Rural–Urban Differences in Delivery Hospitalization Costs by Severe Maternal Morbidity Status

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Background:

Severe maternal morbidity (SMM) during hospitalizations for deliveries affects more than 50 000 U.S. women annually, with risks for long-term morbidity and immediate health care costs more than double that of unaffected deliveries (1, 2). Women in rural areas face greater barriers to preventive and specialty health care services, including limited provider

availability, longer distances to care, and financial constraints (3), which may contribute to adverse obstetric outcomes (4) and higher costs during delivery hospitalizations than their urban counterparts. A previous study found that rural hospitals incurred significantly higher average costs for low-risk deliveries, by nearly $500, compared with urban hospitals (5). It is unclear whether this finding reflects patient residence versus facility location only and whether it applies to the broader population of deliveries, including those affected by SMM. To address this literature gap, this study compares delivery costs between rural and urban residents with and without SMM, with adjustment for other sociodemographic and facility characteristics.

Objective:

To compare delivery hospitalization costs between rural and urban residents by SMM status and degree of complexity (no SMM, any SMM, 1 SMM, and 2 SMMs).

Methods and Findings:

Hospitalizations for deliveries (n = 2 167 876) from the 2012 to 2014 National Inpatient Sample, a nationally representative sample of were converted to costs using Healthcare Cost and Utilization Project Cost-to-Charge Ratios. SMMs were identified by the Centers for Disease Control and Prevention's list of 21 indicators (18 when 3 rare indicators are collapsed; refer to Table 3) and corresponding International Classification of Diseases, Ninth Revision, Clinical Modification codes (2). Rural/urban residence, defined according to the Office of Management and Budget as nonmetropolitan (rural) versus metropolitan (urban) counties, refers to the residence of women who were hospitalized.

Unadjusted rural–urban differences in SMM indicators were first examined as well as covariates that may affect both cost and SMM (1): age, race/ethnicity, income quartile, primary payer, delivery method, hospital bed size, rural/urban hospital location/teaching status, hospital region, and total number of chronic conditions (0 to 18) presented. To compare cost between rural and urban residents, multivariable generalized linear models were applied using a gamma distribution with a log-link function within 4 strata of SMM status and complexity: no SMM, any SMM, 1 SMM, and 2 or more SMM indicators. For deliveries with SMMs, predicted costs were also adjusted for the 18 SMM indicators. All statistical analyses accounted for the complex sampling design with hospital clusters and individual weights using Stata, version 12 (StataCorp).

Among all hospitalizations for deliveries from 2012 to 2014, 1.4% of rural residents and 1.5% of urban residents had at least 1 SMM (P = 0.22) (Table 1). Among hospitalizations with any SMM, a larger proportion of rural versus urban residents had only 1 SMM (87.8% vs. 84.1%; P < 0.001) (Table 1). Average adjusted costs for hospitalizations without SMM indicators were 3% higher for women residing in rural versus urban areas ($4573 vs. $4452; difference, $122 [95% CI, $37 to $205]) (Table 2). Average adjusted costs for hospitalizations with any SMM were 7% higher for women residing in rural versus urban areas ($12 212 vs. $11 432; difference, $780 [CI, $185 to $1375]). Average adjusted costs for hospitalizations with 1 SMM were 7% higher for women residing in rural versus urban

areas ($9721 vs. $9107; difference, $613 [CI, $104 to $1123]). Average adjusted costs for hospitalizations with multiple SMMs were 6% higher for women residing in rural versus urban areas ($25 679 vs. $24 247; difference, $1432 [CI, –$1336 to $4200]), but this difference was not statistically significant.

Discussion:

Building on a previous study showing higher facility costs for rural hospitals among low-risk deliveries (5), this study found that women residing in rural areas have higher hospitalization costs than those in urban areas among deliveries both with and without SMM. Rural–urban differences in hospitalization costs were greater, however, on both absolute and relative scales for deliveries affected by SMM. Because blood transfusions account for most SMM (2), this cost difference may be attributable to increased use of higher-cost emergency-release transfusions among women in rural areas (6). Coupled with another study showing that rural residents are more likely to experience SMM after adjustment for sociodemographic and clinical risk factors (4), this study further indicates that costs among such deliveries are greater for rural residents. Thus, improving access to risk-appropriate delivery care and other hospital quality improvement efforts may help to reduce SMM (4) and associated costs for rural residents. A major limitation is that only hospitalization costs could be examined; a better understanding of rural–urban cost differences for SMM-affected deliveries could be achieved by estimating additional types of cost, such as physician expenses or readmissions should these data become available. Further investigation of maternal comorbid conditions and prenatal care quality received before delivery hospitalizations would also shed further light on other contributors to rural–urban delivery cost differences.

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Table 1.

Characteristics of Delivery Hospitalizations, by Rural and Urban Residence, 2012 to 2014[*]

Characteristic	Weighted, %		P Value
	Rural	**Urban**	
All delivery hospitalizations (unweighted *n* = 2 167 876)[†]	314 603	1 853 273	
Hospitalization characteristics			
SMM			0.22
No	99	98.5	
Yes	1.4	1.5	
1 SMM indicator	87.8	84.1	<0.001
2 SMM indicators	12.2	15.9	
Delivery method			<0.001
Vaginal delivery	67.0	66.8	
Cesarean, primary	16.8	17.6	
Cesarean, repeat	16.2	15.6	
Patient characteristics			
Age *y*	26.5	28.3	<0.001
Race			<0.001
White	68.3	47.8	
Black	7.2	14.6	
Hispanic	8.7	20.8	
Asian/Pacific Islander	1.4	5.6	
Native American	1.6	0.6	
Other	2.5	5.0	
Unknown[‡]	10.2	5.8	
Payer			<0.001
Medicaid	47.7	43.3	
Private	45.1	50.4	
Self-pay	2.4	2.5	
Other[§]	4.8	3.7	
Median ZIP code household income			<0.001
0–25th percentile	47.4	25.0	
26th–50th percentile	37.3	23.7	
51st–75th percentile	13.2	26.5	
76th–100th percentile	2.1	24.8	
Number of chronic conditions[‖]	0.6	0.6	0.077
Hospital characteristics			
Bed size			<0.001
Large	61.9	55.9	
Medium	24.5	30.5	
Small	13.7	13.7	

Characteristic	Weighted, %		*P* Value
	Rural	**Urban**	
Region			<0.001
Northeast	8.7	17.5	
Midwest	31.6	19.9	
South	45.9	38.3	
West	13.8	24.4	
Location/teaching status			<0.001
Rural	68.5	0.8	
Urban, nonteaching	14.4	38.2	
Urban, teaching	17.1	61.0	

SMM = severe maternal morbidity.

*
See Table 3 for the 18 individual SMM indicators.

†
Delivery hospitalizations with missing values in any control variables

except race were excluded from all analyses (4.7%).

‡
Delivery hospitalizations with missing race were categorized as "unknown."

§
Delivery hospitalizations with Medicare, no charge, and other insurance were categorized as "other."

‖
The count of unique chronic diagnoses reported on discharge. Visit https://www.hcup-us.ahrq.gov/toolssoftware/chronic/chronic.jsp for more information.

Table 2.

Adjusted Costs of Delivery Hospitalizations, by Rural and Urban Residence and SMM Status, 2012 to 2014[*]

All Delivery Hospitalizations (Unweighted *n* = 2 167 876)[‡]	Weighted, Adjusted Predicted Cost Per Delivery Hospitalization (95% CI), $[†]			
	All Patients	**Rural**	**Urban**	**Differential Cost Cost$_{(rural)}$ = Cost$_{(urban)}$**[§]
Group 1: deliveries with no SMM indicators (Unweighted *n* = 2 136 550)	4469 (4425 to 4513)	4573 (4487 to 4659)	4452 (4406 to 4497)	**122 (37 to 205)**
Group 2: deliveries with any SMM indicators (Unweighted *n* = 31 326)[‖]	11 532 (11 340 to 11 723)	12 212 (11 632 to 12 791)	11 432 (11 236 to 11 628)	**780 (185 to 1375)**
Group 2a: deliveries with 1 SMM indicator (Unweighted *n* = 26 752)[‖]	9193 (9049 to 9337)	9721 (9250 to 10 192)	9107 (8951 to 9265)	**613 (104 to 1123)**
Group 2b: deliveries with ≥2 SMM indicators (Unweighted *n* = 4574)[‖]	24 398 (23 615 to 25 182)	25 679 (22 917 to 28 441)	24 247 (23 473 to 25 020)	1432 (−1336 to 4200)

SMM = severe maternal morbidity.

[*] All hospital charges were converted to costs using Healthcare Cost and Utilization Project Cost-to-Charge Ratios, and all cost data were converted to 2014 dollars based on Personal Health Care Index hospital care component.

[†] All adjusted costs and cost differences were estimated with multivariable generalized linear model employing a gamma distribution with a log-link function and adjusted for age, race/ethnicity, income quartile, primary payer, delivery method, hospital bed size, hospital location/teaching status, hospital region, and total number of chronic conditions.

[‡] Delivery hospitalizations with missing values in any control variables except race were excluded from all analyses (4.7%). Delivery hospitalizations with missing race were categorized as "unknown."

[§] Differential costs are in boldface for *P* < 0.05.

[‖] For groups 2, 2a, and 2b, the adjusted and differential costs were also adjusted for 18 individual SMM indicators (Table 3).

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Table 3.

Rates of SMM, by Rural and Urban Residence, 2012 to 2014 [*]

SMM[†]	Rates per 10 000 Delivery Hospitalizations, Weighted[‡]			Rates per 100 Delivery Hospitalizations With Any SMM, Weighted, %[‡]		
	All	Rural	Urban	All	Rural	Urban
Unweighted number	2 255 359	324 486	1 930 873	32 984	4797	28 187
Any SMM	146.2	147.8	146.0			
With 1 SMM	-	-	-	85.38	87.70	84.99
With 2 SMMs	-	-	-	**14.62**	**12.30**	**15.01**
Specific SMM indicator						
Blood transfusion	119.7	124.6	118.9	**81.72**	**84.12**	**81.31**
Disseminated intravascular coagulation	**12.48**	**10.11**	**12.88**	**8.55**	**6.88**	**8.84**
Hysterectomy	10.30	9.62	10.41	7.09	6.40	7.21
Adult respiratory distress syndrome	7.13	6.53	7.24	4.93	4.45	5.01
Acute renal failure	**6.61**	**5.02**	**6.87**	**4.50**	**3.44**	**4.69**
Sepsis	**4.76**	**2.99**	**5.06**	**3.19**	**2.00**	**3.39**
Shock	4.19	3.61	4.28	2.90	2.36	3.00
Eclampsia	3.82	3.91	3.81	2.66	2.69	2.65
Pulmonary edema/acute heart failure	3.43	2.84	3.53	2.37	1.93	2.44
Puerperal cerebrovascular disorders	**1.53**	**0.92**	**1.64**	**1.06**	**0.62**	**1.13**
Temporary tracheostomy or ventilation	1.49	1.14	1.55	1.00	0.77	1.04
Air and thrombotic embolism	1.25	1.51	1.21	0.88	1.03	0.85
Cardiac arrest or ventricular fibrillation or conversion of cardiac rhythm	1.05	1.14	1.03	0.75	0.80	0.70
Sickle cell anemia with crisis	**0.87**	**0.28**	**0.97**	**0.58**	**0.15**	**0.66**
Severe anesthesia complications	0.61	0.83	0.57	0.42	0.53	0.39
Heart failure/arrest during procedure or surgery	0.51	0.46	0.52	0.36	0.32	0.36
Amniotic fluid embolism	0.35	0.31	0.35	0.23	0.21	0.23
Acute myocardial infarction or aneurysm	0.32	0.34	0.32	0.23	0.24	0.23

SMM = severe maternal morbidity.

[*] Delivery hospitalizations with missing values in rural/urban (0.9%) were excluded from this analysis.

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†All SMMs were identified by the Centers for Disease Control and Prevention's list of 18 indicators from the International Classification of Diseases, Ninth Revision, Clinical Modification diagnosis and procedure codes, with severity recalculation for implausibly short length of stay.

‡Rates of SMM are in boldface if significantly different ($P < 0.05$) between rural and urban residents.