1.0.

^a18,927 hospitalizations missing race/ethnicity (5.9%).

are consistent with other studies.³ Blood transfusions, which accounted for most of the increase in severe maternal morbidity over time, may relate to postpartum hemorrhage.^{3,4} It is well understood that prior cesarean delivery increases the risk for abnormal placentation in subsequent deliveries, potentially leading to hemorrhage. Further, placental abnormalities, labor induction, cesarean deliveries, and instrumental delivery have increased, which may be related to prenatal obesity and advanced maternal age.^{5,8-13} Increases in severe maternal morbidity nationally have been attributed to maternal factors such as obesity, cesarean delivery, and chronic health conditions.¹⁴ Publicly available data from the Wisconsin Department of Health Services indicate that the proportion of cesarean delivery births increased from 17% to 25% from 2000 to 2007 but remained stable from 2008 to 2014 (25% vs. 26%).¹⁵ Further, the Centers for Disease Control and

Prevention's Pregnancy Risk Assessment Monitoring System, a population-based survey targeting mothers with a live birth, indicates that the proportion of Wisconsin women who were obese prior to pregnancy has remained stable since 2008.¹⁶ While previous studies have identified higher risk of severe maternal morbidity for cesarean deliveries,^{5,14} it is unclear whether severe maternal morbidity increases the risk for cesarean delivery or vice versa. Future examination of prepregnancy maternal health may assist in understanding the relationship between severe maternal morbidity and mode of delivery.

A challenge in understanding blood transfusion trends relates to how the ICD-9-CM code is used in practice in events such as postpartum hemorrhage. This condition is often clinically defined as blood loss greater than 500 ml for a vaginal delivery and 1,000 ml for cesarean delivery,^{5,17} thresholds that are good predictors of

the need for blood transfusion.¹⁷ However, the ICD-9-CM code for blood transfusion does not include information for important contextual details such as units of transfused blood, which may be an important indicator of severity, particularly as calls for in-hospital reviews of severe maternal morbidity suggest reviewing cases where women receive 4 or more units of blood.¹⁸ In addition, lack of detailed clinical information and changes in clinician use of blood transfusion over time further limits our ability to fully explain the increase in blood transfusions in Wisconsin.¹⁹

Our findings for median length of stay and hospital charges likely reflect that women with multiple severe maternal morbidities may tend to have more severe or complex medical complications during delivery hospitalization, which may require longer and more expensive hospital care. Of interest, median length of stay and charges were lower for 25-condition vs 24-condition severe maternal morbidity. This may reflect the predominance of blood transfusions in the 25-condition definitions such that some of those hospitalizations with only blood transfusion may be relatively minor in comparison to the other 24 conditions.

Disparities for severe maternal morbidity by demographic characteristics followed very similar patterns to those recently reported for maternal mortality in Wisconsin.² The rare occurrence of maternal death and small population size for some racial/ethnic groups in the state prevent the ability to examine disparities in maternal mortality across all groups. Thus, severe maternal morbidity can provide a mechanism for identification of these disparities in maternal health and outcomes.

Some limitations of this study should be noted. First, we included only delivery hospitalizations; consequently, women hospitalized prenatally or postpartum for any of the 25 severe maternal morbidity conditions are not captured in our estimation of severe maternal morbidity burden if these conditions were not also present at delivery. Further, though we utilized a validated method for identifying severe maternal morbidity, the use of ICD-9-CM codes for the analysis may result in misclassification as coding practices can vary among medical coders by facility or over time. In addition, the severe maternal morbidity conditions described here each include multiple ICD-9-CM codes, which might obscure whether a few codes disproportionately account for the events in some categories. For example, Wisconsin's rate for operations on the heart, pericardium, and other vessels category was substantially higher than the US rate.⁴ Upon examination of the ICD-9-CM codes contributing to this category, we observed that suture of artery (39.31) was the most common code within this category and very few codes were related to the heart or pericardium. Finally, hospital data does not include contextual information that could enhance the analysis. For example, there are few fields within the dataset that allow for adjustment for potential confounders beyond basic demographic information, including risk factors such as obesity, poverty status, late or no prenatal care,

prior cesarean delivery, or prepregnancy medical condition.^{1,20-22} Consequently, differences identified by geography, demographics, and hospital payer should be interpreted cautiously, as we did not conduct analyses to adjust for confounders. Analyses utilizing hospital discharge data linked to the newborn hospitalization and birth certificate would enable a more complete exploration of contributors to differences and trends in severe maternal morbidity.¹

CONCLUSIONS

Despite these limitations, our analysis of severe maternal morbidities adds to the understanding of perinatal complications in Wisconsin. The Wisconsin Maternal Mortality Review Team has been able to glean some limited information about the increased risk of chronic disease on maternal health, but continued surveillance of severe maternal morbidities would provide more in-depth understanding.² In addition, it is important for physicians and hospitals to be aware of the trends and current distribution of severe maternal morbidities among Wisconsin mothers as they identify needs for quality improvement related to perinatal care. The American College of Obstetricians and Gynecologists recommends that hospitals or birth facilities develop and maintain their own severe maternal morbidity review process to address opportunities for system and caregiver improvement.¹⁴ Our analyses provide important information about groups of women at risk for severe pregnancy complications, which could help identify areas for targeted intervention. Further, our use of a standard approach for identifying and tracking maternal complications provides clinicians and public health partners with a framework for exploring opportunities to improve perinatal care and outcomes.

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