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Site of Delivery Contribution to Black-White Severe Maternal Morbidity Disparity

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Abstract

BACKGROUND—The black-white maternal mortality disparity is the largest disparity among all conventional population perinatal health measures and the mortality gap between black and white women in New York City has nearly doubled in recent years. For every maternal death, 100 women experience severe maternal morbidity, a life threatening diagnosis or undergo a lifesaving procedure during their delivery hospitalization. Like maternal mortality, severe maternal morbidity is more common among black than white women. A significant portion of maternal morbidity and mortality is preventable making quality of care in hospitals a critical lever for improving outcomes. Hospital variation in risk-adjusted severe maternal morbidity rates exists. The extent to which variation in hospital performance on severe maternal morbidity rates contributes to black-white disparities in New York City hospitals has not been studied.

OBJECTIVE—We examined the extent to which black-white differences in severe maternal morbidity rates in New York City hospitals can be explained by differences in the hospitals in which black and white women deliver.

STUDY DESIGN—We conducted a population-based study using linked 2011–2013 New York City discharge and birth certificate datasets (N= 353,773 deliveries) to examine black-white differences in severe maternal morbidity rates in New York City hospitals. Mixed-effects logistic

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CONDENSATION

Differences in delivery hospital contribute to black-white disparities in severe maternal morbidity rates in New York City hospitals.

regression with a random hospital-specific intercept was used to generate risk-standardized severe maternal morbidity rates for each hospital (N=40). We then assessed differences in the distributions of black and white deliveries among these hospitals.

RESULTS—Severe maternal morbidity occurred in 8,882 deliveries (2.5%) and was higher among black than white women (4.2% vs. 1.5%, p<.001). After adjustment for patient characteristics and comorbidities the risk remained elevated for black women (odds ratio=2.02; 95% CI 1.89–2.17). Risk-standardized severe maternal morbidity rates among New York City hospitals ranged from 0.8 to 5.7 per 100 deliveries. White deliveries were more likely to be delivered in low morbidity hospitals: 65% of white versus 23% of black deliveries occurred in hospitals in the lowest tertile for morbidity. We estimated that black-white differences in delivery location may contribute as much as 47.7% of the racial disparity in severe maternal morbidity rates in New York City.

CONCLUSION—Black mothers are more likely to deliver at higher risk-standardized severe maternal morbidity hospitals than are white mothers, contributing to black-white disparities. More research is needed to understand the attributes of high performing hospitals and to share best practices among hospitals.

Keywords

disparities; hospital; severe maternal morbidity

Black women are 12 times more likely to suffer a pregnancy-related death than are white women in New York City.[1] This disparity is three to four times greater than the US black-white maternal mortality disparity.[2] Not only are there striking racial disparities in maternal mortality rates but overall performance on the maternal mortality ratio (MMR) – the number of maternal deaths per 100,000 live births – in the US is poor compared to other countries: we rank 60th among World Health Organization member nations.[3] For every maternal death, 100 women experience severe maternal morbidity.[4,5] Similar to racial/ethnic disparities in maternal mortality, black women are more likely to suffer from severe maternal morbidity than white women.[4]

Quality of health care in hospitals is a critical lever for improving outcomes as data suggest over one-third of maternal morbidity and mortality is preventable.[6–9] Obstetrical complications are sensitive to the quality of care provided at delivery,[10,11] and variations in the quality of maternal care across hospitals exists.[12,13] The contribution of hospital quality to racial disparities in obstetrical outcomes has been less studied. The few studies that have examined this topic suggest that racial/ethnic minority women often deliver in lower quality hospitals.[14,15] In our previous work investigating quality measures and severe maternal morbidity in New York City,[16] we found wide variation in hospital performance. The objective for this study was to examine whether variation in hospital performance on severe maternal morbidity in New York City hospitals contributes to black-white disparities in this outcome. We focus on the black-white severe maternal morbidity disparity, as black-white maternal mortality represents the largest disparity among all the conventional perinatal health measures and the mortality gap between black and white women in NYC has nearly doubled in recent years.[1,2]

MATERIALS AND METHODS

DATA SOURCE

We used Vital Statistics birth records linked with New York State discharge abstract data - The Statewide Planning and Research Cooperative System (SPARCS) for all delivery hospitalizations in New York City from 2011–2013. Data linkage was conducted by the New York State Department of Health and 98.8% of maternal discharge abstracts were linked with infant live birth certificates. Institutional Review Board approvals were obtained from the New York City Department of Health and Mental Hygiene, the New York State Department of Health, and the Icahn School of Medicine at Mount Sinai. Delivery hospitalizations were identified based on ICD-9-CM diagnosis and procedure codes and DRG delivery codes.[17] From linked records, four hospitals with annual delivery volumes less than five births and 1360 deliveries with missing hospital identifiers were excluded. The final sample included 353,773 deliveries at 40 hospitals.

SEVERE MATERNAL MORBIDITY

We used a published algorithm to identify severe maternal morbidity, using diagnoses for life-threatening conditions (e.g. renal failure, eclampsia) and procedure codes for life-saving procedures (e.g. hysterectomy, ventilation, blood transfusion) defined by investigators from the Centers for Disease Prevention and Controls (CDC).[5,18] As specified by the algorithm we excluded hospitalizations with a length of stay less than the 90th percentile as calculated separately for vaginal, primary, and repeat cesarean deliveries.[5] All severe maternal morbidity hospitalizations associated with in-hospital mortality and transfer as well as severe complications identified by procedure codes were included regardless of the length of stay, as recommended.[5] Transfers were defined as discharge disposition after delivery or source of admission for delivery as specified.[5]

COVARIATES

To risk-adjust hospital-level rates of maternal morbidity we used variables from the vital statistics records, including mothers' sociodemographic characteristics (maternal age, self-identified race and ethnicity, parity, education), prenatal care visits, and clinical and obstetric factors (multiple pregnancy, history of previous cesarean delivery, body mass index). New York City Vital Statistics collect self-identified race and ethnicity data. We ascertained patient insurance status from SPARCS. We also included diagnoses for patient risk factors that could lead to maternal morbidity but were likely present on admission to the hospital (e.g. diabetes, hypertension, obesity, premature rupture of membranes, disorders of placentation). These conditions have been used to risk-adjust for severe maternal morbidity,[19] cesarean deliveries, and other maternal outcomes.[16,20,21]

We obtained teaching status from the American Hospital Association, ownership and nursery level from the New York State Department of Health, and volume of deliveries in each hospital from SPARCS to assess how other hospital characteristics are correlated with severe maternal morbidity.

ANALYSIS

We compared the sociodemographic characteristics and clinical conditions of black and white women using Chi Square tests. We used mixed-effects logistic regression with a random hospital-specific intercept to generate risk-standardized severe maternal morbidity rates (SSMMR) for each hospital. The models included covariates described above. Hospital risk-standardized rates were computed from these models using methods recommended by Centers for Medicare and Medicaid Services (CMS) Hospital Compare.[16,22] These rates were the ratio of predicted to expected severe maternal morbidity rates, multiplied by the New York City average severe maternal morbidity rate. For each hospital, the numerator of the ratio is the number of severe maternal morbidity cases predicted on the bases of the hospital's performance with its case-mix, and the denominator is the number of severe maternal morbidity cases expected on the bases of the New York City performance with that hospital's case mix. We ranked hospitals from lowest to highest risk-standardized severe maternal morbidity rates. These analyses did not include hospital-level variables. We conducted a sensitivity analysis using observed to expected rates for hospital ranking and found that rankings differed very little between the CMS model and the standard observed to expected ratio. In addition, because blood transfusions are an important component of severe maternal morbidity, we examined the correlation between hospital rankings based on severe maternal morbidity with and without blood transfusion.

To assess racial disparities in the use of hospitals with the lowest morbidity rates, we calculated the cumulative distributions of births among hospitals ranked from the lowest to the highest standardized morbidity rate for black and white mothers. We used the Kolmogorov-Smirnov test to assess whether the distributions of deliveries among hospitals differed for white and black women.[23]

To address the effects on black severe maternal morbidity rates of these differences in delivery location, we conducted a thought experiment and asked what would happen if black mothers went to the same hospitals as white mothers? We used the same risk-standardized morbidity model and kept all individual patient characteristics the same. We calculated the predicted probability of morbidity for each black mother at each hospital. For each black mother, we took the weighted average of these probabilities, where weights were the percentage of white mothers who went to each hospital. The difference between the predicted probability at the hospital a black mother went to and the weighted average probability if the black mother delivered at the white mother's hospital is the decrease or increase in the probability of a morbid event. The sum of the difference in probabilities across all black women is the morbid events avoided if black mothers went to the same hospitals as white mothers, or the morbid events due to "between-hospital" disparities. A recent simulation study tested this approach against the more common approach of identifying "minority serving" facilities based on the percentage of black patients at a hospital and found that it more accurately measured the magnitude of between-hospital disparities, although both were successful at identifying the existence of disparities.[24]

To investigate the association between hospital characteristics and severe maternal morbidity rates, we estimated the mixed-effects logistic regression that included maternal sociodemographic and clinical factors as well as the hospital characteristics described above.

All statistical analysis was performed using the SAS system software version 9.3 (SAS Institute Inc, Cary, NC).

RESULTS

Black mothers accounted for 21% and white mothers for 32% of the 353,773 deliveries in New York City in 2011–2013. The remainder of the births were to Hispanics (29.9%), Asian/Pacific Islanders (16.7%) and others (1.6%). Table 1 shows the sociodemographic and clinical characteristics of black and white deliveries in our study sample. Severe maternal morbidity rates were higher among black (4.2%) as compared with white (1.5%) mothers. As shown in Table 1, maternal characteristics differed significantly between black and white women.

The majority of the 40 hospitals were private, had Level 3/4 nurseries, and were teaching hospitals.[16] The median percent of black deliveries was 18.4 (IQR 9.5–35.8%). Hospitals were ranked according to risk-standardized morbidity rates, using a model that included maternal sociodemographic and clinical characteristics associated with severe maternal morbidity (Table 2, model 1). Unadjusted severe morbidity rates ranged from 0.6% to 11.5% and risk standardized rates from 0.8% to 5.7% (Figure 1). The risk standardized morbidity rate for the highest morbidity tertile of hospitals was 3.8% compared with 1.5% for the lowest morbidity tertile ($p<0.001$). Hospital rankings based on severe maternal morbidity with and without blood transfusion were strongly correlated ($p<.0001$).

The cumulative distribution of deliveries among hospitals ranked from lowest to highest morbidity rates differed for black and white mothers ($p<0.001$). The majority of white deliveries (65.3%) occurred in the hospitals in the lowest tertile for severe morbidity compared with 23.3% of all black deliveries. Eighteen percent of white deliveries and 37.3% of black deliveries occurred at hospitals in the highest morbidity tertile (Figure 2).

If black mother mothers delivered in the same hospitals as white women, our simulation model estimated that they would experience 940 fewer severe morbid events, leading to a reduction of black severe maternal morbidity rates by 47.7% from 4.2 to 2.9 (1.3 events per 100 deliveries per year)

Results of our model fitting for severe maternal morbidity rates using maternal and hospital-level variables revealed that teaching status, Level 3/4 nursery, private ownership, and very high volume status were associated with lower severe maternal morbidity rates, but did not fully account for the excess risk among black women.(Table 2, model 2)

COMMENT

Black women are more likely to deliver in New York City hospitals with higher risk-adjusted severe maternal morbidity rates. Severe maternal morbidity rates vary six fold across New York City hospitals. Our data demonstrate that racial differences in the distribution of deliveries may contribute to the black/white disparity in severe maternal morbidity rates in New York City Hospitals. If black women delivered at the same hospitals as white women

our results suggest that nearly 1000 black women could avoid a severe morbid event during their delivery hospitalization annually in New York City.

While much of the focus on reducing racial disparities in obstetrics examines social determinants of health, our results highlight the need to address quality of care as an additional means to reduce racial disparities. Data suggest over one-third of maternal deaths and severe events are preventable. [6–9] Current efforts by the American College of Obstetricians and Gynecologists District II, Merck for Mothers, and the New York State Department of Health have made major efforts to standardize care on labor and delivery units and enhance quality.[25–28] Data in obstetrics suggest that team building, specific clinical protocols, and improved communication are important targets for quality improvement in the setting of obstetrics and can improve outcomes.[27] Our findings suggest quality improvement efforts targeting the lowest performing hospitals may both lower severe maternal morbidity rates for all mothers and narrow the black-white morbidity gap.

Our findings are consistent with a recent study using national data on delivery hospitalizations which found that blacks deliver in a concentrated set of hospitals and these hospitals have higher risk-adjusted severe maternal morbidity rates.[14] Unlike this previous study, the current population-based study used a simulation method to quantify the impact of delivery location on the disparity. Others have also found that black-serving hospitals performed worse than other hospitals on delivery-related indicators using data from seven states.[15] In pediatrics, investigators have found that black very low birth weight babies are more likely to be delivered in higher risk-adjusted very low birthweight neonatal mortality hospitals and in other areas of medicine including stroke and heart attack care, studies have documented that black and white patients are treated at different sites of care and black patients are often treated at higher mortality hospitals.[12,13,29,30] Why hospitals that have a greater proportion of black deliveries experience higher risk-adjusted severe maternal morbidity is not known. Teaching status, level of nursery, volume, and ownership were associated with severe maternal morbidity rates in New York City hospitals but did not fully account for the excess risk among black women.

The reasons why women deliver at specific hospitals is complex and may be related to a number of factors, including where a patient lives, distance to the hospital, patterns of racial segregation, physician referral, risk perception, patient choice, access, insurance, and the management of possible medical emergencies during pregnancy.[12,31] Previous studies examining delivery hospital and distance in the setting of very low birth weight births found that distance did not explain why black women were more likely to deliver at higher risk-adjusted neonatal mortality hospitals.[31] The extent to which other factors contributed to site of delivery in this study could not be fully evaluated.

Our analysis has some limitations. We used administrative data (ICD-9 procedure and diagnosis codes) that do not contain important clinical data on severity of illness. Both vital statistics and SPARCS have limitations with reliability of specific variables.[32,33] We used a published algorithm to identify severe maternal morbidity cases and did not conduct a medical chart review for case ascertainment. Nevertheless we conducted a population-based study and were able to construct a robust risk-adjustment model that included important

confounders available in our linked data set (e.g. maternal education, parity, body mass index). We used a simulation model and estimated the extent to which differences in the distribution of deliveries may contribute to disparities. However, similar to others, we were unable to account for unmeasured factors that are associated with both race and severe maternal morbidity. Further, we assumed that unmeasured factors such as social risk are conditionally independent of hospital choice and do not impact choice of hospital after adjusting for a patient's measured factors, such as race, education, and insurance. If this assumption is false, our simulation results could exaggerate the role of hospital in black-white severe maternal morbidity disparities. In other words, we would attribute higher rates of severe maternal morbidity to the hospital when some of the excess risk should be attributed to the social risk or other characteristics of the patient population. We focused on black-white differences in distribution of deliveries given the significant increase in maternal mortality among black women in New York City.[1]

We found that differences in the hospitals in which black and white women deliver contribute to the disparity in severe maternal morbidity rates between blacks and whites in New York City hospitals. The increasing excess of maternal deaths and high rate of severe morbid events among black women in New York City are concerning. Our data suggests that efforts to improve care at the lowest performing hospitals may be an important step to reduce these disparities

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Appendix A. Severe maternal morbidity events and race distribution among hospitals with low (tertile 1) and high (tertile 3) severe maternal morbidity

	Tertile 1, N (%)	Tertile 3, N (%)	P-Value
Deliveries	165276 (100)	87712 (100)	
Death[1]	<10 (<0.01)	12 (0.01)	0.03
Transfers	345 (0.21)	457 (0.52)	<0.001
Hysterectomy	222 (0.13)	158 (0.18)	0.005
Ventilation	118 (0.07)	147 (0.17)	<0.001
Renal Failure	103 (0.06)	141 (0.16)	<0.001
Cardiac Arrest[1]	<10 (<0.01)	<10 (<0.01)	1
Heart Failure Procedure	333 (0.2)	452 (0.52)	<0.001
Shock	72 (0.04)	73 (0.08)	<0.001
Sepsis	47 (0.03)	43 (0.05)	0.009
Coagulation	461 (0.28)	450 (0.51)	<0.001
Amniotic Embolism[1]	<10 (0.01)	<10 (<0.01)	0.07
Thrombotic Embolism	26 (0.02)	59 (0.07)	<0.001
Puerperal CVD	54 (0.03)	70 (0.08)	<0.001
Anesthesia Complications	35 (0.02)	37 (0.04)	0.003
Pulmonary Edema	43 (0.03)	43 (0.05)	0.003
Respiratory Distress	85 (0.05)	101 (0.12)	<0.001
AMI[1]	<10 (<0.01)	<10 (<0.01)	0.42
Eclampsia	40 (0.02)	71 (0.08)	<0.001
Blood Transfusion	1686 (1.02)	3201 (3.65)	<0.001
Sickle Cell Anemia	23 (0.01)	31 (0.04)	<0.001
Intracranial Injury[1]	<10 (<0.01)	<10 (<0.01)	0.35
Injury Thorax/Abdomen/Pelvis[1]	<10 (<0.01)	<10 (<0.01)	0.12
Aneurysm[1]	<10 (<0.01)	<10 (<0.01)	1
Heart Surgery	86 (0.05)	95 (0.11)	<0.001
Cardio monitoring[1]	<10 (<0.01)	<10 (<0.01)	1

	Tertile 1, N (%)	Tertile 3, N (%)	P-Value
Tracheostomy[1]	<10 (<0.01)	<10 (<0.01))	1
Conversion cardiac rhythm	12 (0.01)	12 (0.01)	0.13
Severe Maternal Morbidity	2253 (1.4)	3862 (4.4)	<0.001
Race/Ethnicity[2]			
Asian	38640 (23.4)	8175 (9.3)	<0.001
Black	16936 (10.3)	27164 (31.0)	
Hispanic	35004 (21.2)	30883 (35.2)	<0.001
White	71993 (43.6)	19776 (22.6)	
Other race	2703 (1.6)	1714 (1.9)	

[1]Number of events masked in the compliance with SPARCS regulations

[2]NOTE: differs from percentage given in the manuscript, which measures the percent of black and white women that deliver in each tertile.

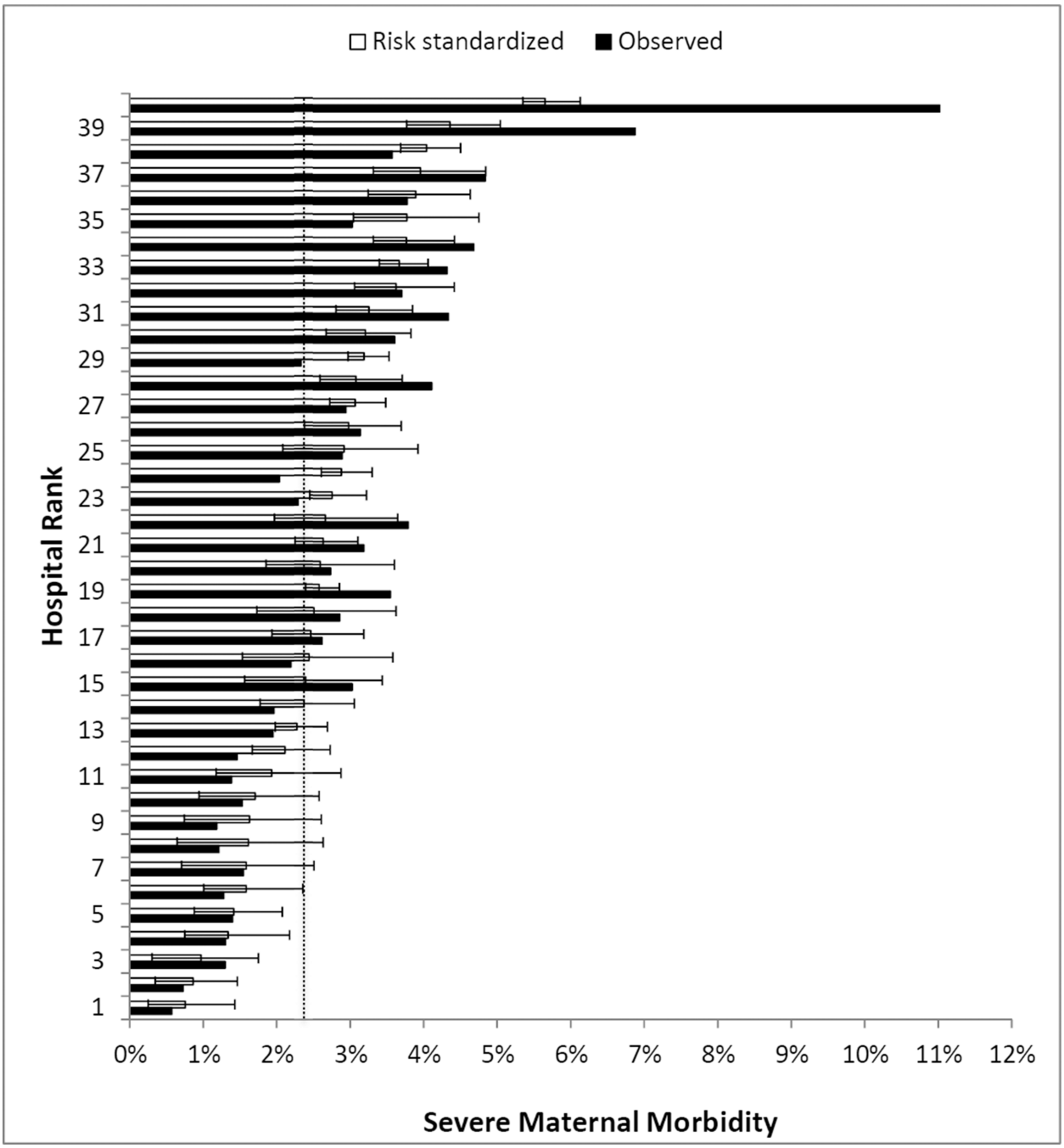

Figure 1.

Observed and Risk-Standardized Severe Maternal Morbidity Rates in New York City Hospitals. Dotted line shows NYC mean observed severe maternal morbidity. 95% CL for risk standardized SMM is shown.

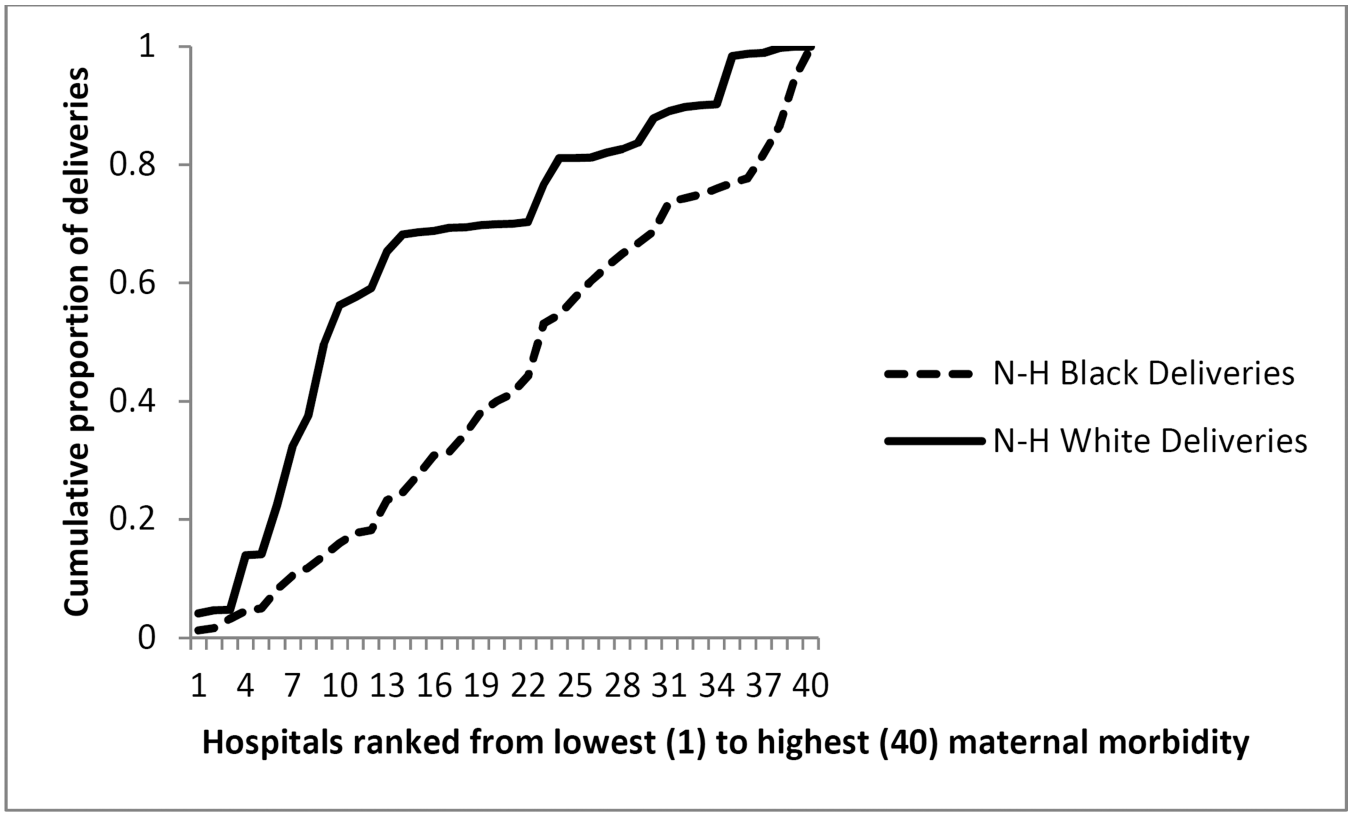

Figure 2.
Cumulative distributions of deliveries according to hospital, ranked from lowest to highest morbidity ratio, for non-Hispanic (N-H) white mothers and non-Hispanic black mothers.

Table 1

Socio-demographic, Clinical and Hospital Characteristics of Deliveries by Race and Ethnicity in New York City Hospitals

	Black		White		P value
	N	%	N	%	
Deliveries	72849	100.00	110200	100.00	
Maternal Age					<.0001
<20	5207	7.15	1341	1.22	
20–29	34815	47.79	37812	34.31	
30–34	17859	24.52	38161	34.63	
35–39	11159	15.32	25135	22.81	
40–44	3477	4.77	7079	6.42	
45+	332	0.46	672	0.61	
Ancestry					<.0001
US Born	42189	57.91	79935	72.54	
Foreign Born	30660	42.09	30265	27.46	
Pre-pregnancy body mass index					<.0001
Underweight (<18.5)	2632	3.61	6549	5.94	
Normal weight (18.5–24.9)	27782	38.14	73017	66.26	
Overweight (25.0–29.9)	21231	29.14	20234	18.36	
Obese (30.0–39.9)	17212	23.63	9006	8.17	
Morbid Obesity (≥40)	3407	4.68	1120	1.02	
Missing BMI	585	0.80	274	0.25	
Smoked during pregnancy	2673	3.67	2573	2.33	<.0001
Alcohol use during pregnancy	1141	1.57	1220	1.11	<.0001
Maternal Education					<.0001
Less than HS	14606	20.05	8726	7.92	
HS	19614	26.92	20612	18.70	
Greater than HS	38232	52.48	80620	73.16	
Missing or unknown	397	0.54	242	0.22	
Insurance					<.0001
Commercial	18299	25.12	70105	63.62	
Medicaid	52683	72.32	38532	34.97	

	Black		White		P value
	N	%	N	%	
Other	607	0.83	815	0.74	
Uninsured	1260	1.73	748	0.68	
Prenatal visits					<.0001
0–5	8623	11.84	3737	3.39	
6–8	11508	15.80	11052	10.03	
≥9	51658	70.91	94833	86.06	
Unknown	1060	1.46	578	0.52	
Parity					<.0001
Nulliparous	41033	56.33	58308	52.91	
Multiparous	31698	43.51	51746	46.96	
Missing	118	0.16	146	0.13	
Type of Pregnancy					<.0001
Singleton	71359	97.95	107165	97.25	
Multiple	1490	2.05	3035	2.75	
Previous Cesarean Comorbidities	13031	17.89	15959	14.48	<.0001
Cardiac Disease	310	0.43	616	0.56	<.0001
Renal Disease	68	0.09	49	0.04	<.0001
Musculoskeletal Disease	225	0.31	341	0.31	0.98
Digestive Disorder	17	0.02	269	0.24	<.0001
Blood Disease	10557	14.49	9013	8.18	<.0001
Mental Disorders	3032	4.16	3364	3.05	<.0001
CNS disease	905	1.24	1310	1.19	0.31
Rheumatic Heart Disease	57	0.08	33	0.03	<.0001
Disorder Placentation	1600	2.20	1599	1.45	<.0001
Chronic Hypertension	2222	3.05	807	0.73	<.0001
Pregnancy Hypertension	7576	10.40	4411	4.00	<.0001
Lupus	147	0.20	117	0.11	<.0001
Collagen Vascular Disorder	24	0.03	72	0.07	0.003
Rheumatoid Arthritis	61	0.08	149	0.14	0.0015
Diabetes	1200	1.65	585	0.53	<.0001

	Black		White		P value
	N	%	N	%	
Gestational diabetes	4455	6.12	3534	3.21	<.0001
Asthma/Chronic bronchitis	5671	7.78	3174	2.88	<.0001
Delivery method					<.0001
Cesarean Delivery	27671	37.98	31405	28.50	
Vaginal delivery	45178	62.02	78795	71.50	
Hospital Characteristics					
Hospital Ownership					<.0001
Public	19595	26.90	3574	3.24	
Private	53254	73.10	106626	96.76	
Teaching Status					<.0001
Not Teaching	1237	1.70	1200	1.09	
Teaching	71612	98.30	109000	98.91	
Nursery Level					<.0001
Level 2	5725	7.86	7219	6.55	
Level 3–4	67124	92.14	102981	93.45	
Delivery Volume					<.0001
Low	12464	17.11	3143	2.85	
Medium	21473	29.48	4203	3.81	
High	17228	23.65	22954	20.83	
Very High	21684	29.77	79900	72.50	

Table 2

	Model 1: Without Hospital Characteristics Odds Ratio (95% CI)	P value	Model 2: With Hospital Characteristics Odds Ratio (95% CI)	P value
Maternal Age				
<20	1.20 (1.09–1.33)		1.19 (1.07–1.31)	0.05
20–34	Reference		Reference	
35–39	1.20 (1.13–1.27)	0.02	1.21 (1.14–1.29)	0.03
40–44	1.41 (1.29–1.55)	0.06	1.42 (1.30–1.57)	0.04
>45	1.84 (1.45–2.34)	<0.001	1.85 (1.46–2.35)	<.001
Maternal race/ethnicity				
Hispanic	1.52 (1.42–1.63)	0.01	1.40 (1.31–1.51)	
Non-Hispanic black	2.02 (1.89–2.17)	<0.001	1.82 (1.69–1.95)	<.001
Non-Hispanic white	Reference		Reference	
Asian	1.08 (0.99–1.18)	<0.001	1.09 (0.99–1.18)	0.002
Other	1.31 (0.85–2.04)	0.91	1.43 (1.31–1.51)	0.90
Maternal nativity				
Born in the US	0.97 (0.92–1.01)	0.16	0.97 (0.93–1.02)	0.28
Foreign born	Reference		Reference	
Maternal Education				
Less than HS *	1.12 (1.05–1.19)	0.01	1.08 (1.008–1.15)	0.07
HS	1.02 (0.96–1.09)	<0.001	1.00 (0.94–1.06)	<.001
Greater than HS	Reference		Reference	
Insurance				
Commercial	Reference		Reference	
Uninsured	1.27 (1.05–1.53)	0.08	1.11 (0.92–1.35)	0.43
Medicaid	1.12 (1.05–1.19)	0.80	1.01 (0.95–1.08)	0.41
Other	1.06 (0.82–1.37)	0.65	1.07 (0.83–1.38)	0.84
Prenatal visits				
0–5	1.42 (1.31–1.52)	<0.001	1.34 (1.24–1.45)	0.004
6–8	1.19 (1.12–1.27)	0.30	1.16 (1.09–1.24)	0.31
≥9	Reference		Reference	
Unknown	1.38 (1.13–1.69)	0.14	1.35 (1.11–1.65)	
Parity				
Nulliparous	Reference		Reference	
Multiparous	0.96 (0.94–0.98)	<0.001	0.96 (0.94–0.98)	<.001
Type of Pregnancy				
Singleton	Reference		Reference	
Multiple	3.04 (2.76–3.34)	<0.001	3.06 (2.78–3.37)	<.001
Pre-pregnancy body mass index				
Underweight (<18.5)	1.06 (0.95–1.18)	0.75	0.96 (0.94–0.98)	0.49
Normal weight (18.5–24.9)	Reference		Reference	

	Model 1: Without Hospital Characteristics Odds Ratio (95% CI)	P value	Model 2: With Hospital Characteristics Odds Ratio (95% CI)	P value
Overweight (25.0–29.9)	0.99 (0.94–1.05)	0.15	0.98 (0.93–1.04)	0.15
Obese (30.0–39.9)	0.96 (0.90–1.02)	0.01	0.94 (0.88–1.004)	0.01
Morbid obese (≥40)	1.13 (1.001–1.28)	0.12	1.11 (0.98–1.25)	0.16
Missing	1.14 (0.87–1.43)	0.52	1.08 (0.84–1.38)	0.66
Smoked during pregnancy	0.93 (0.81–1.06)	0.28	0.92 (0.94–0.98)	0.19
Alcohol use during pregnancy	1.16 (0.99–1.35)	0.07	1.11 (0.95–1.3)	0.21
Previous Cesarean	2.27 (2.16–2.39)	<0.001	2.29 (2.18–2.41)	<.001
Comorbidity				
Cardiac	2.90 (2.36–3.94)	<0.001	2.91 (2.36–3.59)	<.001
Musculoskeletal	2.72 (0.96–7.72)	0.06	2.58 (0.91–7.28)	0.07
Digestive	1.19 (0.57–2.48)	0.64	1.19 (0.57–2.48)	0.64
Blood disorder	3.75 (3.56–3.94)	<0.001	3.73 (3.55–3.91)	<.001
Mental disorder	1.40 (1.26–1.55)	<0.001	1.38 (1.25–1.53)	<.001
CNS	1.37 (1.15–1.62)	<0.001	1.37 (1.16–1.62)	<.001
Rheumatic heart	2.97 (1.81–4.86)	<0.001	2.88 (1.76–4.73)	<.001
Disorder of placentation	6.64 (6.13–7.19)	<0.001	6.57 (6.07–7.12)	<.001
Chronic Hypertension	1.34 (1.17–1.54)	<0.001	1.32 (1.15–1.51)	<.001
Pregnancy hypertension	2.95 (2.78–3.13)	<0.001	2.9 (2.73–3.08)	<.001
Lupus	0.92 (0.32–2.64)	0.88	0.97 (0.34–2.76)	0.96
Collagen/vascular	0.45 (0.14–1.52)	0.2	0.46 (0.34–2.76)	0.21
Rheumatoid arthritis	0.48 (1.16–1.47)	0.2	0.51 (0.17–1.55)	0.23
Diabetes	1.27 (1.08–1.49)	0.004	1.26 (1.08–1.48)	0.004
Pregnancy diabetes	1.21 (1.11–1.32)	<0.001	1.17 (1.08–1.28)	<.001
Asthma/chronic pulmonary	1.05 (0.96–1.15)	0.28	1.05 (0.96–1.15)	0.25
Hospital Characteristics[1]				
Hospital Ownership				
Public			1.12 (1.06–1.19)	<.001
Private			Reference	
Teaching Status				
Not Teaching			Reference	
Teaching			0.66 (0.55–0.79)	<.001
Nursery Level				
Level 2			1.27 (1.22–1.33)	<.001
Level 3–4			Reference	
Delivery Volume[3]				
Low			1.69 (1.54–1.85)	<.001
Medium			1.53 (1.42–1.65)	<.001
High			1.32 (1.23–1.41)	0.16
Very High			Reference	

[*] HS – High school