New York City, 2008–2012

Severe Maternal Morbidity

NYC
Health

New York City Department of Health and Mental Hygiene
Bureau of Maternal, Infant and Reproductive Health

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Suggested citation: New York City Department of Health and Mental Hygiene (2016). Severe Maternal Morbidity in New York City, 2008–2012. New York, NY.

Table of
Contents

List of Figures and Tables

Appendix B Tables

Executive Summary

Despite a century of significant improvements in maternal health, pregnancy-related deaths in the United States continue to rise. Similarly, severe maternal morbidity (SMM)—life-threatening complications during delivery—has increased steadily in recent years. To date, much of the national conversation on maternal health has focused on maternal mortality, although it represents a small proportion of the total burden of maternal morbidity.[1] This report focuses on SMM in New York City from 2008 to 2012.

Key Findings

- The rate of SMM in New York City increased 28.2% from 2008 to 2012 (197.2 per 10,000 deliveries in 2008 to 252.9 per 10,000 deliveries in 2012).

- New York City's rate of SMM was 1.6 times the national rate from 2008 to 2009.

- Black non-Latina women had the highest SMM rate—three times that of White non-Latina women. This rate remained high even after stratifying by other known risk factors such as low education, neighborhood poverty level and pre-pregnancy obesity. Rates were also high among Puerto Rican and other Latina women compared to White non-Latina women.

- SMM rates were highest among women living in high-poverty neighborhoods.

- The leading indicators of SMM included blood transfusion, disseminated intravascular coagulation, hysterectomy, ventilation and adult respiratory distress syndrome. These indicators reflect the management of, and the end-organ failure associated with, many of the leading causes of pregnancy-related mortality, including hemorrhage, pregnancy-induced hypertension and embolism.

- Women with an underlying chronic condition such as hypertension, diabetes or heart disease were three times as likely to have SMM as women with no chronic conditions.

- The economic burden of SMM was high, with SMM deliveries costing, on average, $15,714 compared to $9,357 for deliveries without SMM (after adjusting for other drivers of cost). From 2008 to 2012, the total excess costs related to SMM in New York City exceeded $85 million, an extra $17 million each year.

Key Recommendations

- Implement programmatic and policy interventions aimed at improving women's overall health and directed at populations disproportionately burdened by SMM

- Document costs and cost savings of interventions

- Conduct ongoing surveillance to measure the impact of interventions and track progress in reducing SMM in New York City

- Research the conditions and modifiable risk factors that contribute to SMM disparities, including qualitative research on the experiences of women and families impacted by SMM

Background

Maternal morbidity is a continuum from mild adverse effects to life-threatening events or death (Figure 1). SMM events are 100 times more common than maternal deaths. They affect approximately 52,000 women in the U.S. each year.[1] Rates of maternal mortality and morbidity have steadily increased over the last decade. From 1998 to 2009, the U.S. pregnancy-related mortality rate increased from 12.0 to 17.8 deaths per 100,000 live births, and the SMM rate increased from 73.8 to 129.1 per 10,000 live births.[1,2] Improved documentation and surveillance may have contributed to these increases.[3] Other potential drivers include delayed childbearing, increased cesarean delivery, emerging infections and increasing prevalence of pre-pregnancy obesity and underlying chronic conditions.[4,5]
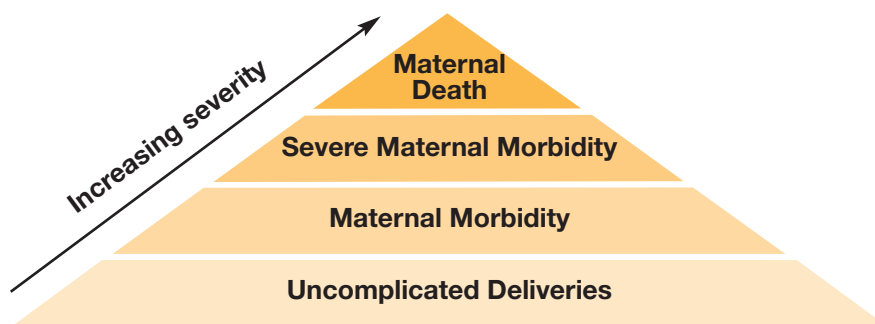
Figure 1.   Continuum of Maternal Morbidity Showing Variation in Severity

There are also persistent disparities by race and ethnicity, particularly between Black and White non-Latina women. Nationally, Black non-Latina women are three times as likely to die during pregnancy or childbirth and twice as likely as White non-Latina women to experience SMM.[5,6] A recent report on New York City pregnancy-associated mortality found that Black non-Latina women were 12 times as likely as White non-Latina women to die from pregnancy-related causes.[7]

There are likely many contributors to these disparities, including pre-conception health status, prevalence of obesity and other co-morbidities and access to care.[8] Factors associated with poverty, such as inadequate housing, residential segregation and lower educational attainment, which disproportionately impact Black women, also increase risk for SMM.[8,9] And racism and its attendant stresses, too, likely contribute to adverse maternal health outcomes.[9] It is important to note that while research has primarily focused on the Black-White disparity, emerging data shows that other demographic groups, such as recent immigrants, have similar poor maternal health outcomes.[6,10]

Little is known about the costs of SMM, particularly to the health care system. Childbirth is one of the most frequent and expensive reasons for hospitalization. The roughly 3.8 million childbirth admissions in 2011 cost $12.4 billion, accounting for 10% of all U.S. hospitalizations and 3% of all health care costs.[11] Although SMM is estimated to occur in less than 2% of all deliveries, these events likely increase the average cost of medical care due to the need for additional procedures and longer hospital stays.[1] Documenting the health care cost of SMM is necessary to calculate the costs and benefits of interventions.

The New York City Health Department, in partnership with the Fund for Public Health in New York, embarked on a two-year project in 2013 to design the first citywide SMM surveillance system. With its racially and economically diverse population, roughly 120,000 deliveries per year and a pregnancy-related mortality ratio higher than that of the U.S., New York City was uniquely suited for the development of an SMM surveillance system.[7]

Data Sources

Birth Certificates: The Health Department's Bureau of Vital Statistics collects information on all live births in the city and issues birth certificates. In addition to registering the birth, the birth certificate contains a confidential medical report: demographic information—including the mother's age, race, nativity and borough of residence—and information about the pregnancy, such as parity, prenatal care and method of delivery. A copy of the confidential medical report of birth and the data elements it contains is available in the Technical Appendix in the Annual Summary of Vital Statistics at nyc.gov/html/doh/html/data/vs-summary.shtml.

Inpatient Hospital Discharge Data: The New York State Department of Health Statewide Planning and Research Cooperative System (SPARCS) tracks all inpatient hospital discharges. The hospital discharge records contain length of stay, International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes, hospital charges and additional services provided. The vast majority (99%) of New York City deliveries occur in hospitals and therefore have associated hospital discharge records. SPARCS data elements can be found at www.health.ny.gov/statistics/sparcs/sysdoc/iptable.htm.

Data Matching

The New York State Department of Health matched New York City birth certificates with the mother's delivery hospitalization record from SPARCS. Multiple births (e.g., twins, triplets) were counted as one delivery. Approximately 96% of all live deliveries were matched with a hospital discharge record. More information on the method of identifying deliveries and match quality is available in **Appendix A** and **Appendix B**, **Table 1**.

Figure 2. Data Matching Process for Birth Certificates and SPARCS Records, New York City, 2008–2012

All live birth certificates in New York City 2008–2012 N=625,505

All deliveries in New York City 2008–2012 N=613,314

Data matching

SPARCS hospital discharge records New York City 2008–2012

Matched birth-SPARCS records 2008–2012 N=588,232 95.9% of all deliveries
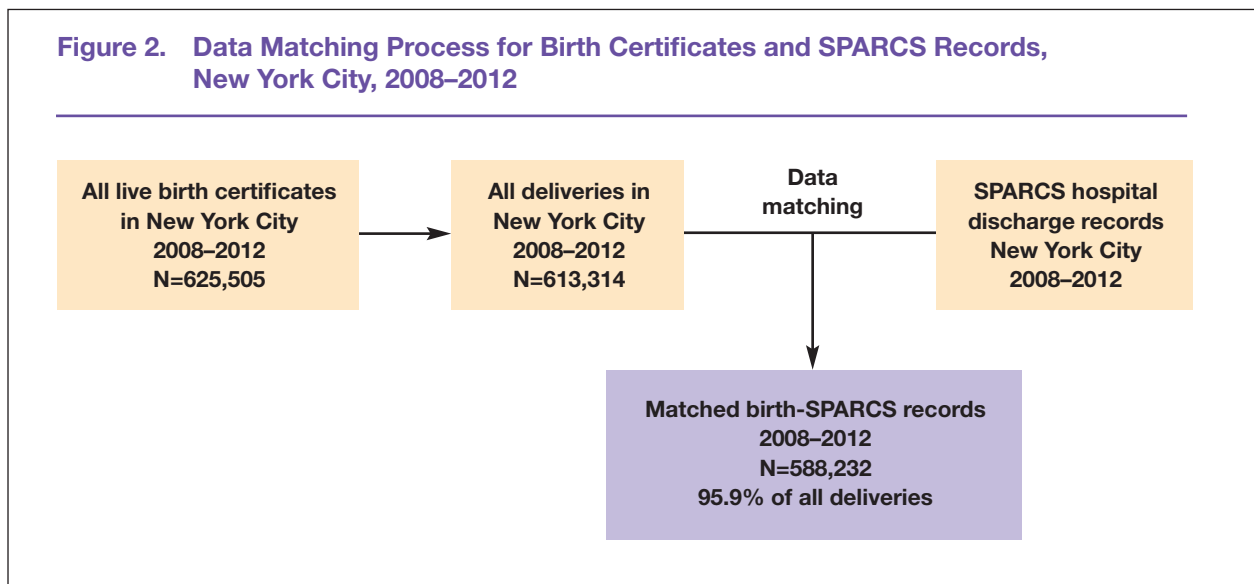
Identification of Severe Maternal Morbidity

SMM events were identified during delivery hospitalizations using an algorithm developed by researchers at the Centers for Disease Control and Prevention (CDC).[1] The algorithm identifies 25 indicators of SMM that represent either serious complications of pregnancy or delivery—such as eclampsia or acute renal failure—or procedures used to manage serious conditions—such as blood transfusion, ventilation or hysterectomy. Of the 25 indicators, 18 were identified using ICD-9-CM diagnosis codes. Seven indicators used procedure codes from the hospital discharge record. A complete list of conditions and codes is available in Appendix D. Compared to a review of clinical indicators in medical records, the CDC algorithm has a 77% sensitivity.[12]

To ensure that only the most severe cases of these 25 indicators during delivery hospitalizations were captured, these indicators were classified as SMM only if they additionally met one of the following criteria:

- The mother's length of stay was equal to or greater than the 90th percentile by delivery method.
- The mother was transferred before or after delivery to a different facility.
- The mother died during delivery hospitalization.
- At least one of the seven procedure indicators was present.

Analysis

All SMM rates in this report were calculated per 10,000 live deliveries that successfully matched with a SPARCS record. Throughout the report, the unit will be referred to as "per 10,000 deliveries." Chi-square tests and bivariate logistic regression were used to test the significance of the association between maternal characteristics and SMM. Two-sided Cochran-Armitage tests were used to examine the significance of SMM trends. All associations and trends presented in this report are statistically significant (p<0.05) unless otherwise noted.

Total charges reported in SPARCS were used to estimate the total health care costs related to SMM. Because charges reflect the amount the hospital billed for services (not the cost for the hospital to provide those services), three adjustments converted charges to estimated costs, using a methodology used by the Healthcare Cost and Utilization Project at the National Agency for Healthcare Research and Quality (see Appendix A):

1. Adjustment for hospital-specific markup using cost-to-charge ratios[13]
2. Adjustment for department-specific markup (e.g., higher markup on surgery)[14]
3. Adjustment for inflation over time[15]

The formula for calculating SMM costs is: Total cost = total charges * hospital-specific cost-to-charge ratio * diagnosis-related group-specific adjustment factor * inflation multiplier.

The report authors calculated unadjusted mean costs and 95% confidence intervals (CI) for deliveries with and without SMM and constructed a multivariable regression model to control for other demographic, clinical and hospital-level cost factors. The model included age, race/ethnicity, insurance status, plurality, delivery method and presence of a comorbidity. Finally, using the adjusted mean difference and prevalence of SMM, the report authors estimated the total excess costs related to SMM from 2008 to 2012. All analyses, apart from mapping, were conducted using SAS 9.2. Mapping was performed using ArcGIS 10.2.1.

Figure 3. **Severe Maternal Morbidity Rate per 10,000 Deliveries and Number of Cases, New York City, 2008–2012**
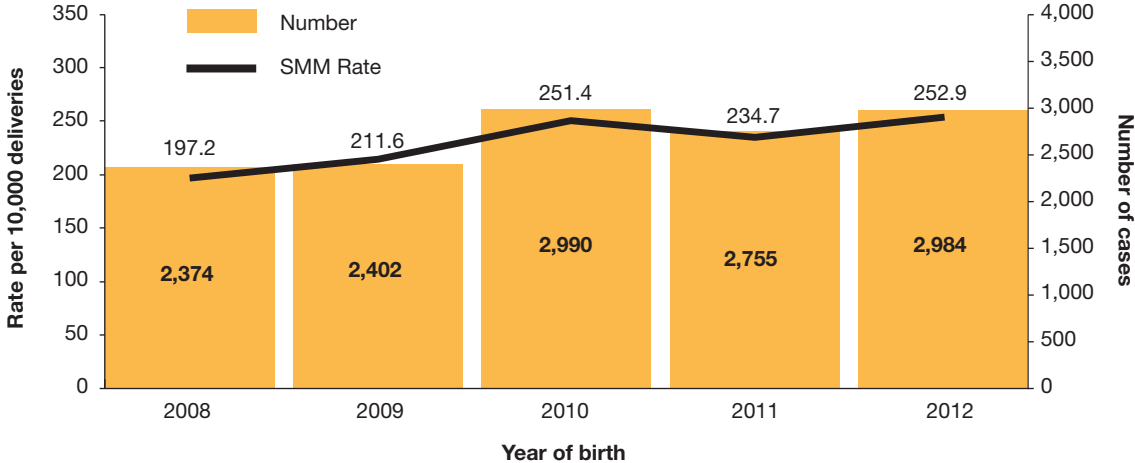
- In 2012, there were 2,984 cases of SMM in New York City with a rate of 252.9 per 10,000 deliveries. This represented a 28.2% (p<0.001) increase from 2008, when the SMM rate was 197.2.

- The U.S. SMM rate in 2008-2009 was 129.1 per 10,000 deliveries.[1] During that same period, the rate of SMM in New York City was 1.6 times the national rate, with 204.2 per 10,000 deliveries.

Figure 4. **Distribution of Severe Maternal Morbidity Indicators, New York City, 2008–2012**
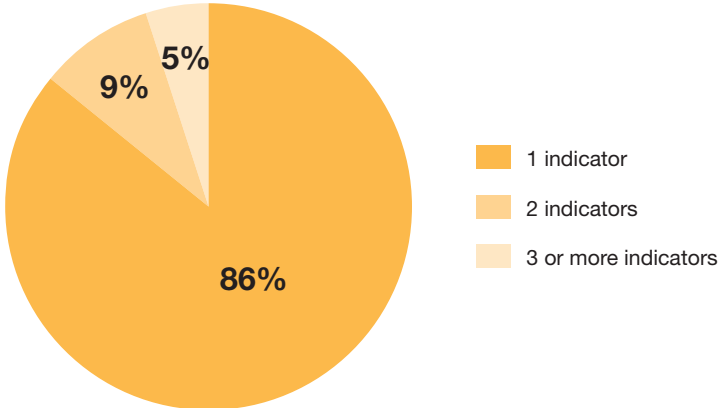
- The majority of deliveries with SMM (86%) had one indicator (out of a total of 25 SMM indicators), 9% of deliveries had two indicators and 5% had three or more indicators present.

Leading Indicators

Figure 5. Leading Diagnosis-Based Indicators of Severe Maternal Morbidity, New York City, 2008–2012

Indicator	Rate per 10,000 deliveries
Complications of surgery or medical procedures	19.7
Disseminated intravascular coagulation	17.1
Adult respiratory distress syndrome	6.6
Acute renal failure	6.5
Eclampsia	4.3

Rate per 10,000 deliveries
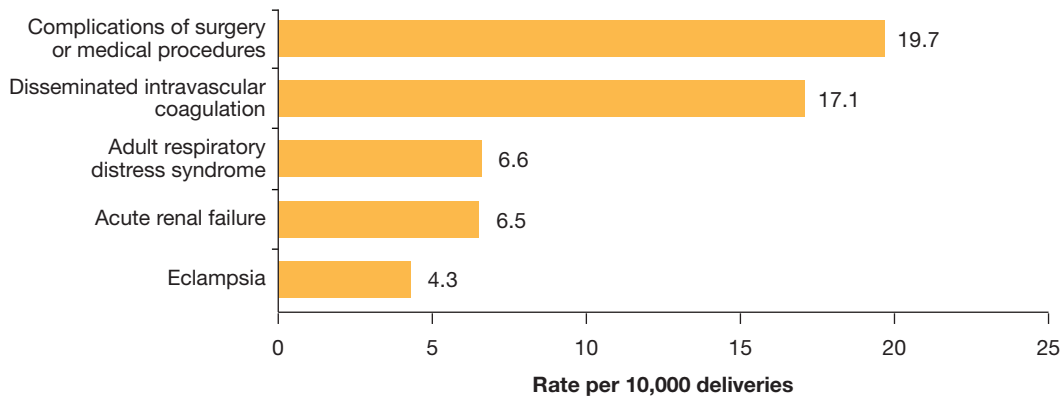
- The leading diagnosis-based indicators of SMM were complications of surgery or medical procedures (19.7 per 10,000 deliveries), disseminated intravascular coagulation (17.1 per 10,000 deliveries), adult respiratory distress syndrome (6.6 per 10,000 deliveries), acute renal failure (6.5 per 10,000 deliveries) and eclampsia (4.3 per 10,000 deliveries); see Appendix D for a complete list and description of SMM indicators.

- The ICD-9-CM codes used to identify complications of surgery or medical procedures (669.4x, 997.1) indicated a broad range of diagnoses, from anemia to heart failure, making interpretation difficult.

- The other leading indicators reflect the end-organ failure associated with many of the leading causes of pregnancy-related mortality reported in the latest New York City report, including hemorrhage, pregnancy-induced hypertension and embolism.[16]

Figure 6. Leading Procedure-Based Indicators of Severe Maternal Morbidity, New York City, 2008–2012

Indicator	Rate per 10,000 deliveries
Blood transfusion	176.5
Hysterectomy	12.5
Ventilation	11.4
Operations on the heart and pericardium	6.4

Rate per 10,000 deliveries
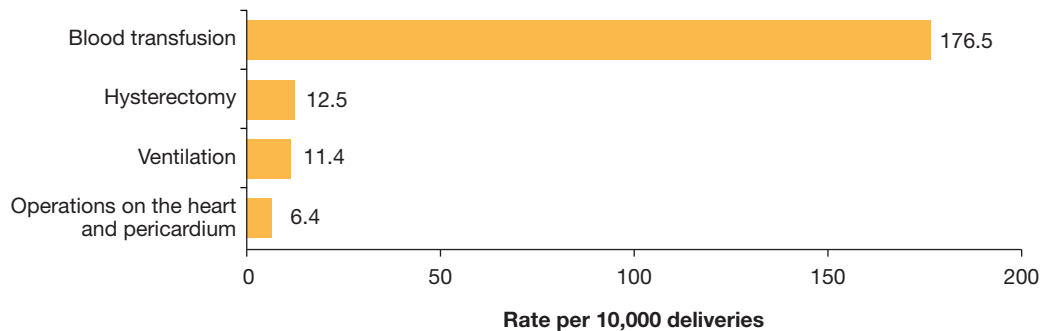
- Blood transfusion (176.5 per 10,000 deliveries) accounted for roughly 65% of all SMM cases. However, procedure codes indicating transfusions do not specify the amount of blood transfused; therefore, it was impossible to distinguish minor versus massive transfusions. The SMM rate without including blood transfusion as an indicator was 80.0 per 10,000 deliveries [data not shown].

- Other leading procedure-based indicators included hysterectomy (12.5 per 10,000 deliveries), ventilation (11.4 per 10,000 deliveries) and operations on the heart and pericardium (6.4 per 10,000 deliveries).

Figure 7.   Severe Maternal Morbidity Indicator Rates in New York City and the U.S., 2008-2009
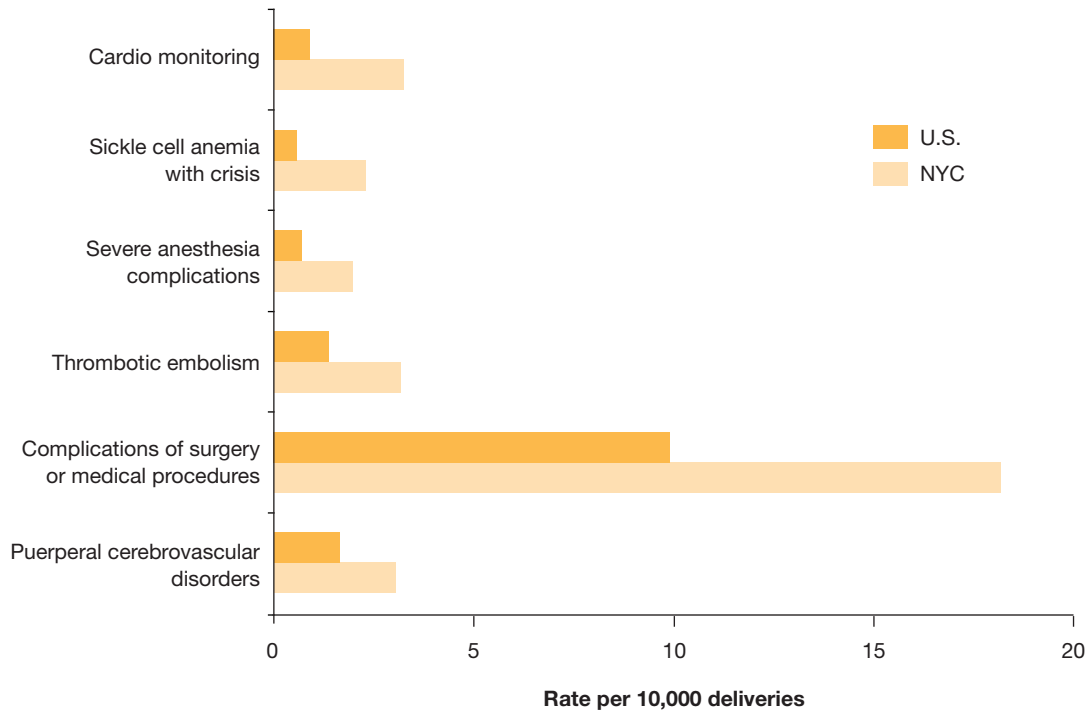
- There were six indicators of SMM in New York City with rates approximately two or more times as high as rates in the U.S.[1] These are puerperal cerebrovascular disorders, complications of surgery or medical procedures, thrombotic embolism, severe anesthesia complications, sickle cell anemia with acute crisis and cardio monitoring.

Maternal Demographic Characteristics

Figure 8. Severe Maternal Morbidity by Maternal Age, New York City, 2008–2012
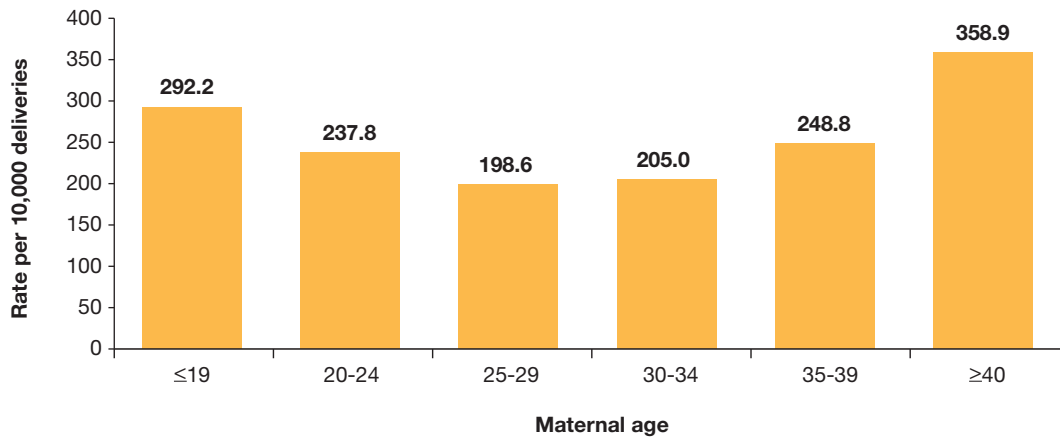
Figure 8. Severe Maternal Morbidity by Maternal Age, New York City, 2008–2012

Figure 9. Distribution of Live Births and Severe Maternal Morbidity by Maternal Age, New York City, 2008–2012

Figure 9. Distribution of Live Births and Severe Maternal Morbidity by Maternal Age, New York City, 2008–2012
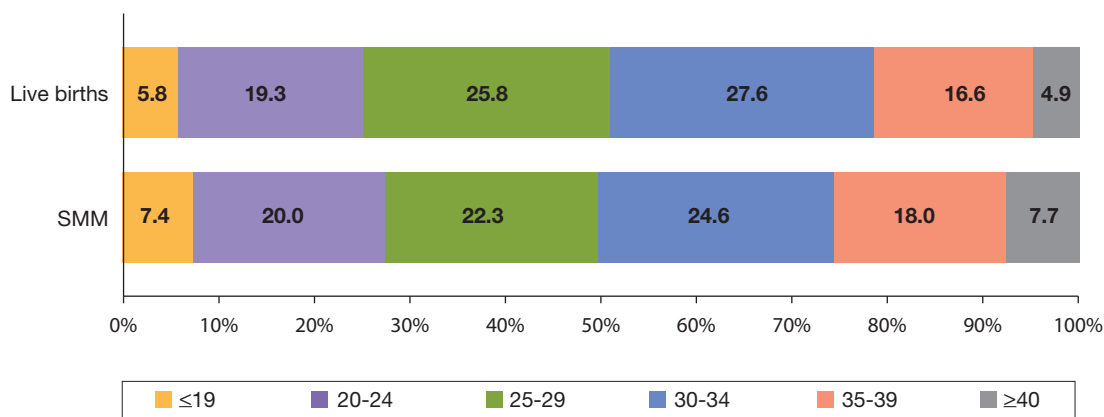
- The greatest proportion of SMM cases occurred among women aged 25 to 29 (22.3%) and 30 to 34 (24.6%). These same age groups, though, had the two lowest rates of SMM (198.6 and 205.0 per 10,000 deliveries, respectively), as shown above in Figure 8. This is because the majority of all deliveries (53.4%) occurred among women 25 to 34, as shown in Figure 9.

- While women 40 and older giving birth represented less than 5% of all deliveries, they made up close to 8% of all SMM cases. Of all women giving birth from 2008–2012, those 40 and older had the highest rate of SMM (358.9 per 10,000 deliveries).

- Adolescents (≤19 years of age) had the second highest SMM rate at 292.2 per 10,000 deliveries.

Figure 10. Severe Maternal Morbidity by Maternal Race/Ethnicity, New York City, 2008–2012
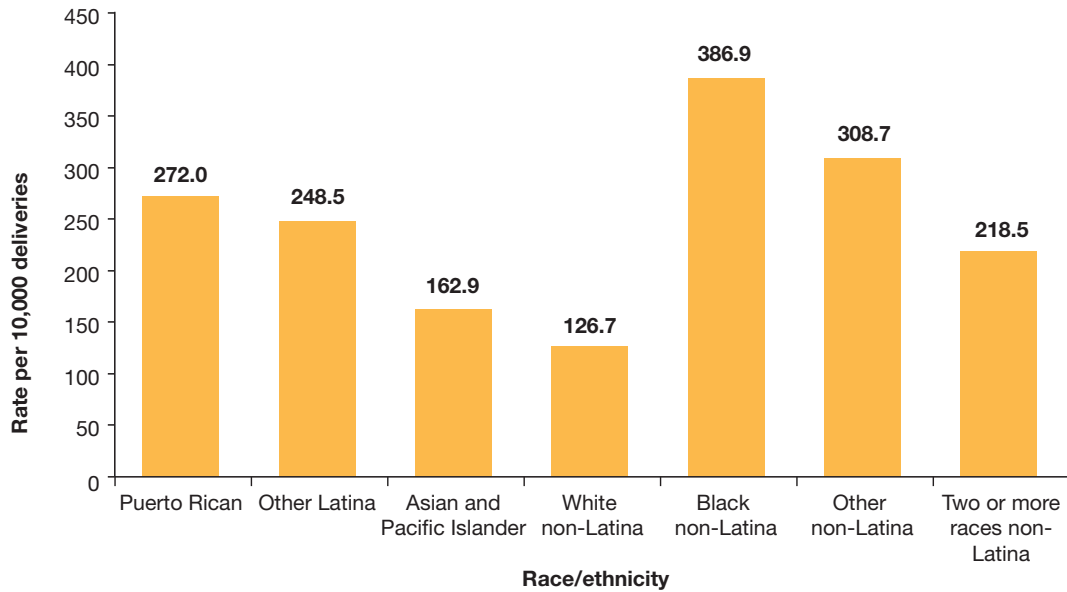
Figure 11. Distribution of Live Births and Severe Maternal Morbidity Cases by Race/Ethnicity, New York City, 2008–2012
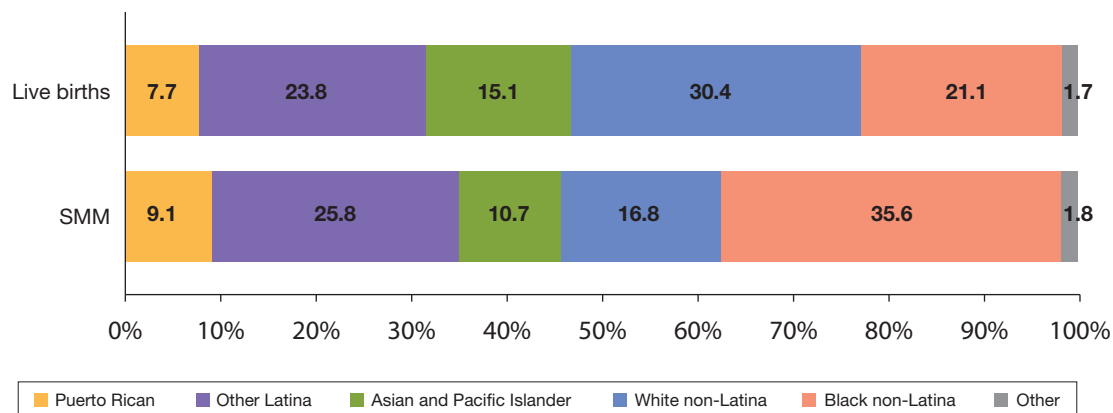
- The SMM rate among Black non-Latina women (386.9 per 10,000 deliveries) was three times that of White non-Latina women (126.7 per 10,000 deliveries).

- The disparity between Black non-Latina and White non-Latina women can also be seen in the disproportionately higher percentage of SMM cases (35.6%) relative to live births (21.1%) for Black non-Latina women. By contrast, White non-Latina women comprised 16.8% of SMM cases but 30.4% of live births.

- The SMM rate was high among women who were Puerto Rican (272.0 per 10,000 deliveries) or of other Latina origin (248.5 per 10,000 deliveries). The majority of other Latina women were of Dominican or Mexican ancestry.

Figure 12. Severe Maternal Morbidity by Maternal Region of Birth,* New York City, 2008–2012
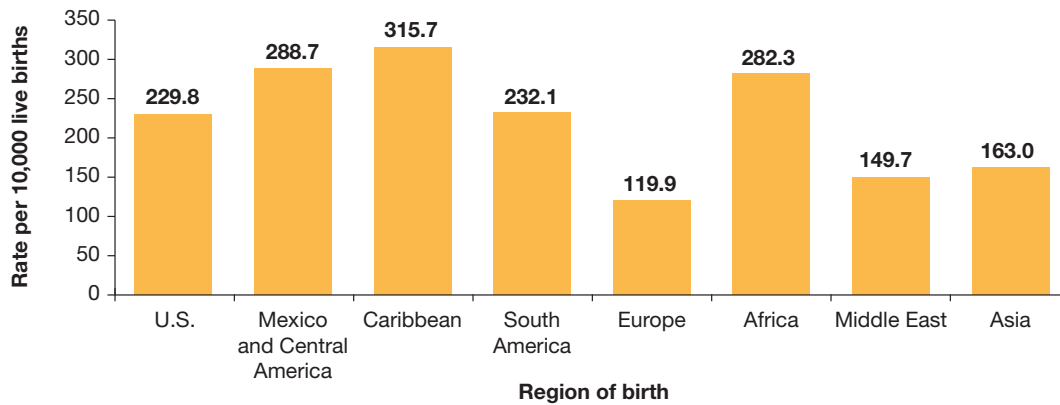
* Region of birth based on the mother's reported country of birth. Australian Region and Canada were excluded because of small numbers.

Table 1. Top 10 Non-U.S. Countries of Birth by Number and Rate of Severe Maternal Morbidity, New York City, 2008–2012

Birth countries with the greatest number of cases			Birth countries with the highest SMM rates		
Country of birth	Number	Rate	Country of birth	Number	Rate
Mexico	1,049	300.7	Haiti	363	494.0
Dominican Republic	898	242.8	St. Vincent	53	476.2
Jamaica	475	364.7	Barbados	38	464.0
China	391	111.8	Nigeria	122	435.6
Haiti	363	494.0	Jordan	17	409.6
Ecuador	300	221.6	Grenada	62	403.9
Guyana	280	307.6	Dominica	15	402.1
Trinidad	236	340.1	Sierra Leone	24	392.2
Bangladesh	236	266.6	Ghana	122	379.0
Pakistan	150	238.5	Antigua and Barbuda	24	366.4
U.S.	6,588	229.8	U.S.	6,588	229.8

Countries with <15 cases of SMM were excluded

- The SMM rate among U.S.-born women was similar to that of foreign-born women (229.8 and 229.3 per 10,000 deliveries, respectively) [data not shown].

- Among foreign-born women, those from Mexico, the Caribbean, Central America and Africa had the highest SMM rates (315.7, 288.7 and 282.3 per 10,000 deliveries, respectively). Within these regions, women from Haiti, St. Vincent, Barbados and Nigeria had the highest rates of SMM. Birth countries with the highest absolute number of cases included Mexico (n=1,049), the Dominican Republic (n=898), Jamaica (n=475) and China (n=391). Women from Haiti had both a high absolute burden and rate of SMM, with 363 cases and a rate of 494.0 per 10,000 deliveries.

- In general, women who immigrated less than a year before their delivery had higher SMM rates than women who had been living in the U.S. for more than a year (See Appendix B, Table 3).

Figure 13. Severe Maternal Morbidity by Educational Attainment, New York City, 2008–2012
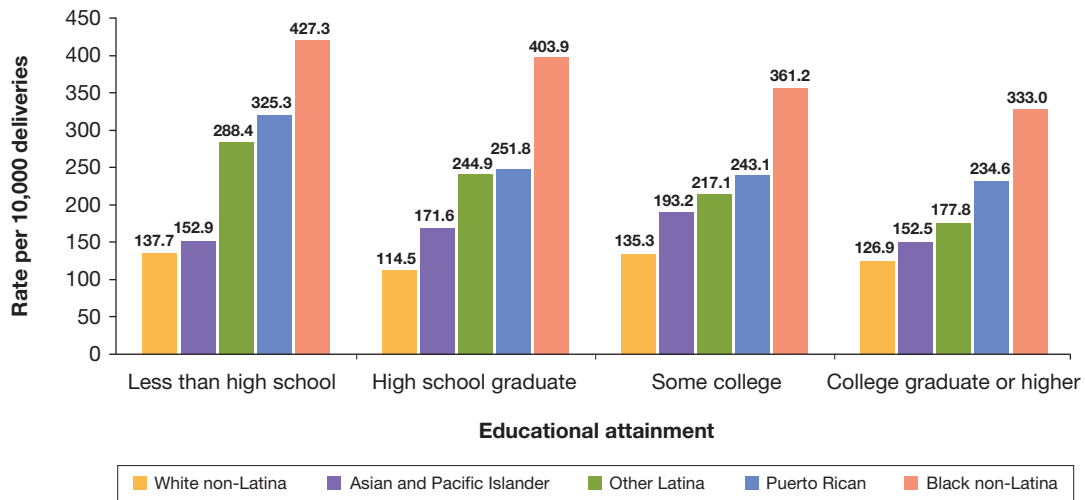
- Though the SMM rate varies by race/ethnicity, overall the rate was highest among women who had less than a high school education (283.9 per 10,000 deliveries) and lowest among those with at least a college degree (164.5 per 10,000 deliveries) (Appendix B, Table 3). The high rate among those with less than a high school education remained consistent even after restricting to women aged 21 and older.

- Black non-Latina women with at least a college degree had higher SMM rates than women of other race/ethnicities who never graduated high school.

Figure 14. Severe Maternal Morbidity by Health Insurance Coverage, New York City, 2008–2012
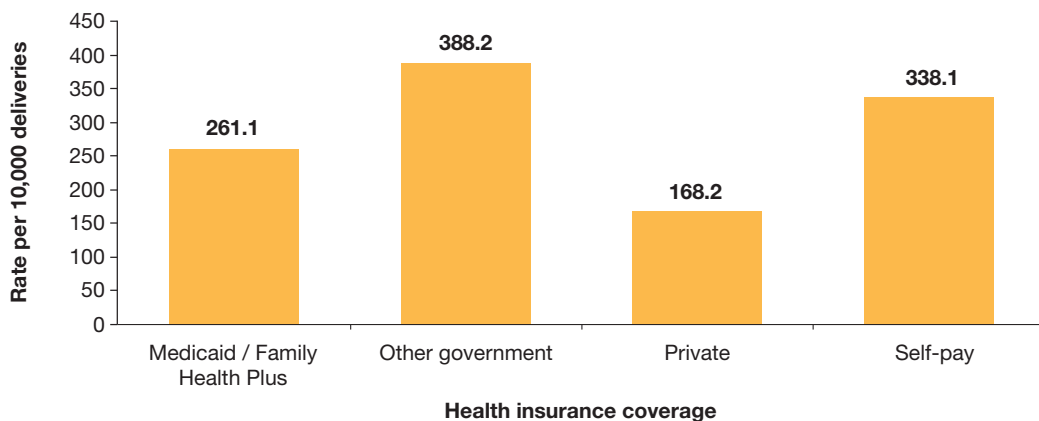
- The SMM rate for women insured by Medicaid or Family Health Plus at the time of delivery was higher than that of women with private insurance (261.1 versus 168.2 per 10,000 deliveries, respectively).

- Women who had other government insurance (i.e., Medicare, CHAMPUS, etc.) and those who self paid represented only 3% of all live births but had the highest SMM rates (388.2 and 338.1 per 10,000 deliveries, respectively).

Place-Based Characteristics

Figure 15. Severe Maternal Morbidity by Community District of Residence,* New York City, 2008–2012

Rate per 10,000 deliveries

Rate among all New York City residents (231.9 per 10,000 deliveries)

Manhattan
- Battery Park, Tribeca (101)
- Greenwich Village, SoHo (102)
- Lower East Side (103)
- Chelsea, Clinton (104)
- Midtown (105)
- Murray Hill (106)
- Upper West Side (107)
- Upper East Side (108)
- Manhattanville (109)
- Central Harlem (110)
- East Harlem (111)
- Washington Heights (112)

Bronx
- Mott Haven (201)
- Hunts Point (202)
- Morrisania (203)
- Concourse, Highbridge (204)
- University/Morris Heights (205)
- East Tremont (206)
- Fordham (207)
- Riverdale (208)
- Unionport, Soundview (209)
- Throgs Neck (210)
- Pelham Parkway (211)
- Williamsbridge (212)

Brooklyn
- Williamsburg, Greenpoint (301)
- Fort Greene, Brooklyn Heights (302)
- Bedford Stuyvesant (303)
- Bushwick (304)
- East New York (305)
- Park Slope (306)
- Sunset Park (307)
- Crown Heights North (308)
- Crown Heights South (309)
- Bay Ridge (310)
- Bensonhurst (311)
- Borough Park (312)
- Coney Island (313)
- Flatbush, Midwood (314)
- Sheepshead Bay (315)
- Brownsville (316)
- East Flatbush (317)
- Canarsie (318)

Queens
- Astoria, Long Island City (401)
- Sunnyside, Woodside (402)
- Jackson Heights (403)
- Elmhurst, Corona (404)
- Ridgewood, Glendale (405)
- Rego Park, Forest Hills (406)
- Flushing (407)
- Fresh Meadows, Briarwood (408)
- Woodhaven (409)
- Howard Beach (410)
- Bayside (411)
- Jamaica, St. Albans (412)
- Queens Village (413)
- The Rockaways (414)

Staten Island
- Port Richmond (501)
- Willowbrook, South Beach (502)
- Tottenville (503)

*Analysis was restricted to New York City residents, who comprised 92% (n=542,585) of all deliveries in the city's facilities.

Figure 16. Map of Severe Maternal Morbidity by Community District of Residence, New York City, 2008–2012

SMM per 10,000 deliveries by community district

- 113.3 - 160.9
- 161.0 - 231.9
- 232.0 - 340.9
- 341.0 - 497.4
- Action Center Neighborhoods
- Parks and airports
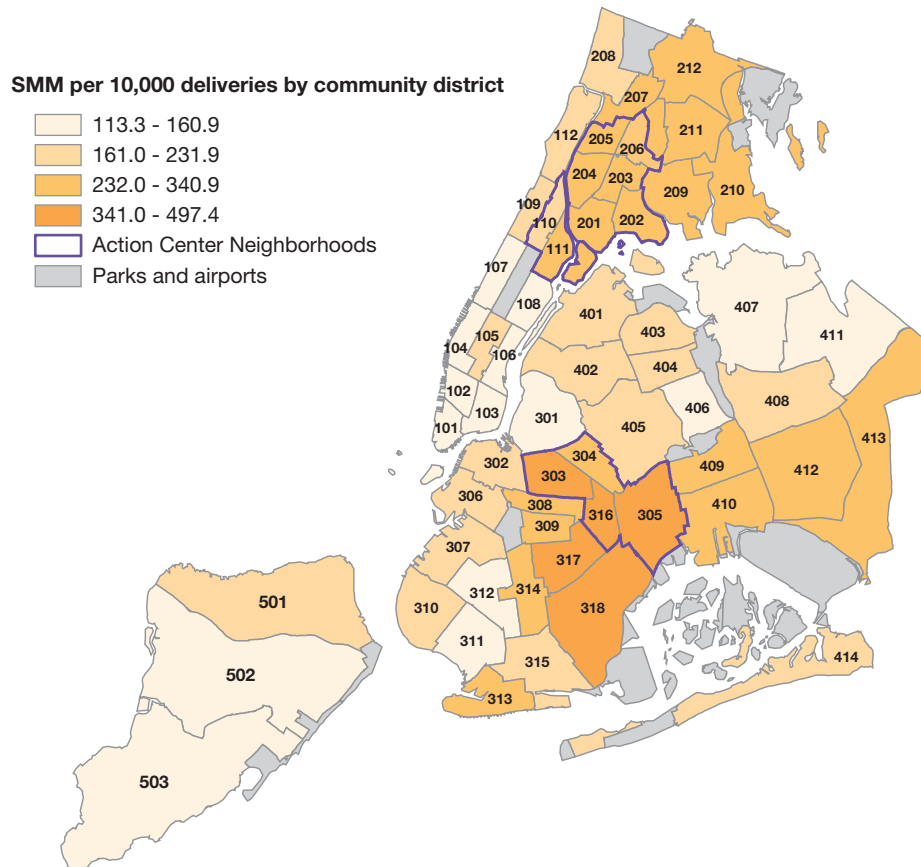
The numbers shown in the map correspond to the community districts listed in Figure 15.

New York City Residents and Boroughs

- The average SMM rate for New York City residents was 231.9 per 10,000 deliveries. The Bronx and Brooklyn had the highest borough SMM rates (295.7 and 255.3 per 10,000 deliveries, respectively); Manhattan and Staten Island had the lowest (162.2 and 163.5 per 10,000 deliveries, respectively). In Queens, the SMM rate was 210.2 per 10,000 deliveries (Appendix B, Table 3).

Community Districts

- The community districts with the highest SMM rates were all in Brooklyn: Brownsville (497.4 per 10,000 deliveries), East Flatbush (479.8 per 10,000 deliveries) and East New York (404.2 per 10,000 deliveries) (Appendix B, Table 4). The majority of deliveries in these neighborhoods were to Black non-Latina women: 76% of all deliveries in Brownsville, 87% in East Flatbush and 52% of all deliveries in East New York were to Black non-Latina women [data not shown].

- The community districts with the lowest SMM rates were Borough Park (113.3 per 10,000 deliveries) in Brooklyn, and Greenwich Village/SoHo (114.5 per 10,000 deliveries) and Battery Park/Tribeca (117.9 per 10,000 deliveries), both in Manhattan (Appendix B, Table 4).

Neighborhood Health Action Centers

The Neighborhood Health Action Centers, opening soon, are part of New York City's plan to promote health equity and reduce health disparities at the neighborhood level.

- SMM rates in three neighborhoods where the Action Centers will operate, and where the Health Department now has program offices, all exceed the citywide average.

- The highest SMM rate was in north and central Brooklyn (Community Districts 303-305 and 316), with 395.0 per 10,000 deliveries, followed by the south Bronx (Community Districts 201-206), with 302.6 per 10,000 deliveries and east and central Harlem (Community Districts 110-111), with 236.2 per 10,000 deliveries. The SMM rate among non-Action Center neighborhoods was 208.2 per 10,000 (Appendix B, Table 3).

Figure 17. Severe Maternal Morbidity by Neighborhood Poverty Level* and Race/Ethnicity, New York City, 2008–2012
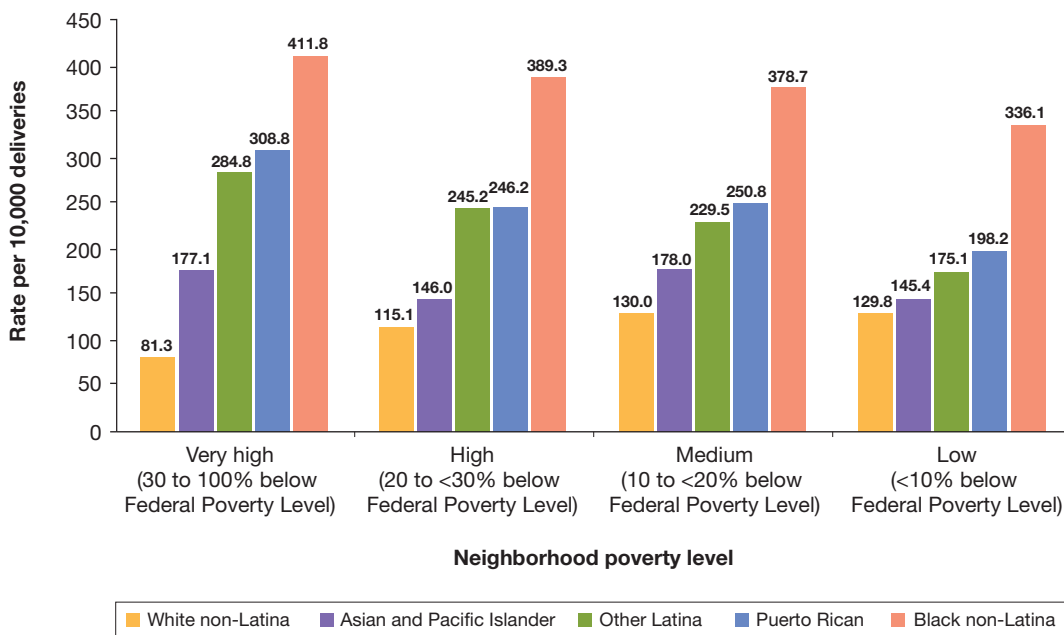
*Neighborhood poverty level was based on the mother's New York City residence zip code and indicates the percentage of residents of that zip code with incomes below the Federal Poverty Level. Analysis was restricted to New York City residents.

- Though the SMM rate differed by race/ethnicity, overall the rate was highest among women living in very high-poverty zip codes with 30% or more of residents below the Federal Poverty Level (282.7 per 10,000 deliveries) and was lowest among women living in low-poverty zip codes with less than 10% of residents below the Federal Poverty Level (162.7 per 10,000 deliveries) (Appendix B, Table 3). However, the low-poverty SMM rate for Black non-Latina women was higher than the very high-poverty SMM rates for other racial/ethnic groups.

Figure 18. Severe Maternal Morbidity by Time of Entry to Prenatal Care and Adequacy of Care,* New York City, 2008–2012
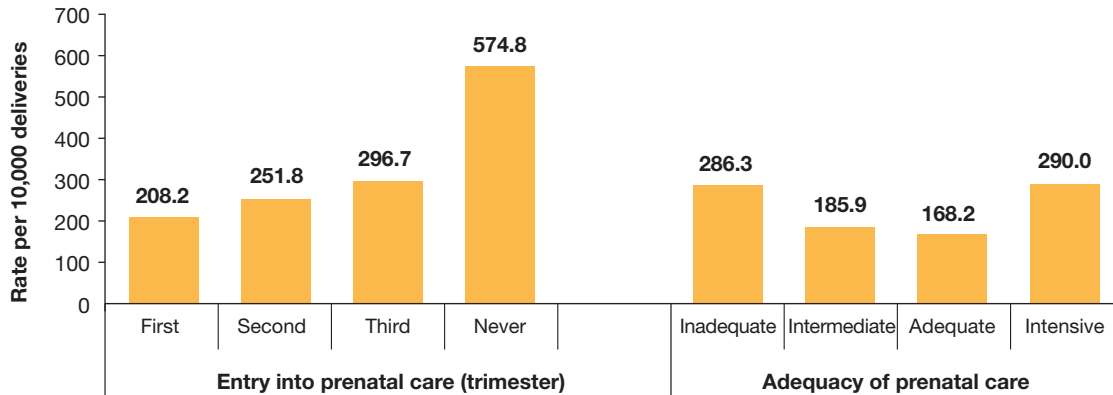
*Adequacy of care was based on the Kotelchuck Index, which takes into account the month of prenatal care initiation, the number of prenatal care visits and the gestational age of the baby at delivery. More information is available in Appendix C.

- The SMM rate was highest among women who received no prenatal care (574.8 per 10,000 deliveries) or late (third-trimester) care (296.7 per 10,000 deliveries). Less than 7% of women received no or late prenatal care.

- Women with inadequate and intensive prenatal care had the highest SMM rates (286.3 and 290.0 per 10,000, respectively).

Figure 19. Severe Maternal Morbidity by Parity, New York City, 2008–2012
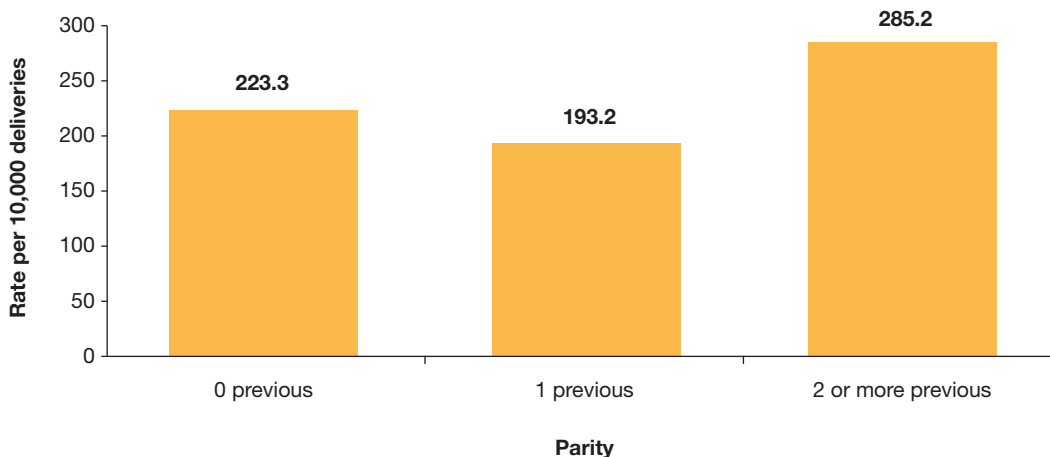
- Women with two or more previous live births had the highest SMM rate (285.2 per 10,000 deliveries) compared to those with zero or one previous live birth (223.3 and 193.2 per 10,000 deliveries, respectively).

Figure 20. Severe Maternal Morbidity by Delivery Type and Plurality, New York City, 2008–2012
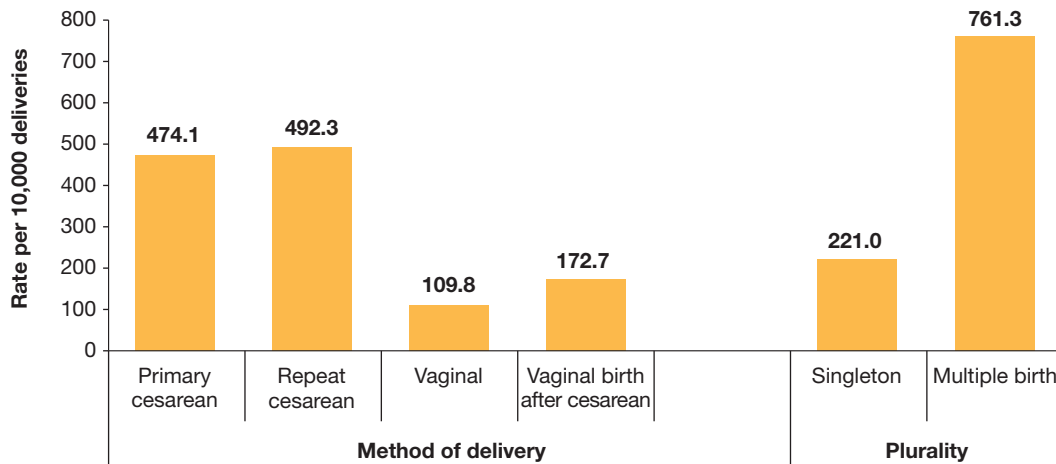
- Cesarean deliveries accounted for 31.9% of all live births but 66.8% of SMM cases (Appendix B, Table 5).

- The SMM rate was higher among women with a primary or repeat cesarean (474.1 and 492.3 per 10,000 deliveries, respectively), compared to women with a vaginal birth (109.8 per 10,000 deliveries) or vaginal birth after a cesarean (172.7 per 10,000 deliveries). Since it was difficult to differentiate between morbidity caused by cesarean delivery versus morbidity requiring a cesarean delivery, results should be interpreted with caution.

- Multiple births accounted for 1.6% of all deliveries but 5.3% of SMM cases (Appendix B, Table 5). The SMM rate was more than three times as high among women with multiple birth deliveries as among women with singleton births (761.3 versus 221.0 per 10,000 deliveries, respectively).

Figure 21. Severe Maternal Morbidity by Pregnancy Intention,* New York City, 2008–2012
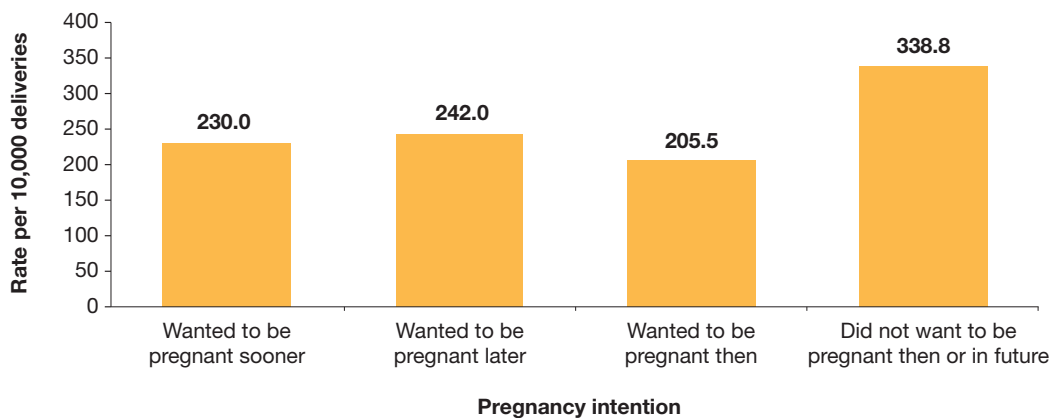
*One question on the birth certificate asks women to recall how they felt about becoming pregnant before they were pregnant.

- Women who said they did not want to be pregnant then or in the future were 1.6 times as likely to have SMM as women who reported wanting to get pregnant when they did (338.8 versus 205.5 per 10,000 deliveries, respectively).

Figure 22. Severe Maternal Morbidity by Level of Care,* New York City, 2008–2012
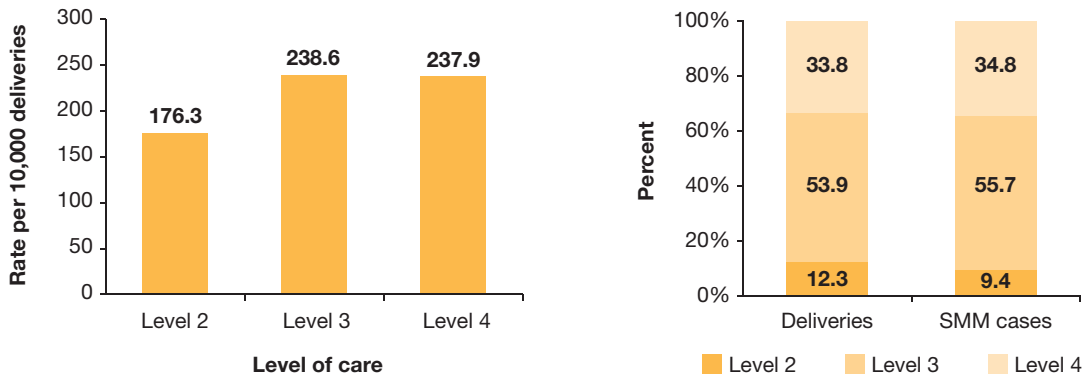
*Based on criteria developed by the American College of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine, New York City maternity hospitals fall within one of these categories: Level 2 (specialty care), Level 3 (subspecialty care) or Level 4 (Regional Perinatal Health Care Centers, i.e., facilities equipped to provide the highest level of care to women who are critically ill or with complex maternal conditions).[17]
Note: Facility-level analyses include hospitals with five or more births in every year 2008–2012 (N=583,921 deliveries).

- Women who delivered at Level 3 and 4 hospitals had the highest SMM rates (238.6 and 237.9 per 10,000 deliveries, respectively). New York City, overall, has a high level of perinatal care (as defined by the Levels of Maternal Care criteria), and the proportion of SMM cases occurring at Level 4 hospitals (34.8%) was similar to the overall proportion of deliveries occurring at Level 4 facilities (33.8%).

Figure 23. Severe Maternal Morbidity by Pre-Pregnancy Body Mass Index and Race/Ethnicity, New York City, 2008–2012
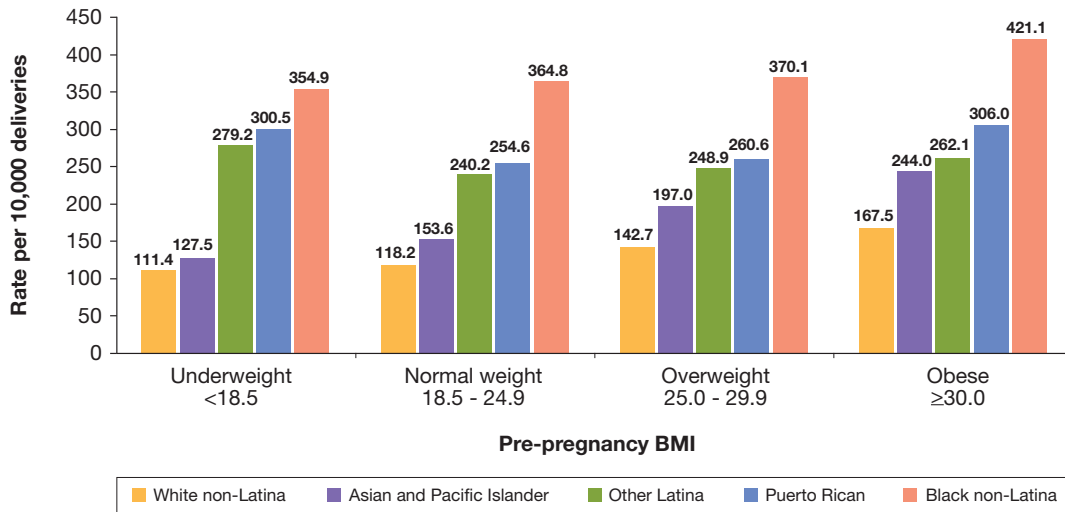
- SMM rates mostly increased as pre-pregnancy body mass index (BMI) increased. Overall, women who were underweight or normal weight had the lowest SMM rates (182.3 and 197.2 per 10,000 deliveries, respectively) (Appendix B, Table 5). Women who were obese at the time they became pregnant (BMI ≥30) had the highest rate of SMM (311.0 per 10,000 deliveries) (Appendix B, Table 5).

- Black non-Latina women consistently had the highest rates of SMM for all BMI groups. In addition, Black non-Latina women with normal pre-pregnancy BMI had higher rates of SMM (364.8 per 10,000 deliveries) than women of every other race/ethnicity who were obese.

Figure 24. Severe Maternal Morbidity by Chronic Condition, New York City, 2008–2012
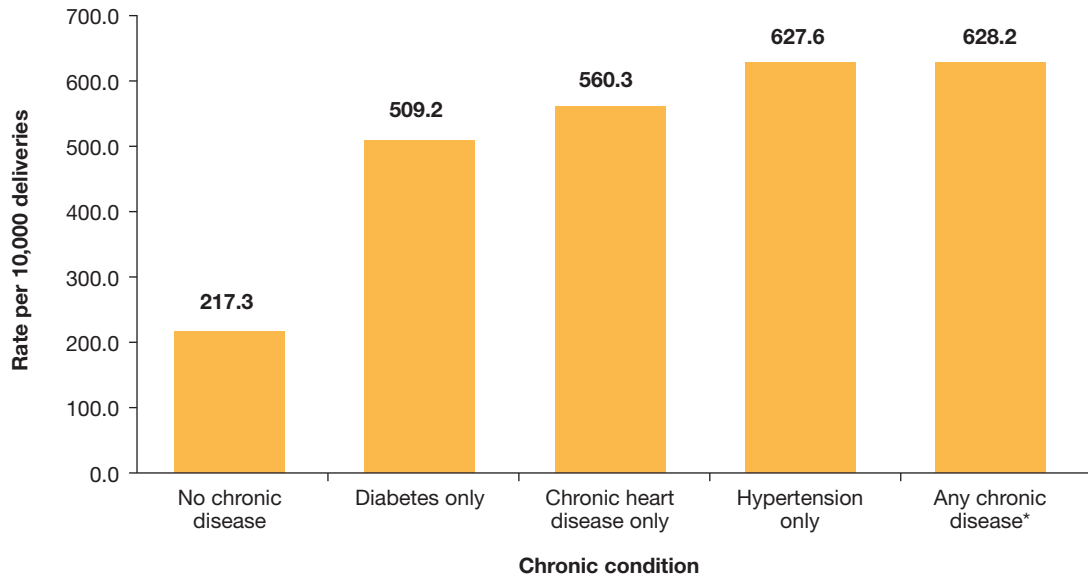
*Any chronic disease includes women with diabetes, heart disease or hypertension or any combination of these conditions.

- Women with any chronic condition (diabetes, heart disease or hypertension) were almost three times as likely to have SMM as women with none of these chronic conditions (628.2 versus 217.3 per 10,000 deliveries, respectively).

- While Black non-Latina women were more likely to deliver with a chronic condition than White non-Latina women (5.4% versus 2.0%), even without a chronic condition, they had higher SMM rates than other racial/ethnic groups at 361.9 per 10,000 deliveries [data not shown].

Figure 25. Estimated Delivery Cost by Number of Severe Maternal Morbidity Indicators, New York City, 2008–2012
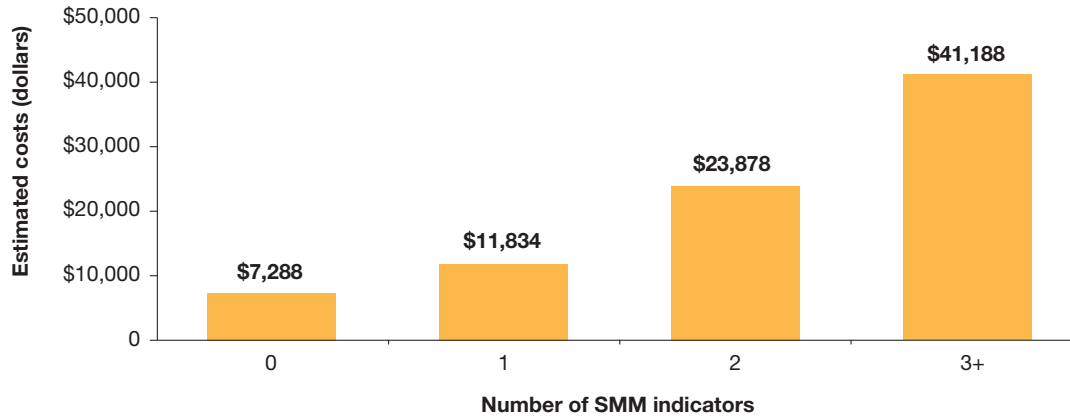
Figure 26. Estimated Delivery Cost With and Without Severe Maternal Morbidity, Adjusting for Other Factors,* New York City, 2008–2012
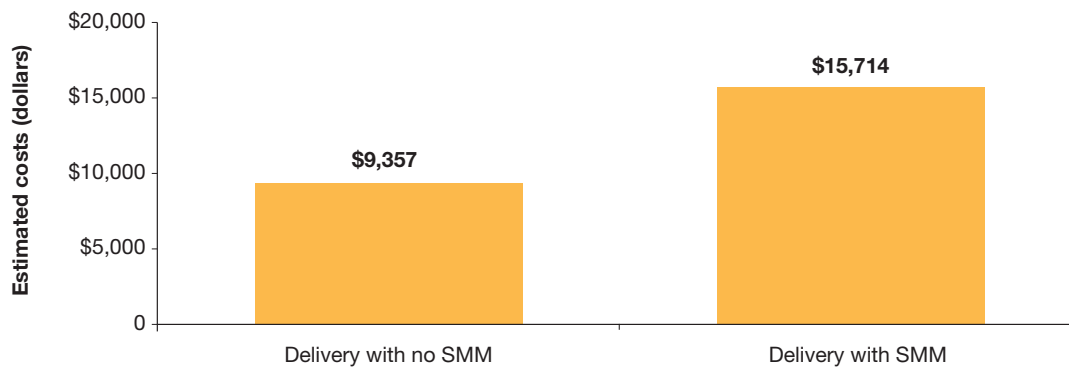
*Adjusted for maternal age, race/ethnicity, payer, method of delivery, plurality and comorbidity and clustered by hospital. The total sample for the adjusted analysis was 582,006 (excludes missing observations).

- The average cost of delivery increased as the number of SMM indicators increased. For women with two indicators, the average cost of delivery was $23,878, or more than three times the delivery cost for women with no indicators. With three or more SMM indicators, the average cost was more than five times as high as the cost of a delivery with no indicators ($41,188 versus $7,288, respectively).

- After adjusting for other maternal, clinical and hospital level factors, the average cost of delivery with SMM was $15,714 (95% CI: $13,342-18,509) compared to $9,357 (95% CI: $8,412-10,410) for deliveries without SMM. Therefore, the average difference between the cost of deliveries with and without SMM was $6,357 (95% CI: $6,200-6,516).

- With 13,505 cases of SMM in New York City from 2008–2012 and an adjusted difference in cost of $6,357 per case, the total excess costs related to SMM exceeded $85 million (13,505 * $6,357 = $85,851,285), an average of $17 million a year.

Recommendations

SMM is a pressing public health concern. The findings of this report point to many challenges and knowledge gaps in the effort to improve maternal health and reduce SMM, especially among women at highest risk. The Health Department recommends a concerted effort involving government, stakeholders, clinicians, researchers and others. Specific recommendations include:

1. **Implement interventions that improve women's overall health.** Increasing awareness of birth control options and access to family planning services, stressing the importance of preconception health and managing chronic diseases, enrolling women in insurance programs and prenatal care and educating women about the risk and warning signs of maternal morbidity may reduce SMM.

2. **Focus on reducing SMM among populations with the highest rates.** The data in this report show that certain neighborhoods have higher rates of SMM than others. Clinical, policy and program interventions should be directed at neighborhoods in which Black non-Latina and Latina women bear high burdens of SMM. Place-based approaches are part of the Health Department's overall commitment to addressing health inequities among neighborhoods. (For reference, see the Department's recently published Community Health Profiles).[18]

3. **Explore savings of specific SMM interventions.** Compare intervention costs and health care costs to estimate savings. Explore the societal costs of SMM, including time away from work and the need for long-term rehabilitation.

4. **Evaluate SMM trends.** Ongoing SMM surveillance will help document the effect of program and policy interventions and track progress in reducing SMM. Opportunities to improve surveillance methods, including the quality of blood transfusion measurements and the implementation of ICD-10 coding, should be explored. Surveillance should be expanded to include postpartum re-admissions and other pregnancy outcomes.

5. **Share population-level data with health care providers to improve their understanding of factors that contribute to health inequities.** Providers can tailor interventions to the health care needs and risks inherent in the patient populations they serve.

6. **Research the modifiable contributors to poor health and poor pregnancy outcomes.** While surveillance data are useful for highlighting overall trends and stark inequities by demographic characteristics, including race/ethnicity, education and neighborhood, they also raise many questions about the structural and social barriers women face in their daily lives that can be detrimental to their overall health and can contribute to poor pregnancy outcomes. Future research, including qualitative research that examines the experiences of women and families impacted by SMM, could help elucidate the social determinants of disease and identify modifiable risk factors.

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Appendix A. Methodology Notes

Data Matching and Quality

The New York State Department of Health matched SPARCS delivery hospitalizations and birth certificates, using an algorithm of identifying variables. Only one infant birth certificate was matched per hospital discharge record, even when there was a multiple birth. Each matched record represents a delivery where at least one live birth occurred. Matched records from 2008 and 2009 were updated in July 2014, and matched records from 2010 to 2012 were updated in June 2015.

To identify the overall match rate, the report authors calculated the number of deliveries (n=613,314) from the overall number of New York City births from 2008 to 2012 (n=625,505). The number of deliveries comprises all records from singleton births and one record per multiple birth. The analytical sample contained 588,232 birth certificates that successfully matched to a hospital discharge record. Using the number of deliveries between 2008 and 2012 as the denominator, the overall match rate was 95.9%.

The match rate for 2009 (91.3%) was noticeably lower than for other years (Appendix B, Table 1). In 2009, no birth certificates from deliveries of multiple births matched with a SPARCS record. Almost 2% of deliveries resulted in a multiple birth in 2009, and these women are not included in the matched data. Also, the SPARCS file was inadvertently truncated in 2009. Analysis of the birth certificates that would have matched had the SPARCS files not been truncated showed that missing records belonged disproportionately to Asian and Pacific Islander women; therefore these deliveries are underrepresented in 2009 (p<0.05).

Identification of Severe Maternal Morbidity

SMM was identified during delivery hospitalizations with the same criteria the CDC used to identify SMM in a national sample of delivery hospitalizations.[1] However, there are four key differences:

1. **New York City delivery hospitalizations were identified by the presence of a matched birth certificate.** In the national sample, there was no matched birth certificate, and delivery hospitalizations were identified by the presence of specific obstetric ICD-9-CM and diagnosis-related group (DRG) codes.[19] Sensitivity testing of the New York City matched sample showed that over 99% of the hospital discharge records would have been identified as deliveries using the specific codes. However, there may be delivery hospitalization records that were not included in the analytic sample because they did not match with a birth certificate.

2. **Since the New York City sample was defined by the presence of a birth certificate, every delivery in the New York City sample resulted in at least one live birth.** The national sample includes deliveries resulting in both live births and stillbirths. Information on women with a pregnancy resulting in stillbirth was not included in the analysis. As women with a pregnancy resulting in stillbirth may have a greater risk of complications in pregnancy and therefore SMM, this research could potentially be underestimating the rate of SMM in New York City. For information on all live births as well as other pregnancy outcomes occurring in New York City, see the Annual Summary of Vital Statistics (nyc.gov/html/doh/html/data/vs-summary.shtml).

3. **The New York City sample provides population-level estimates of all live deliveries in New York City.** The report authors did not need to account for sampling in the New York City analysis, as all deliveries resulting in a live birth that matched with a hospital-discharge record were included. The national analysis used the Nationwide Inpatient Sample, which is a sample of hospital discharge records in the United States. To produce national population-level estimates, records were weighted to account for complex sampling.

4. **While New York City hospital discharge records contain 25 ICD-9-CM diagnosis codes and 15 ICD-9-CM procedure codes, the discharge records used in the national sample contained only 15 diagnosis codes and 15 procedure codes.** More diagnosis codes on the New York City discharge records could identify more cases of SMM than would be captured with 15 diagnosis codes. However, sensitivity testing showed that the rate of SMM in New York City only decreased by 0.1% after restricting to 15 diagnosis codes.

Cost Analysis

The report authors excluded 14 records from three non-obstetric facilities that had fewer than five births in a given year. These deliveries were not representative of standard care: the average charge was $117,390 (compared to $13,955 for other deliveries), and the average length of stay was close to 13 days. The authors also excluded approximately 700 deliveries that occurred in late 2012, but were discharged in 2013, for which there was no cost information. Therefore, the analytical sample included 583,555 records (99.3% of the total sample). Converting costs to charges involved adjusting for three separate factors, outlined below:

1. **Hospital-specific mark-up:** To account for the variation in mark-up among hospitals, year- and hospital-specific cost-to-charge ratios (CCR) were used based on the Healthcare Cost and Utilization Project from annual cost reports.[13] The average CCR for all hospitals and years included in the sample ranged from 0.3870 to 0.4543. More information on the CCR files used in this report is available at https://www.hcup-us.ahrq.gov/db/state/costtocharge.jsp.

2. **Department-specific mark-up:** To account for mark-up between departments within a facility (for example, higher mark-up for operating room services compared to routine bed care),[20] costs were multiplied by the DRG adjustment factors, which were calculated by the Healthcare Cost and Utilization Project using service-specific charge to cost data[14]. DRGs are available in hospital discharge records and are coded based on the services a patient received, as well as patient characteristics such as age and comorbidities. Adjustment factors ranged from 0.8862 (DRG=5, Liver Transplant with Multiple Comorbid Conditions) to 1.3828 (DRG = 775, Vaginal Delivery without complicating diagnosis). Adjustment factors by DRG are available from the Agency for Healthcare Research and Quality at http://www.hcup-us.ahrq.gov/reports/methods/2011_04.pdf.

3. **Inflation:** To account for cost inflation, costs were multiplied by a year-specific factor, bringing everything to 2012 dollars, based on the Bureau of Labor Statistics' Consumer Price Index for medical care.[15] In the sample, 2008 costs increased by 12%, 2009 by 11%, 2010 by 8%, and 2011 by 5%.

Missing Data

Records with missing data on a variable of interest were not included in the presentation of the data for that variable (e.g., if a record was missing information on maternal age, that record would not be represented in the graph of SMM by maternal age). All variables presented in this report had less than 4% missing data. In some cases, the sample was restricted to a subset that had a particular characteristic present (e.g., area-based poverty was only presented among New York City residents).

Limitations

The matched birth certificate-hospital discharge data used in this report provide a unique opportunity to examine the clinical characteristics of a delivery, such as diagnoses and procedures that occur in the hospital, in conjunction with demographic characteristics that are not often captured in hospital discharge data. Despite the advantages of the matched dataset, several limitations should be noted.

In administrative data such as hospital discharge records, events based on ICD-9-CM codes may be over- or underreported, or the severity of certain events may not be accurately captured. In particular, women who received a code for blood transfusion may have had blood loss or hemorrhage with varying levels of severity. Additionally, the quality of billing information in hospital discharge data is known to vary. Even with the charge conversion method, the cost is an estimate and does not represent the amount paid by insurance companies or individuals. Births that do not occur in hospitals are underrepresented in the matched data, as they often will have no associated hospital discharge records. Pregnancies not resulting in a live birth, including ectopic and molar pregnancies, spontaneous abortions and stillbirths, were excluded. Postpartum hospitalizations were not included here because of differences in the data file construction. Finally, certain variables of interest, such as homelessness, were not accurately captured in these data and therefore could not be examined.

Appendix B. Supplemental Data Tables

Table 1. **Number of Total Deliveries, Matched SPARCS and Birth Certificate Records, and the Percent Matched by Year, New York City, 2008–2012**

Year	All deliveries	Matched files	Percent
2008	125,216	120,379	96.1%
2009	124,311	113,539	91.3%
2010	122,295	118,933	97.3%
2011	120,612	117,400	97.3%
2012	120,880	117,981	97.6%
All	613,314	588,232	95.9%

Table 2. **Rate of Severe Maternal Morbidity Indicators per 10,000 Deliveries, New York City, 2008–2012**

SMM indicator	Rate per 10,000 deliveries
Diagnosis-based indicators	
Complications during procedure or surgery	19.7
Disseminated intravascular coagulation	17.1
Adult respiratory distress syndrome	6.6
Acute renal failure	6.5
Eclampsia	4.3
Shock	3.4
Sepsis	3.1
Thrombotic embolism	2.8
Puerperal cerebrovascular disorders	2.6
Pulmonary edema	2.4
Sickle cell anemia with crisis	2.2
Severe anesthesia complications	2.1
Cardiac arrest	0.6
Amniotic fluid embolism	0.4
Acute myocardial infarction	0.3
Intracranial injuries	–
Internal injuries of thorax, abdomen, and pelvis	–
Aneurysm	–
Procedure-based indicators	
Blood transfusion	176.5
Hysterectomy	12.5
Ventilation	11.4
Operations on the heart and pericardium	6.4
Cardio monitoring	3.7
Conversion of cardiac rhythm	0.7
Temporary tracheostomy	–
SMM rate overall	**229.6**

Note: Indicators with cell sizes less than 15 were suppressed.

Table 3.   Severe Maternal Morbidity by Maternal Demographics and Place of Residence, New York City, 2008–2012 (n=588,232)

	SMM cases	Rate per 10,000 deliveries	Total deliveries	Percent of total deliveries	Percent of SMM cases
Maternal age					
≤19	998	292.2	34,152	5.8%	7.4%
20-24	2,698	237.8	113,478	19.3%	20.0%
25-29	3,013	198.6	151,689	25.8%	22.3%
30-34	3,327	205.0	162,286	27.6%	24.6%
35-39	2,430	248.8	97,680	16.6%	18.0%
≥40	1,039	358.9	28,947	4.9%	7.7%
Race/ethnicity					
Puerto Rican	1,226	272.0	45,080	7.7%	9.1%
Other Latina	3,486	248.5	140,278	23.8%	25.8%
Asian and Pacific Islander	1,447	162.9	88,832	15.1%	10.7%
White non-Latina	2,265	126.7	178,808	30.4%	16.8%
Black non-Latina	4,808	386.9	124,268	21.1%	35.6%
Other non-Latina	72	308.7	2,332	0.4%	0.5%
Non-Latina of two or more races	168	218.5	7,689	1.3%	1.2%
Unknown	33	349.2	945	0.2%	0.2%
Region of birth					
U.S.	6,588	229.8	286,634	48.7%	48.8%
Mexico and Central America	1,375	288.7	47,628	8.1%	10.2%
Caribbean	2,243	315.7	71,044	12.1%	16.6%
South America	788	232.1	33,944	5.8%	5.8%
Europe	373	119.9	31,105	5.3%	2.8%
Africa	591	282.3	20,932	3.6%	4.4%
Middle East	185	149.7	12,361	2.1%	1.4%
Asia	1,301	163.0	79,821	13.6%	9.6%
Australian region	–	–	880	0.1%	0.1%
Canada	32	109.4	2,925	0.5%	0.2%
Unknown	19	198.3	958	0.2%	0.1%
Years in U.S.					
Not foreign-born	6,588	229.8	286,634	48.7%	48.8%
Less than 1 year	436	255.3	17,078	2.9%	3.2%
1+ years	6,271	225.7	277,878	47.2%	46.4%
Unknown*	210	316.2	6,642	1.1%	1.6%
Education					
Less than high school	3,942	283.9	138,868	23.6%	29.2%
High school graduate	3,251	244.4	132,999	22.6%	24.1%
Some college	3,128	244.1	128,156	21.8%	23.2%
College graduate or higher	3,059	164.5	185,976	31.6%	22.7%
Unknown	125	559.8	2,233	0.4%	0.9%
Insurance					
Medicaid/Family Health Plus	8,915	261.1	341,406	58.0%	66.0%
Other government	374	388.2	9,634	1.6%	2.8%
Private	3,741	168.2	222,464	37.8%	27.7%
Self-pay	274	338.1	8,105	1.4%	2.0%
Other	85	253.4	3,354	0.6%	0.6%
Unknown	116	354.8	3,269	0.6%	0.9%

Table 3.   Severe Maternal Morbidity by Maternal Demographics and Place of Residence, New York City, 2008–2012 (n=588,232) *(continued)*

	SMM cases	Rate per 10,000 deliveries	Total deliveries	Percent of total deliveries	Percent of SMM cases
Borough of residence					
Bronx	2,966	295.7	100,290	17.0%	22.0%
Brooklyn	4,991	255.3	195,526	33.2%	37.0%
Manhattan	1,488	162.2	91,718	15.6%	11.0%
Queens	2,712	210.2	129,002	21.9%	20.1%
Staten Island	426	163.5	26,049	4.4%	3.2%
Non-residents	921	201.8	45,632	7.8%	6.8%
Unknown	–	–	15	0.0%	–
Action Center Neighborhoods					
Bronx	1,541	302.6	50,921	9.4%	12.2%
Harlem	378	236.2	16,004	2.9%	3.0%
Brooklyn	1,608	395.0	40,704	7.5%	12.8%
Not in Action Center neighborhood	9,055	208.2	434,846	80.1%	72.0%
Unknown	–	–	110	0.0%	0.0%
Neighborhood poverty level**					
Low (<10% below Federal Poverty Level)	1,331	162.7	81,790	15.1%	10.6%
Medium (10 to <20% below Federal Poverty Level)	3,653	217.3	168,085	31.0%	29.0%
High (20 to <30% below Federal Poverty Level)	3,730	239.7	155,631	28.7%	29.6%
Very high (30 to 100% below Federal Poverty Level)	3,863	282.7	136,661	25.2%	30.7%
Unknown	–	–	418	0.1%	–

*Unknown number of years in the U.S. includes foreign-born women with unknown years in U.S. and women with unknown nativity

**Action Center neighborhood and neighborhood poverty level only reported for New York City residents (n=542,585). Neighborhood Health Action Centers (formerly District Public Health Offices), opening soon, are part of New York City's plan to better link New Yorkers with local health and community services. The Action Centers will operate in neighborhoods with high rates of chronic disease and premature death.

Note: Indicators with cell sizes less than 15 were suppressed

Table 4. Severe Maternal Morbidity by Community District of Residence, New York City, 2008–2012

Community District name	Community District number	SMM rate
Manhattan		**162.2**
Battery Park, Tribeca	101	117.9
Greenwich Village, SoHo	102	114.5
Lower East Side	103	130.2
Chelsea, Clinton	104	154.2
Midtown	105	170.5
Murray Hill	106	128.7
Upper West Side	107	125.1
Upper East Side	108	125.9
Manhattanville	109	216.0
Central Harlem	110	221.1
East Harlem	111	251.4
Washington Heights	112	187.3
Bronx		**295.7**
Mott Haven	201	326.4
Hunts Point	202	283.7
Morrisania	203	336.0
Concourse, Highbridge	204	305.4
University/Morris Heights	205	277.3
East Tremont	206	290.8
Fordham	207	270.7
Riverdale	208	186.2
Unionport, Soundview	209	316.7
Throgs Neck	210	280.7
Pelham Parkway	211	297.6
Williamsbridge	212	327.5
Brooklyn		**255.3**
Williamsburg, Greenpoint	301	122.5
Fort Greene, Brooklyn Heights	302	191.3
Bedford Stuyvesant	303	374.8
Bushwick	304	326.4
East New York	305	404.2
Park Slope	306	174.1
Sunset Park	307	179.4
Crown Heights North	308	339.8
Crown Heights South	309	287.3
Bay Ridge	310	168.2
Bensonhurst	311	159.2
Borough Park	312	113.3
Coney Island	313	261.0
Flatbush, Midwood	314	266.8
Sheepshead Bay	315	184.4
Brownsville	316	497.4
East Flatbush	317	479.8
Canarsie	318	379.9
Queens		**210.2**
Astoria, Long Island City	401	198.7
Sunnyside, Woodside	402	180.9
Jackson Heights	403	218.4
Elmhurst, Corona	404	209.5
Ridgewood, Glendale	405	171.5
Rego Park, Forest Hills	406	138.2
Flushing	407	126.5
Fresh Meadows, Brianwood	408	172.9
Woodhaven	409	238.7
Howard Beach	410	249.2
Bayside	411	156.4
Jamaica St. Albans	412	318.9
Queens Village	413	275.4
The Rockaways	414	209.6
Staten Island		**163.5**
Port Richmond	501	196.9
Willowbrook, South Beach	502	141.9
Tottenville	503	130.4

Table 5.   Severe Maternal Morbidity by Prenatal and Delivery Characteristics, New York City, 2008–2012 (n=588,232)

	SMM cases	Rate per 10,000 deliveries	Total deliveries	Percent of total deliveries	Percent of SMM cases
Prenatal care initiation					
1st trimester	8,443	208.2	405,586	69.0%	62.5%
2nd trimester	3,142	251.8	124,782	21.2%	23.3%
3rd trimester	1,066	296.7	35,925	6.1%	7.9%
Never	237	574.8	4,123	0.7%	1.8%
Unknown	617	346.3	17,816	3.0%	4.6%
Adequacy of prenatal care					
Inadequate	2,853	286.3	99,664	16.9%	21.1%
Intermediate	1,230	185.9	66,158	11.2%	9.1%
Adequate	4,061	168.2	241,467	41.0%	30.1%
Intensive	4,593	290.0	158,389	26.9%	34.0%
Unknown	768	340.5	22,554	3.8%	5.7%
Parity					
0 Previous live births	6,023	223.3	269,746	45.9%	44.6%
1 Previous live birth	3,373	193.2	174,583	29.7%	25.0%
2+ Previous live births	4,091	285.2	143,444	24.4%	30.3%
Unknown	18	392.2	459	0.1%	0.1%
Method of delivery					
Primary cesarean	5,576	474.1	117,606	20.0%	41.3%
Repeat cesarean	3,450	492.3	70,079	11.9%	25.5%
Vaginal	4,275	109.8	389,240	66.2%	31.7%
Vaginal birth after cesarean	171	172.7	9,899	1.7%	1.3%
Unknown	33	234.4	1,408	0.2%	0.2%
Plurality					
Singleton birth	12,790	221.0	578,840	98.4%	94.7%
Multiple birth	715	761.3	9,392	1.6%	5.3%
Pregnancy intention					
Wanted to be pregnant sooner	2,728	230.3	118,473	20.1%	20.2%
Wanted to be pregnant later	2,807	242.0	115,981	19.7%	20.8%
Wanted to be pregnant then	6,351	205.5	309,105	52.5%	47.0%
Did not want to be pregnant then or future	854	338.8	25,209	4.3%	6.3%
Unknown	765	393.0	19,464	3.3%	5.7%
Facility level of care*					
Level 2	1,271	176.3	72,112	12.3%	9.4%
Level 3	7,507	238.6	314,639	53.9%	55.7%
Level 4	4,690	237.9	197,170	33.8%	34.8%
Pre-pregnancy BMI					
Underweight (<18.5)	587	182.3	32,202	5.5%	4.3%
Normal weight (18.5 - 24.9)	6,228	197.2	315,772	53.7%	46.1%
Overweight (25 - 29.9)	3,450	251.2	137,318	23.3%	25.5%
Class I (30 - 34.9)	1,710	284.0	60,221	10.2%	12.7%
Class II (35 - 39.9)	730	323.4	22,570	3.8%	5.4%
Class III (≥40)	534	416.1	12,833	2.2%	4.0%
Unknown	266	363.6	7,316	1.2%	2.0%
Chronic disease^					
No chronic disease	12,400	217.3	570,642	97.0%	91.8%
Any chronic disease	1,105	628.2	17,590	3.0%	8.2%

*Facility level of care is only reported for deliveries at hospitals with >5 births in all years (n=583,921 deliveries)
^ Any chronic disease includes deliveries to women with chronic hypertension, pre-existing diabetes or chronic heart disease
Note: Indicators with cell sizes less than 15 were suppressed

Appendix C. Notes

1. All demographic variables, prenatal care and pregnancy history variables, and maternal height and weight (used to calculate body mass index) were ascertained from the birth certificate. Hospital-specific variables, including facility-level information and costs, were ascertained from the hospital discharge record.

2. Respondents were allowed to select multiple races and ancestries on the birth certificate. Responses were coded into the seven race/ethnicity categories used in this report by the New York City Bureau of Vital Statistics following the rules of the National Center for Health Statistics. Individuals are first assigned to Puerto Rican or other Hispanic ethnicities based on ancestry, regardless of race. Then, those of non-Hispanic ancestries are classified by race as Asian and Pacific Islander, White non-Hispanic, Black non-Hispanic or Other/Multiple race. (This report uses the term Latina instead of Hispanic.)

3. U.S.-born refers to women born in the 50 states, District of Columbia or other U.S. territories including American Samoa, Guam, Puerto Rico and the U.S. Virgin Islands. All others with a known country of birth were considered foreign-born.

4. Women who indicated their highest level of education was an Associate's degree were categorized as "Some College."

5. Health insurance status indicates the primary payer for the delivery as recorded on the birth certificate.

6. Women were considered New York City residents if their usual residence reported on the birth certificate was in the Bronx, Brooklyn, Manhattan, Queens or Staten Island.

7. Neighborhood poverty level was defined using women's zip code of residence as recorded on the birth certificate. The American Community Survey five-year estimate from 2008–2012 provided information on area-based poverty level. Area-based poverty level by zip code was based on the proportion of residents living below the Federal Poverty Level. Area-based poverty levels were only assigned to New York City residents with valid New York City zip codes.

8. Community district boundaries are determined by the New York City Department of City Planning and are used to facilitate the delivery of city services. Additional information on community districts can be found at www.nyc.gov/dcp.

9. Neighborhood Health Action Centers (formerly District Public Health Offices), opening soon, are part of New York City's plan to better link New Yorkers with local health and social services. The Action Centers will operate in neighborhoods with high rates of chronic disease and premature death. Action Center catchment area boundaries are determined by community districts in this report: the Bronx includes community districts 201-206, Brooklyn includes 303-305 and 316 and Harlem includes 110-111.

10. Prenatal care adequacy was measured using the Kotelchuck Index.[21] The Kotelchuck Index utilizes timing of prenatal care initiation, number of prenatal care visits, infant birth weight, infant sex and gestational age to determine the adequacy of prenatal care. The value for gestational age used in this calculation was the clinical estimate of gestation, which is the birth attendant's final estimate of gestation in completed weeks.

11. Information on perinatal levels of care for hospitals was found on the New York State Hospital Profiles available at http://profiles.health.ny.gov/hospital and was linked to births using the facility recorded on the hospital discharge record.

12. Chronic conditions were identified from SPARCS data using previously identified ICD-9-CM codes.[6] Chronic heart disease was identified by the presence of ICD-9-CM codes 412-414, 394-397, 424, 428.22, 428.23, 428.32, 428.33, 428.42, 428.43; chronic hypertension by ICD-9-CM codes 401-405, 642.7, 642.0-642.2; and diabetes by ICD-9-CM codes 249, 250, 648.0. Chronic hypertension does not include exclusively pregnancy-related hypertensive disorders. Diabetes does not include women with exclusively gestational diabetes.

13. For the cost analysis, the report authors defined comorbidity using an index developed by Bateman et al, which includes 20 different conditions.[22] Multiple gestation and previous cesarean section were removed from the list because they were included as separate factors in the analysis. The final list included 18 conditions. Codes were also removed from two conditions (sickle cell anemia and eclampsia) that overlapped with codes included in the SMM algorithm (282.6 and 642.6). The prevalence of a comorbidity using this adapted algorithm was 14.7% in the total delivery sample.

Appendix D. Complete List of SMM Indicators and Associated ICD-9-CM Codes

Classification	Condition	Description	ICD-9-CM codes
Diagnosis	Acute myocardial infarction	Heart attack	410.xx
	Acute renal failure	Kidney failure	584.x, 669.3x
	Adult respiratory distress syndrome	Respiratory failure	518.5x, 518.81, 518.82, 518.84,799.1
	Amniotic fluid embolism	Condition where amniotic fluid or fetal material enters the mother's bloodstream causing systemic collapse of organ functions	673.1x
	Aneurysm	Abnormal widening of a blood vessel which may cause rupture and acute blood loss	441.xx
	Cardiac arrest/ventricular fibrillation	Failure of the heart to pump blood	427.41, 427.42, 427.5
	Complications during procedure or surgery	Complications of obstetrical surgery and procedures, including cardiac complications	669.4x, 997.1
	Disseminated intravascular coagulation	Interruption of blood clotting mechanism leading to bleeding	286.6, 286.9, 666.3x
	Eclampsia	Onset of seizures during pregnancy	642.6x
	Internal injuries of thorax, abdomen and pelvis	Injuries to internal organs, including the lungs, uterus, liver and kidneys	860.xx—869.xx
	Intracranial injuries	Injuries to the skull and brain	800.xx, 801.xx, 803.xx, 804.xx, 851.xx-854.xx
	Puerperal cerebrovascular disorders	Stroke	430, 431, 432.x, 433.xx, 434.xx, 436, 437.x, 671.5x, 674.0x, 997.2, 999.2
	Pulmonary edema	Excess fluid in the lungs not allowing for oxygenation of tissues	428.1, 518.4
	Sepsis	Whole-body response to an infection causing collapse and lack of organ function	038.xx, 995.91, 995.92
	Severe anesthesia complications	Complications resulting from pain control procedures	668.0x, 668.1x, 668.2x
	Shock	Condition where organs are not getting enough blood flow	669.1x, 785.5x, 995.0, 995.4, 998.0x
	Sickle cell anemia with crisis	Episodes of acute pain in a person with sickle cell anemia	282.62, 282.64, 282.69
	Thrombotic embolism	Blood clot	415.1x, 673.0x, 673.2x, 673.3x, 673.8x
Procedure	Blood transfusion	Transfusion of whole blood and other blood products	99.0x
	Cardio monitoring	Monitoring of cardiac output and blood pressure and gases	89.6x
	Conversion of cardiac rhythm	Procedure that restores an irregular heartbeat to normal rhythm	99.6x
	Hysterectomy	Removal of the uterus	68.3x-68.9
	Operations of the heart and pericardium	Operations on the heart and membrane enclosing the heart	35.xx, 36.xx, 37.xx, 39.xx
	Temporary tracheostomy	Procedure where an alternate breathing route is provided through the trachea (windpipe)	31.1
	Ventilation	Assisted breathing	93.90, 96.01-96.05, 96.7x