Agency for Healthcare Research and Quality
H-CUP HEALTHCARE COST AND UTILIZATION PROJECT

Trends in Severe Maternal Morbidity Complications by Patient Characteristics, 2016–2021

Statistical Brief #312 | September 2024

Lawrence D. Reid, Ph.D., M.P.H.

Introduction

Monitoring severe maternal morbidity (SMM) using hospital discharge data is vital to improving maternal health outcomes in the United States. SMM reflects a composite of 20 indicators of unexpected outcomes of labor and delivery that may result in life-threatening complications to a woman's health.[1] Leading indicators of SMM include disseminated intravascular coagulation (i.e., diffuse blood clots), acute renal failure, and acute respiratory distress. SMM is associated with a host of adverse maternal and infant health outcomes and increased healthcare utilization.[2,3,4] Recent findings suggest the COVID-19 virus and pandemic were associated with an increase in SMM through 2020[5] for certain deliveries. Less is known, however, about what type of SMM complications have increased in prevalence in recent years and how this varies across patient characteristics.

This Healthcare Cost and Utilization Project (HCUP) Statistical Brief presents trend statistics on SMM overall and for groups of SMM complications by patient characteristics. Using weighted estimates from the 2016–2021 National Inpatient Sample (NIS), the annual rate of SMM among inpatient delivery stays is examined. Rates in 2020 and 2021 are stratified by COVID-19 status. Annual rates of SMM and specific indicators were categorized into six groups of complications (hemorrhage, respiratory, cardiac, renal, sepsis,[a] and other). Rates of SMM by patient characteristics (age, race, expected payer, community-level income, and patient location) are compared between 2016 and 2021, and the SMM rate among deliveries without COVID-19 is presented for 2021. Finally, the 2016 and 2021 rates of SMM complications are compared by patient characteristic subgroups. Because of the large sample size of the NIS data, small differences can be statistically significant but not clinically important. Thus, only differences greater than or equal to 10 percent are discussed in the text.

Highlights

- From 2016 to 2021, the rate of severe maternal morbidity (SMM) increased 40 percent, from 72.0 to 101.1 per 10,000 delivery stays.
- Patients with the largest increase in the SMM rate from 2016 to 2021 include:
  - Women of Asian/Pacific Islander non-Hispanic race and ethnicity (56 percent)
  - Women with self-pay/no charge as the expected payer (48 percent)
  - Women aged 12–19 and 20–24 years (44 percent)
  - Women living in middle community-level income areas (43 percent)
  - Women living in large metro areas (42 percent)
- Delivery stays with respiratory complications (137 percent) followed by renal complications (119 percent) and sepsis (54 percent) had the largest six-year rate increase compared with all other complications.
- Although the SMM rates increased between 2016 and 2021 for women of all ethnicities, the increase was largest for women who were Other, non-Hispanic (48 percent), Black non-Hispanic, and Hispanic (43 percent for both), as compared to women who were White, non-Hispanic (34 percent).

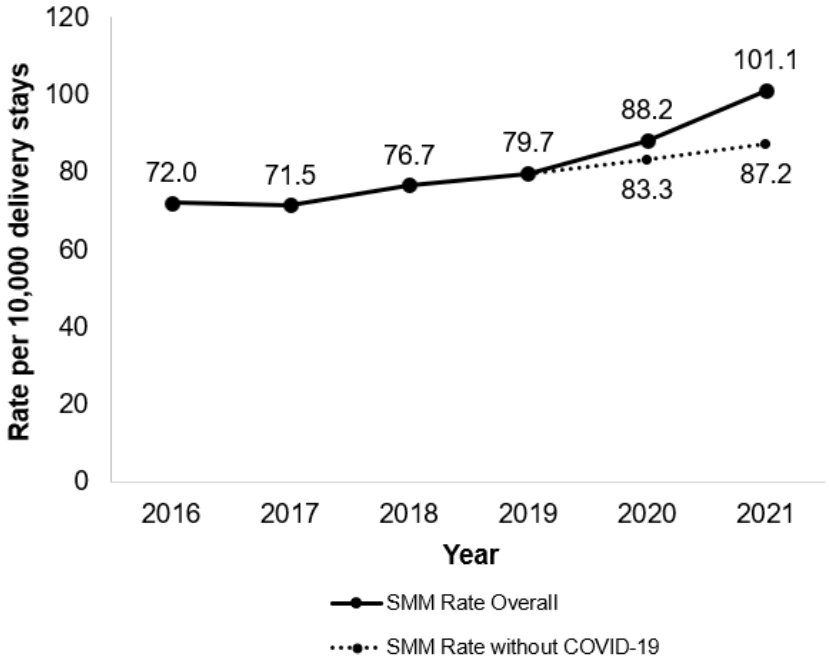
[a] HCUP note: The definition for sepsis-related SMM differs from the definition used in several recent HCUP Statistical Briefs (SB308, SB309, SB310) where sepsis is defined by any diagnosis indicating a sepsis infection and for adult and maternal stays, an indication of organ dysfunction.

Findings

Rate of severe maternal morbidity (SMM), 2016–2021

Figure 1 presents trends in the rate of delivery stays with SMM during the 2016–2021 period. When examining annual trends in inpatient stays involving SMM, it is important to also understand the influence of the COVID-19 pandemic beginning in 2020. For this reason, data are presented overall and among delivery stays without a COVID-19 diagnosis in 2020 and 2021.

Figure 1. Rates of severe maternal morbidity (SMM), 2016–2021



Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), National Inpatient Sample (NIS), 2016–2021.

- From 2016 to 2021, the overall rate of SMM (i.e., cases with and without a COVID-19 diagnosis) increased 40 percent, from 72.0 cases per 10,000 delivery stays in 2016 to 101.1 in 2021.
- Among delivery stays without COVID-19, however, the rate of SMM per 10,000 delivery stays increased 21 percent, from 72.0 per 10,000 in 2016 to 87.2 in 2021.

Patient characteristics of delivery stays with SMM, 2016 and 2021

Table 1 presents the number and annual rate of SMM delivery stays by patient characteristics comparing 2016 and 2021 overall (i.e., cases with and without a COVID-19 diagnosis). The number and rate of SMM delivery stays with a COVID-19 diagnosis by patient characteristics are also shown.

Table 1. Number and rate of severe maternal morbidity (SMM) by patient characteristics and COVID-19 status, 2016 and 2021

Characteristic	Number of SMM cases			SMM rate[a]		
	2016	2021 overall[b]	2021 without COVID-19	2016	2021 overall[b]	2021 without COVID-19
Total	27,300	35,300	29,800	72.0	101.1	87.2
Age group, years						
12–19	1,400	1,400	1,200	64.5	92.5	81.7
20–24	4,600	5,200	4,400	58.9	84.4	72.7
25–34	14,400	18,900	15,800	66.8	92.7	79.1
35–55	6,900	9,900	8,500	107.9	142.6	125.1
Patient race and ethnicity						
API NH	1,700	2,300	2,100	76.6	119.8	107.3
Black NH	5,900	7,800	6,700	111.1	158.4	138.6
Hispanic	5,200	7,500	6,200	71.4	102.4	86.4
White NH	11,700	14,700	12,500	62.0	82.9	71.4
Other NH	1,400	1,800	1,600	73.7	108.9	96.2
Primary expected payer						
Medicaid	13,100	16,200	13,400	80.7	114.3	97.2
Private insurance	12,300	16,600	14,300	63.7	89.3	77.9
Self-pay/no charge	600	900	700	67.6	100.2	87.0
Other*	1,300	1,500	1,300	90.6	133.2	116.5
Community-level income						
Quartile 1 (lowest)	8,900	10,800	8,900	83.3	114.5	97.1
Quartiles 2 and 3	12,700	16,800	14,100	68.8	98.4	84.0
Quartile 4 (highest)	5,300	7,400	6,500	64.2	90.5	81.7
Patient residence						
Large metro	16,200	21,000	18,200	74.9	106.4	93.9
Medium/small metro	7,700	10,000	8,100	69.7	95.7	79.5
Nonmetro	3,300	4,200	3,400	64.8	90.1	75.0

Abbreviations: API: Asian/Pacific Islander; metro: metropolitan; NH: non-Hispanic.
Notes: Total number of SMM cases is rounded to the nearest 100. [a]Rate per 10,000 delivery stays; [b]with and without COVID-19; *Other includes Medicare and other Federal and local government programs (e.g., TRICARE, CHAMPVA, Indian Health Service, Black Lung, Title V) and Workers' Compensation. Race and ethnicity data were missing for 5.8% and 3.5% of delivery stays in 2016 and 2021, respectively.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), National Inpatient Sample (NIS), 2016 and 2021.

- Comparing 2016 to 2021, the overall rate of SMM increased the most within each patient characteristic for deliveries for women aged 12–19 and 20–24 years (44 percent increase for both age groups), women who were Asian/Pacific Islander non-Hispanic (56 percent increase), women with self-pay/no charge or other expected payers (48 and 47 percent increase, respectively), and women who resided in middle-income (43 percent increase) or large metropolitan areas (42 percent increase). Similar findings were observed among delivery stays without COVID-19.

- In 2021, among delivery stays for Black non-Hispanic (NH) women, the overall SMM rate (158.4 per 10,000 delivery stays) was 91 percent higher than the rate for White NH women (70.9 per 10,000); in 2016 the rate for Black NH women was 79 percent higher than the rate for White NH women.

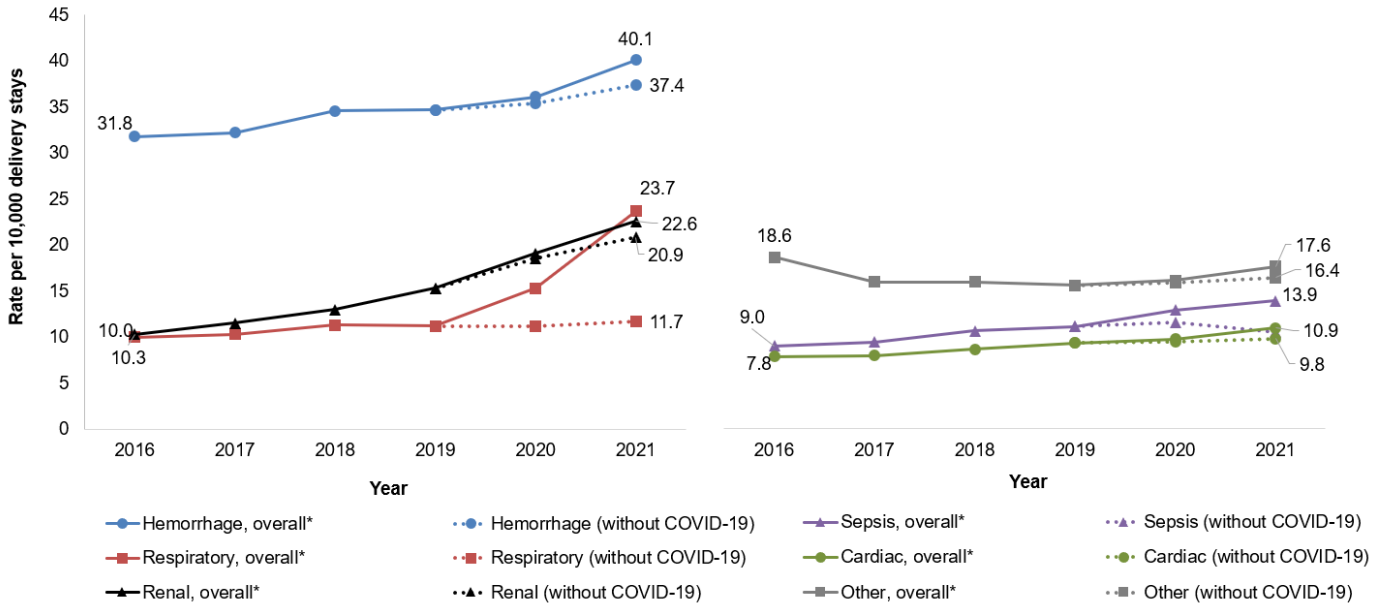
- The gap in SMM rates between Hispanic and White NH women more than doubled from a 15 percent difference in 2016 to a 33 percent difference in 2021, with Hispanic women having higher rates of SMM than White NH women.

Rate of severe maternal morbidity (SMM) by SMM complication groups, 2016–2021

Figure 2 presents the rate of delivery stays with SMM by six groups of SMM complications from 2016 to 2021, taking into account COVID-19 status in 2020 and 2021. The 20 individual SMM indicators were mapped into six non-mutually exclusive complications: hemorrhage, respiratory, renal, sepsis, cardiac, and other SMM-related complications.

Additional detail on the categorization of the complications is shown in Appendix Table A.3. Annual rates of SMM by complication groups are provided in Appendix Table B.1.

Figure 2. Rate of severe maternal morbidity (SMM) by complication groups, 2016–2021



Note: *Overall is the SMM-related condition group with and without COVID-19.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), National Inpatient Sample (NIS), 2016–2021.

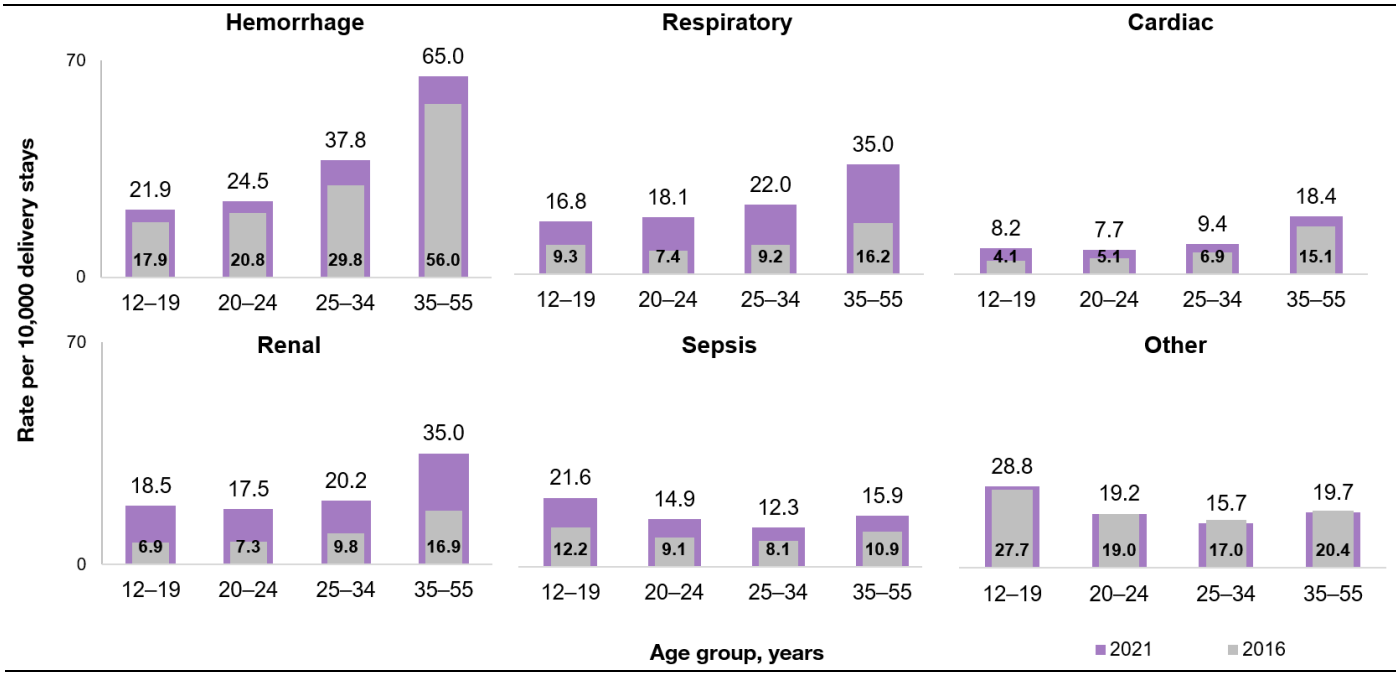
- Among delivery stays with and without COVID-19, rates were highest for hemorrhage-related SMM and lowest for cardiac-related SMM during the 2016–2021 period.
- From 2016 to 2021, the rate of delivery stays with respiratory and renal-related SMM more than doubled (137 and 119 percent increase, respectively). The increase among respiratory-related SMM delivery stays, however, was largely due to COVID-19 as the rate increased only 19 percent among delivery stays without COVID-19 during the same period.
- Rates for delivery stays with sepsis, cardiac, and hemorrhage-related SMM increased 54, 39, and 26 percent from 2016 to 2021, respectively.

Rate of severe maternal morbidity (SMM) by complication group and patient characteristics, 2016 and 2021

Figures 3 through 8 present the overall rate of SMM delivery stays by six groups of SMM complications in 2016 and 2021 for selected patient characteristics. The 20 individual SMM indicators were mapped into six non-mutually exclusive groups of complications: hemorrhage, respiratory, renal, sepsis, cardiac, and other SMM-related complications.

Additional detail on the categorization of the complications is shown in Appendix Table A.3. Annual rates of SMM by complication group are provided in Appendix Table B.1. SMM rates of non-COVID-19 deliveries by each of the complications for select patient characteristics in 2021 are provided in Appendix Table B.2.

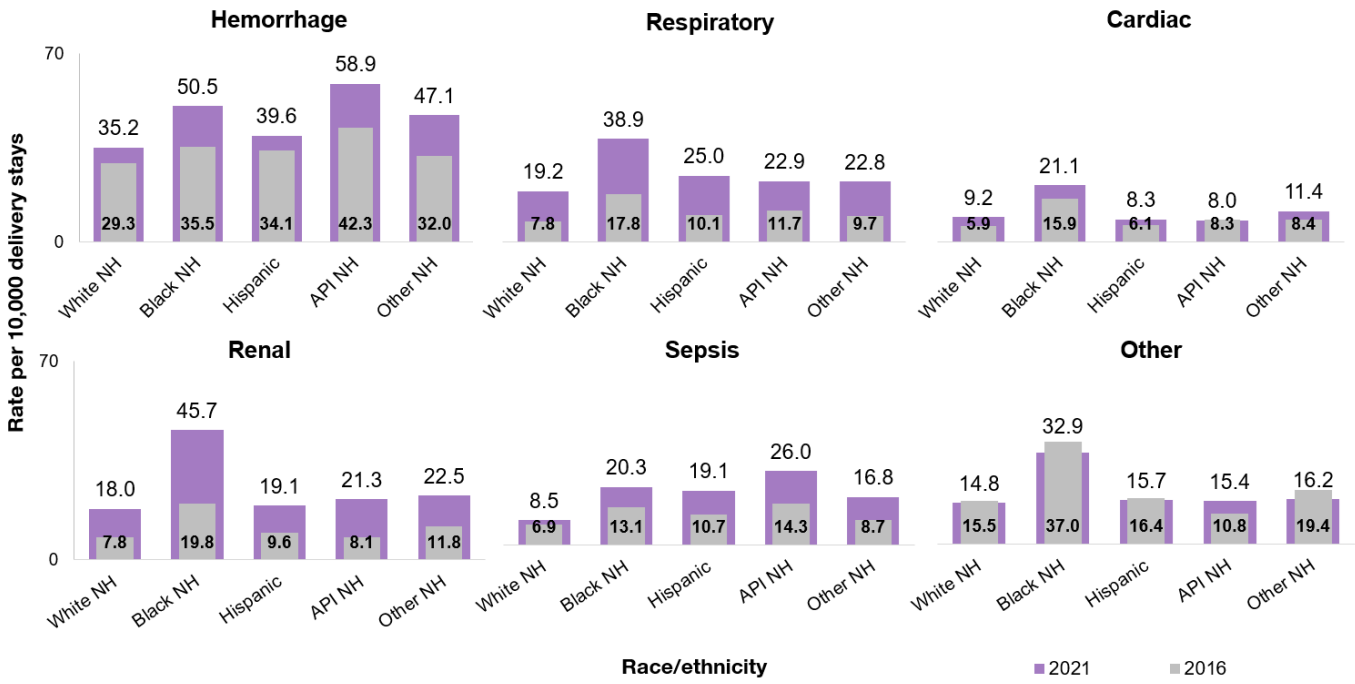
Figure 3. Rate of severe maternal morbidity (SMM) by complication groups and patient age groups, 2016 and 2021



Note: Rates of SMM in 2021 include women with and without COVID-19. See Appendix for 2021 rates without COVID-19.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), National Inpatient Sample (NIS), 2016 and 2021.

- Across age and SMM complications, renal-related SMM delivery stays for women aged 12–19 years had the largest percent change in rates from 2016 to 2021 (167 percent increase), followed by respiratory and renal-related SMM delivery stays for women aged 20–24 years (146 and 141 percent increases, respectively).
- Rates of SMM were highest among delivery stays for women aged 35–55 years for all complications with two exceptions—the rates of sepsis-related and other-related SMM delivery stays were highest for women aged 12–19 years in 2016 and in 2021.
- In 2021, the largest age-related gap in SMM complication delivery rates was for hemorrhage-related SMM; rates for women aged 35–55 years were nearly triple those of women aged 12–19 years. In 2016, the age-related gap in SMM complication delivery rates was largest among cardiac-related SMM, with rates for women aged 35–55 years nearly four times the rate for women aged 12–19 years.

Figure 4. Rate of severe maternal morbidity (SMM) by complication groups and patient race/ethnicity, 2016 and 2021



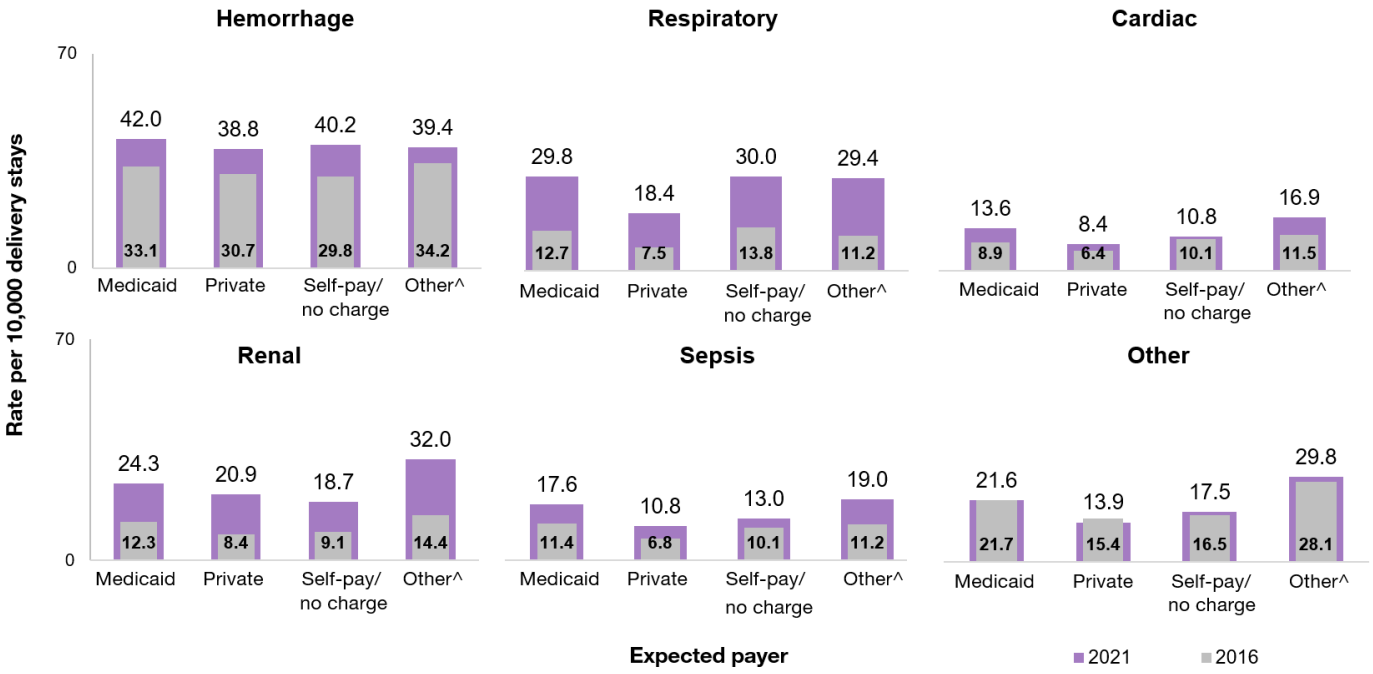
Abbreviations: API: Asian/Pacific Islander; NH: non-Hispanic.
Note: 2021 SMM rates include those with and without COVID-19. See Appendix for 2021 rates without COVID-19.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), National Inpatient Sample (NIS), 2016 and 2021.

- The renal-related SMM rate among delivery stays for Asian/Pacific Islander non-Hispanic (NH) women had the largest six-year increase (165 percent increase) across the SMM complications and racial and ethnic groups from 2016 to 2021, followed by respiratory-related SMM among delivery stays for Hispanic (148 percent increase) and White NH (147 percent increase) women.

- Delivery stays for Black non-Hispanic women had the highest rates of respiratory, cardiac, renal, and other-related SMM complications.

- In 2021, delivery stays related to sepsis had the largest racial and ethnic disparity, with the rate for Asian/Pacific Islander non-Hispanic (NH) women (26.0 per 10,000 delivery stays) more than triple the rate for White NH women (8.5 per 10,000).

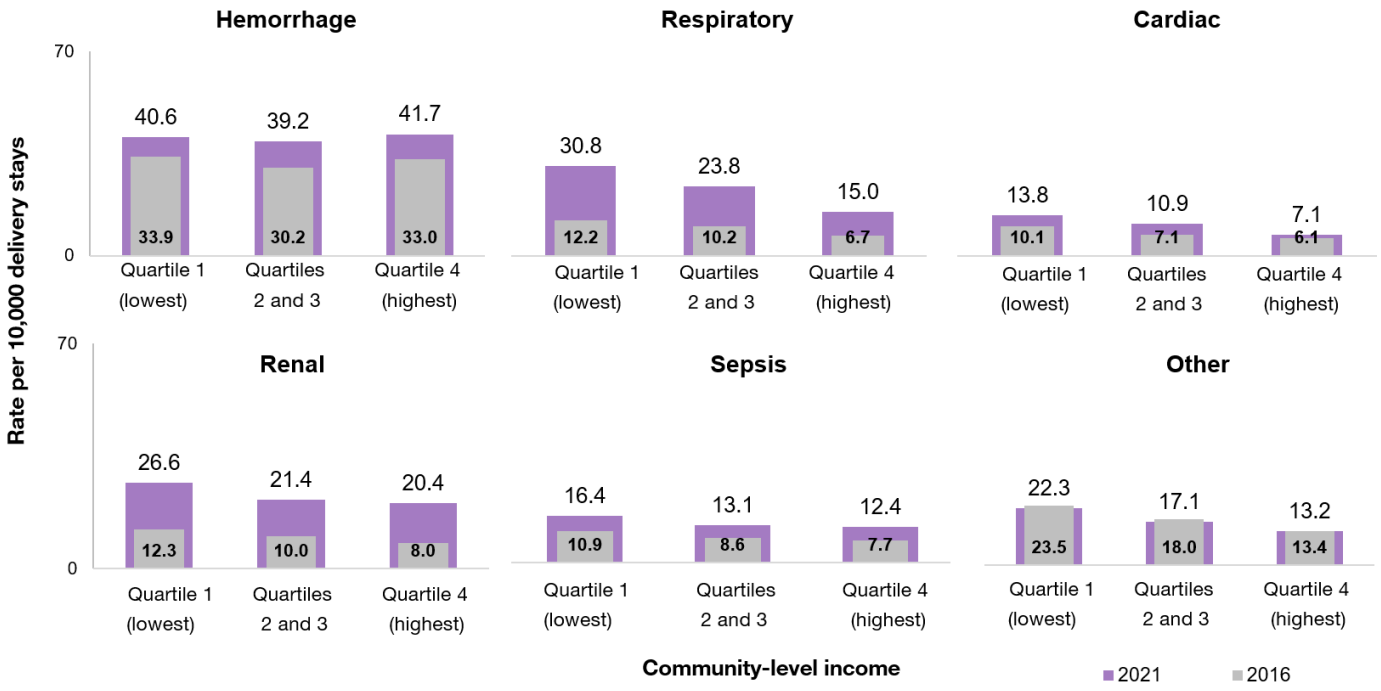
Figure 5. Rate of severe maternal morbidity (SMM) by complication groups and expected payer, 2016 and 2021



Notes: ^Other includes Medicare and TRICARE expected payers. 2021 SMM rates include those with and without COVID-19. See Appendix for 2021 rates without COVID-19.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), National Inpatient Sample (NIS), 2016 and 2021.

- The rate of delivery stays related to respiratory conditions billed to other payers increased 164 percent over the six-year period (164 percent increase, from 11.2 to 29.4 per 10,000), the largest increase of any other type of complication and expected payer.
- The rate of delivery stays with renal-related SMM complications billed to private insurance increased by 149 percent (8.4 to 20.9 per 10,000), the second largest increase in rates of deliveries with any other type of complication and expected payer.

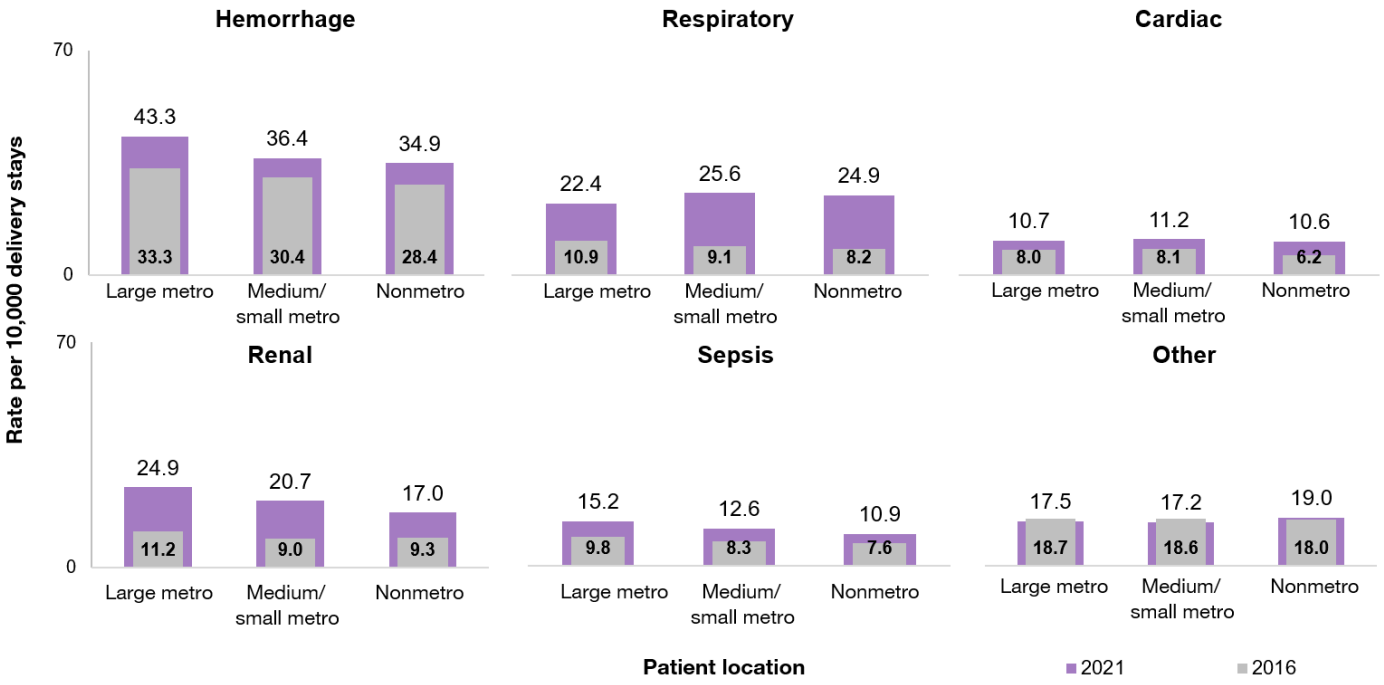
Figure 6. Rate of severe maternal morbidity (SMM) by complication groups and community-level income quartiles, 2016 and 2021



Note: 2021 SMM rates include those with and without COVID-19. See Appendix for 2021 rates without COVID-19.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), National Inpatient Sample (NIS), 2016 and 2021.

- The rate of renal-related SMM delivery stays for women from the highest community-level income areas increased by 154 percent over the six years (8.0 to 20.4 per 10,000), the largest increase compared with any other complications for women from the highest income areas.
- The rate of respiratory-related SMM delivery stays for women from the lowest income areas increased 152 percent (12.2 to 30.8 per 10,000 stays), the largest increase compared with any other complications for women from the lowest income areas.
- Community-level income SMM rate differences were largest for respiratory-related SMM, with the rate for the lowest income quartile approximately double the rate for the highest income quartile in 2016 and in 2021.

Figure 7. Rate of severe maternal morbidity (SMM) by complication groups and patient location, 2016 and 2021



Abbreviation: metro: metropolitan.
Source: Agency for Healthcare Research and Quality (AHRQ), Healthcare Cost and Utilization Project (HCUP), National Inpatient Sample (NIS), 2016 and 2021.

- The rate of respiratory-related SMM among delivery stays for women from nonmetropolitan areas more than tripled (204 percent increase) from 8.2 per 10,000 stays in 2016 to 24.9 per 10,000 in 2021. Respiratory-related SMM rates more than doubled among delivery stays for women from medium/small metropolitan (181 percent increase) and large metropolitan (106 percent increase) areas.
- In 2021, the rate of renal-related SMM delivery stays for women from large metropolitan areas was 46 percent higher than those from nonmetropolitan areas.
- Rates of renal-related SMM more than doubled from 2016 to 2021 among delivery stays for women from medium/small metropolitan (131 percent increase) and large metropolitan (122 percent increase) areas.

References

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[4] Debbink MP, Metz TD, Nelson RE, et al. Directly measured costs of severe maternal morbidity events during delivery admission compared with uncomplicated deliveries. *Am J Perinatol*. 2022;39(6):567–576.

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Data Source

This Statistical Brief uses data from the HCUP 2016–2021 National Inpatient Sample (NIS). For additional information about the HCUP NIS, please visit https://hcup-us.ahrq.gov/db/nation/nis/nisdbdocumentation.jsp.

Population Studied

This analysis focused on delivery-related inpatient stays with any *International Classification of Diseases, Tenth Revision, Clinical Modification/Procedure Coding System* (ICD-10-CM/PCS) diagnosis or procedure of severe maternal morbidity (SMM). Although the maximum number of diagnoses varies in the 2016–2021 National Inpatient Sample (NIS), with 30 diagnoses in the 2016 NIS and 40 diagnoses in 2017–2021, this analysis used all available diagnoses in the data year. Within each year, the number of diagnoses in the individual State Inpatient Databases (SID) used to create the NIS vary and may be different than the maximum retained in the NIS. No more than 1 percent of records have diagnoses excluded from the NIS in any given year.

The unit of analysis is the hospital discharge (i.e., the hospital stay), not a person or patient. This means that a person who is admitted to the hospital multiple times in one year will be counted each time as a separate discharge from the hospital.

Identification of delivery stays and severe maternal morbidity

Inpatient delivery stays were identified using the any-listed ICD-10-CM/PCS and Medicare Severity Diagnosis Related Groups (MS-DRG) codes to define delivery stays (see Appendix Table A.1). Delivery stays were defined as records that included a delivery code and did not include an abortion code. The table below shows the weighted annual number of inpatient stays in the NIS identified as delivery stays.

Annual number of inpatient delivery stays in the HCUP National Inpatient Sample (NIS), 2016–2021

2016	2017	2018	2019	2020	2021
3,783,846	3,704,136	3,634,579	3,583,224	3,453,756	3,487,597

Severe maternal morbidity was identified using any-listed ICD-10-CM/PCS diagnosis and procedures codes as specified in Appendix Table A.2.

Identification of delivery-related inpatient stays for COVID-19

The identification of inpatient stays related to COVID-19 was based on any of the following ICD-10-CM diagnoses:

- J1282, Pneumonia due to coronavirus disease 2019
- U071, COVID-19
- U099, Post COVID-19 condition, unspecified

Definitions

Diagnoses

The principal diagnosis is that condition established after study to be chiefly responsible for the patient's admission to the hospital. Secondary diagnoses are conditions that coexist at the time of admission that require or affect patient care treatment received or management, or that develop during the inpatient stay. Any-listed diagnoses include the principal diagnosis plus all secondary diagnoses.

ICD-10-CM Coding System

ICD-10-CM is the *International Classification of Diseases, Tenth Revision, Clinical Modification*. There are over 70,000 ICD-10-CM diagnosis codes.

Reporting of race and ethnicity

Data on Hispanic ethnicity are collected differently among the States and also can differ from the census methodology of collecting information on race (White, Black, Asian/Pacific Islander, American Indian/Alaska Native, Other [including mixed race]) separately from ethnicity (Hispanic, non-Hispanic). State data organizations often collect Hispanic ethnicity as one of several categories that include race. Therefore, for multistate analyses, HCUP creates the combined categorization of race and ethnicity for data from States that report ethnicity separately. When a State data organization collects Hispanic ethnicity separately from race, HCUP uses Hispanic ethnicity to override any other race category to create a Hispanic category for the uniformly coded race/ethnicity data element, while also retaining the original race and ethnicity data. This Statistical Brief reports race and ethnicity for the following categories: Asian/Pacific Islander non-Hispanic (NH), Black NH, Hispanic, White NH, and other NH race and ethnicity (including American Indian/Alaska Native and Other).

Primary expected payer

To make coding uniform across all HCUP data sources, the primary expected payer for the hospital stay combines detailed categories into general groups:

- Medicaid: includes fee-for-service and managed care Medicaid
- Private insurance: includes commercial nongovernmental payers, regardless of the type of plan (e.g., private health maintenance organizations [HMOs], preferred provider organizations [PPOs])
- Self-pay/No charge: includes self-pay, no charge, charity, and no expected payment
- Other payers: includes Medicare (fee-for-service and managed care Medicare) and other Federal and local government programs (e.g., TRICARE, CHAMPVA, Indian Health Service, Black Lung, Title V) and Workers' Compensation

Hospital stays that were expected to be billed to the State Children's Health Insurance Program (SCHIP) are included under Medicaid.

For this Statistical Brief, when more than one payer is listed for a hospital discharge, the first-listed payer is used.

Community-level income

Community-level income is based on the median household income of the patient's ZIP Code of residence. Quartiles are defined so that the total U.S. population is evenly distributed.

Location of patient residence

Place of residence is based on the urban-rural classification scheme for U.S. counties developed by the National Center for Health Statistics (NCHS) and based on the Office of Management and Budget (OMB) definition of a metropolitan service area as including a city and a population of at least 50,000 residents. For this Statistical Brief, we collapsed the NCHS codes into the following three categories:
Large metropolitan (metro) area:

- Large Central Metropolitan: Counties in a metropolitan area with 1 million or more residents that satisfy at least one of the following criteria: (1) containing the entire population of the largest principal city of the metropolitan statistical area (MSA), (2) having their entire population contained within the largest principal

city of the MSA, or (3) containing at least 250,000 residents of any principal city in the MSA
- Large Fringe Metropolitan: Counties in a metropolitan area with 1 million or more residents that do not qualify as large central metropolitan counties

Medium/small metro area:
- Medium Metropolitan: Counties in a metropolitan area of 250,000–999,999 residents
- Small Metropolitan: Counties in a metropolitan area of 50,000–249,999 residents

Nonmetro area:
- Micropolitan: Counties in a nonmetropolitan area of 10,000–49,999 residents
- Noncore: Counties in a nonmetropolitan and non-micropolitan area

Calculations

Percentage change

Percentage change between years was calculated using the following formula:

$$\text{Percentage change} = \left(\frac{\text{2021 value} - \text{2016 value}}{\text{2016 value}}\right) \times 100$$

NOTE: Percentage change values are provided in whole numbers when referenced in text.

About HCUP

The Healthcare Cost and Utilization Project (HCUP, pronounced "H-Cup") is a family of healthcare databases and related software tools and products developed through a Federal-State-Industry partnership and sponsored by the Agency for Healthcare Research and Quality (AHRQ). HCUP databases bring together the data collection efforts of State data organizations, hospital associations, and private data organizations (HCUP Partners) and the Federal government to create a national information resource of encounter-level healthcare data. HCUP includes the largest collection of longitudinal hospital care data in the United States, with all-payer, encounter-level information beginning in 1988. These databases enable research on a broad range of health policy issues, including cost and quality of health services, medical practice patterns, access to healthcare programs, and outcomes of treatments at the national, State, and local market levels. For more information about HCUP, see https://hcup-us.ahrq.gov.

HCUP would not be possible without the contributions of the following data collection Partners from across the United States:

Alaska Department of Health
Alaska Hospital and Healthcare Association
Arizona Department of Health Services
Arkansas Department of Health
California Department of Health Care Access and Information
Colorado Hospital Association
Connecticut Hospital Association
Delaware Division of Public Health
District of Columbia Hospital Association
Florida Agency for Health Care Administration
Georgia Hospital Association
Hawaii Laulima Data Alliance
Hawaii University of Hawai'i at Hilo
Illinois Department of Public Health
Indiana Hospital Association
Iowa Hospital Association
Kansas Hospital Association
Kentucky Cabinet for Health and Family Services
Louisiana Department of Health
Maine Health Data Organization
Maryland Health Services Cost Review Commission
Massachusetts Center for Health Information and Analysis
Nebraska Hospital Association
Nevada Department of Health and Human Services
New Hampshire Department of Health & Human Services
New Jersey Department of Health
New Mexico Department of Health
New York State Department of Health
North Carolina Department of Health and Human Services
North Dakota (data provided by the Minnesota Hospital Association)
Ohio Hospital Association
Oklahoma State Department of Health
Oregon Association of Hospitals and Health Systems
Oregon Health Authority
Pennsylvania Health Care Cost Containment Council
Rhode Island Department of Health
South Carolina Revenue and Fiscal Affairs Office
South Dakota Association of Healthcare Organizations
Tennessee Hospital Association
Texas Department of State Health Services
Utah Department of Health
Vermont Association of Hospitals and Health Systems
Virginia Health Information

Michigan Health & Hospital Association
Minnesota Hospital Association
Mississippi State Department of Health
Missouri Hospital Industry Data Institute
Montana Hospital Association
Washington State Department of Health
West Virginia Department of Health and Human Resources
Wisconsin Department of Health Services
Wyoming Hospital Association

Suggested Citation

Reid L. Trends in Severe Maternal Morbidity Complications by Patient Characteristics, 2016–2021. HCUP Statistical Brief #312. September 2024. Agency for Healthcare Research and Quality, Rockville, MD. https://hcup-us.ahrq.gov/reports/statbriefs/sb312-severe-maternal-morbidity-2016-2021.pdf.

Acknowledgments

The author would like to acknowledge the contributions of Pam Owens and Kim Martin of the Agency for Healthcare Research and Quality/HCUP.

* * *

For More Information

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- HCUPnet, HCUP's interactive query system, at https://datatools.ahrq.gov/hcupnet
- HCUP Summary Trend Tables at https://hcup-us.ahrq.gov/reports/trendtables/summarytrendtables.jsp for monthly information on hospital utilization

AHRQ welcomes questions and comments from readers of this publication who are interested in obtaining more information about access, cost, use, financing, and quality of healthcare in the United States. We also invite you to tell us how you are using this Statistical Brief and other HCUP data and tools, and to share suggestions on how HCUP products might be enhanced to further meet your needs. Please email us at hcup@ahrq.gov or send a letter to the address below:

Craig A. Umscheid, M.D., M.S., Director
Center for Quality Improvement and Patient Safety (CQuIPS)
Agency for Healthcare Research and Quality (AHRQ)
5600 Fishers Lane
Rockville, MD 20857

Pamela L Owens, Ph.D., Director
Division of Healthcare Data and Analytics (DHDA)
Center for Quality Improvement and Patient Safety (CQuIPS)
Agency for Healthcare Research and Quality (AHRQ)
5600 Fishers Lane
Rockville, MD 20857

This Statistical Brief was posted online on September 27, 2024.