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Differences in Morbidity and Mortality Rates in Black, White, and Hispanic Very Preterm Infants Among New York City Hospitals

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IMPORTANCE Substantial quality improvements in neonatal care have occurred over the past decade yet racial and ethnic disparities in morbidity and mortality remain. It is uncertain whether disparate patterns of care by race and ethnicity contribute to disparities in neonatal outcomes.

OBJECTIVES To examine differences in neonatal morbidity and mortality rates among non-Hispanic black (black), Hispanic, and non-Hispanic white (white) very preterm infants and to determine whether these differences are explained by site of delivery.

DESIGN, SETTING, AND PARTICIPANTS Population-based retrospective cohort study of 7177 nonanomalous infants born between 24 and 31 completed gestational weeks in 39 New York City hospitals using linked 2010 to 2014 New York City discharge abstract and birth certificate data sets. Mixed-effects logistic regression with a random hospital-specific intercept was used to generate risk-adjusted neonatal morbidity and mortality rates for very preterm infants in each hospital. Hospitals were ranked using this measure, and differences in the distribution of black, Hispanic, and white very preterm births were assessed among these hospitals. The statistical analysis was performed in 2016-2017.

EXPOSURE Race/ethnicity.

MAIN OUTCOMES AND MEASURES Composite of mortality (neonatal or in-hospital up to 1 year) or severe neonatal morbidity (bronchopulmonary dysplasia, severe necrotizing enterocolitis, retinopathy of prematurity stage 3 or greater, or intraventricular hemorrhage grade 3 or greater).

RESULTS Among 7177 very preterm births (VPTBs), morbidity and mortality occurred in 2011 (28%) and was higher among black (893 [32.2%]) and Hispanic (610 [28.1%]) than white (319 [22.5%]) VPTBs (2-tailed $P < .001$). The risk-standardized morbidity and mortality rate was twice as great for VPTB infants born in hospitals in the highest morbidity and mortality tertile (0.40; 95% CI, 0.38-0.41) as for those born in the lowest morbidity and mortality tertile (0.16; 95% CI, 0.14-0.18). Black (1204 of 2775 [43.4%]) and Hispanic (746 of 2168 [34.4%]) VPTB infants were more likely than white (325 of 1418 [22.9%]) VPTB infants to be born in hospitals in the highest morbidity and mortality tertile (2-tailed $P < .001$; black-white difference, 20%; 95% CI, 18%-23% and Hispanic-white difference, 11%; 95% CI, 9%-14%). The largest proportion of the explained disparities can be attributed to differences in infant health risks among black, Hispanic, and white VPTB infants. However, 40% (95% CI, 30%-50%) of the black-white disparity and 30% (95% CI, 10%-49%) of the Hispanic-white disparity was explained by birth hospital.

CONCLUSIONS AND RELEVANCE Black and Hispanic VPTB infants are more likely to be born at hospitals with higher risk-adjusted neonatal morbidity and mortality rates, and these differences contribute to excess morbidity and mortality among black and Hispanic infants.

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Substantial improvements in neonatal care have been documented over the past decade.[1] From 2005 to 2014, rates of death before discharge and serious morbidities decreased among neonatal intensive care units (NICUs) in the United States; by 2014, most NICUs achieved rates of performance equivalent to the best quartile of the 2005 benchmark.[1,2] In fact, 98% of NICUs achieved the risk-adjusted rate of mortality of the best 10% of units in 2005.[2] Despite these improvements, wide variation in mortality and serious morbidities exist across NICUs.[1,3,4]

Although rates of death have decreased, persistent racial/ethnic neonatal mortality disparities exist, with non-Hispanic black neonates dying at more than twice the rate of non-Hispanic white neonates and Puerto Rican neonates also having an elevated risk of death.[5] Limited research also suggests that, compared with non-Hispanic white preterm infants, non-Hispanic black and Hispanic preterm infants are at increased risk for severe neonatal morbidities, such as necrotizing enterocolitis,[6] intraventricular hemorrhage,[7] retinopathy of prematurity,[7] and bronchopulmonary dysplasia.[8] Disparities in these morbidities are associated with later neurodevelopmental disabilities, placing very preterm birth (VPTB) infants at a disadvantage over the life course.[3,9]

Data from the early 2000s document wide variation in very preterm neonatal outcomes across hospitals and showed that non-Hispanic black infants were more likely to be born in hospitals with poorer neonatal outcomes.[10,11] Risks of morbidity have also been related to hospital factors and suggest that quality of care contributes to variation across hospitals.[12] The extent to which these variations contribute to racial/ethnic disparities in neonatal mortality and morbidity is not known.

Given the quality-improvement trajectory over the past decade, we wondered whether disparate patterns of care by race and ethnicity were still apparent, whether hospital performance varied for both serious very preterm morbidities and mortality, and about the extent to which variations in hospital performance contributed to disparities in care for non-Hispanic black, Hispanic, and non-Hispanic white very preterm infants. Our objectives were to (1) measure risk-adjusted neonatal morbidity and mortality rates for VPTBs in New York City hospitals; (2) assess whether non-Hispanic black, Hispanic, and non-Hispanic white births occur at hospitals with different risk-adjusted neonatal morbidity and mortality rates; and (3) determine whether differences in site of care by race/ethnicity contribute to excess morbidity and mortality events.

Key Points

Question Do differences in where non-Hispanic black, Hispanic, and non-Hispanic white very preterm infants are born contribute to racial and ethnic disparities in morbidity and mortality?

Findings In a population-based cohort study including 7177 very preterm infants born in 39 New York City hospitals, hospital rates of risk-standardized very preterm birth morbidity and mortality varied widely, and non-Hispanic black and Hispanic infants were more likely than non-Hispanic white infants to be born in hospitals with the highest risk-standardized rates of morbidity and mortality. These differences in hospital of birth explained 39.9% of the black-white disparity and 29.5% of the Hispanic-white disparity in outcomes.

Meaning Poor performance at hospitals where non-Hispanic black and Hispanic mothers deliver is an important and modifiable cause of racial disparities in neonatal outcomes.

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),[13] for all live births in New York City hospitals in years 2010 through 2014. The New York State Department of Health linked the data by using a probabilistic linking method, and 99.9% of infant discharge abstracts were linked with infant birth certificates. The linkage rate with maternal discharge abstracts was 96%. The linked data set included birth data, death data, and SPARCS record for all infants born between 2010 and 2014 who were discharged by December 31, 2014, and all deaths from 2010 to 2015. The linked data set comprised 596 295 births in 41 hospitals. We excluded births from 1 hospital that was not open for most of the study period, leaving 595 835 births in 40 hospitals. Additional maternal procedures and diagnosis codes were merged from a separate linked birth-maternal SPARCS data set after selecting the study cohort described below. 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. We received a waiver of informed consent from the Icahn School of Medicine at Mount Sinai.

Cohort Selection

We created a VPTB cohort of 8311 infants born from 24 to 31 completed weeks of gestation. We excluded infants with congenital anomalies and infants born in 1 hospital with a total volume of VPTB infants that did not meet our inclusion criterion of more than 25 for 2010 through 2014 (n = 11). The final cohort for analysis was 7177 infants in 39 hospitals. For infants transferred before death (n = 522), mortality was attributed to the hospital of birth. Neonatal morbidities after transfer were not included in our data set.

Outcome Variable

Our outcome variable was a combined measure of neonatal mortality and severe neonatal morbidity. Neonatal mortality was defined as death up to but not including 28 days, or within 1 year if continuously hospitalized. Severe neonatal morbidity was defined by the presence in the infant hospital record of the *International Classification of Diseases, Ninth Revision* code for any of the following diagnoses or procedures: bronchopulmonary dysplasia, necrotizing enterocolitis (unspecified, stage 2 or 3, laparotomy), retinopathy of prematurity (stage 3, 4, or 5), and intraventricular hemorrhage (grade 3 or 4) (eTable 1 in the Supplement).[14]

Covariates

We obtained maternal sociodemographic characteristics from the birth certificate, including race, ethnicity, maternal educational level, nativity, and age. We created a race/ethnicity variable by combining the race and information on Hispanic ethnicity into the following categories: non-Hispanic black, Hispanic, non-Hispanic white, Asian, and other. For this analysis, we refer to non-Hispanic black as *black* and non-Hispanic white as *white*. Maternal morbidities were ascertained using a combination of the mother's SPARCS record and birth certificate to maximize sensitivity of our measures (eTable 2 in the Supplement).[15,16] We used the clinical estimate of gestational length in weeks and birth weight from the birth certificate. Congenital anomalies were identified using diagnosis codes from the infant's SPARCS record (eTable 3 in the Supplement).[17] Similar to other models on neonatal mortality rates,[10] we adjusted for the mother's sociodemographic characteristics (age, race, nativity, educational level, and insurance), maternal behaviors (tobacco, alcohol, and drug use during pregnancy and prenatal care visits), maternal medical risk factors (parity, comorbidities, pregnancy complications, and body mass index), and infant factors (multiple birth, sex, birth weight, gestational age, Apgar score at 1 minute, and delivery method). Missing values for each variable were included as dummy variables in the model and ranged from 0.3% to 3.7%. The exception was delivery type; 7 observations were missing and therefore were excluded from the analysis.

Statistical Analysis

We conducted a bivariate analysis of maternal and infant covariates with neonatal morbidity and mortality using χ^2 tests. We used mixed-effects logistic regression with a random hospital-specific intercept to generate risk-standardized neonatal morbidity and mortality rates for each hospital. The covariates for risk adjustment were maternal sociodemographic characteristics, including race/ethnicity, medical, and obstetric factors, as well as infant factors occurring before birth (**Table 1**). Because birth weight and gestational age are collinear, we calculated a *z* score of birth weight for gestational age using the 2010 US birth weight standard by sex.[18] We then included gestational age and *z* score as risk-adjustment covariates. Hospital risk-standardized rates were computed from this model by using methods recommended by Hospital Compare.[19] These rates were the ratio of predicted to expected neonatal morbidity and mortality rates multiplied by the sample mean neonatal morbidity and mortality rate. For each hospital, the numerator of the ratio is the predicted number of neonatal morbidity cases and deaths based on the hospital's performance with its case mix, and the denominator is the expected number of cases and deaths based on the New York City performance with that hospital's case mix. We then ranked hospitals from lowest to highest risk-standardized neonatal morbidity and mortality. We conducted sensitivity analyses of hospital rankings by repeating the analysis as follows: (1) with neonatal mortality only as the outcome; (2) within the cohort of very low-birth-weight infants based on 6594 infants with a birth weight from 500 to 1499 g; and (3) after excluding the Apgar score from the risk-adjustment model. Because our data did not include morbidities after an infant was transferred to another hospital or care facility and because transferred infants differed from nontransferred infants with regard to morbidity and mortality, we also conducted a fourth sensitivity analysis after excluding hospitals with level 2 nurseries because the hospitals that transferred a substantial proportion (>20%) of infants were all level 2 nurseries.

To assess racial/ethnic disparities in the use of hospitals, we used the Kolmogorov-Smirnov test to assess whether the distributions of VPTB infants among hospitals differed by racial and ethnic group.[20] We used χ^2 tests to compare the percentage of black, Hispanic, and white VPTB infants in the highest morbidity and mortality tertile of hospitals (defined by the number of hospitals in each group). We then explored interactions between maternal race/ethnicity and hospital morbidity and mortality tertile by comparing risk-adjusted neonatal morbidity and mortality rates by race/ethnicity in hospitals in the low-, middle-, and high-morbidity and mortality tertiles.

We also assessed how maternal and infant characteristics and choice of delivery hospital contributed to the observed ethnic disparities in neonatal morbidity and mortality rates. We grouped mothers' characteristics into those representing health risks (age, parity, delivery type, smoking status, body mass index, pregnancy complications, and comorbidities) and socioeconomic status (educational level, insurance, and an indicator for non-US born). Infant characteristics included birth weight, gestational age, sex, and multiple pregnancies. We used methods described by Fairlie et al[21] to assess the contribution of each of these 4 factors to disparities in neonatal morbidity and mortality. Briefly, these methods involved (1) taking a random sample of black mothers equal in number to the sample of white mothers; (2) matching the sampled black mothers to white mothers based on the predicted probability of morbidity and mortality from the first logit model described above, with dummy variables included for each hospital; (3) sequentially replacing each black mother's characteristics, including choice of hospital, with the matched white mother's characteristics for each of the mother, infant, and hospital choice characteristics; and (4) predicting morbidity and mortality for each black mother with these new sets of variables. Because the results of these steps depend on the sample of black mothers chosen and the sequence by which white mother, infant, and hospital characteristics are substituted for black mother characteristics, this process was repeated 500 times, taking a different sample of black mothers and a different sequence for substituting variables with each iteration and calculating the mean of the results.

A *P* value of .05 was set a priori to denote statistical significance. All *P* values were 2-sided. Statistical analyses were performed using SAS software, version 9.4 (SAS Institute Inc) or Stata, version 14 (StataCorp).

Results

Maternal and Infant Demographic Characteristics

Of 595 835 births, black infants accounted for 20.8% (n = 123 739), Hispanic infants for 30.3% (n = 180 340), and

Table 1. Sample Characteristics and Risk of Neonatal Morbidity or Mortality Among Very Preterm Birth Infants, New York City, NY, 2010-2014

Variable	Total No.	Died <28 d (or <365 d if Continuously Hospitalized) or Neonatal Morbidity From Birth to Discharge, No. (%)[a]	χ^2 *P* Value	Died <28 d (or <365 d if Continuously Hospitalized), No. (%)	χ^2 *P* Value	Any Severe Morbidity, No. (%)	χ^2 *P* Value
Total[b]	7177	2011 (28.0)		570 (7.9)		1597 (22.5)	
Mother's race/ethnicity[b]							
Non-Hispanic black	2775	893 (32.2)	<.001	232 (8.4)	.43	721 (26.0)	<.001
Hispanic	2168	610 (28.1)		164 (7.6)		500 (23.1)	
Non-Hispanic white	1418	319 (22.5)		102 (7.2)		239 (16.9)	
Asian	776	178 (22.9)		67 (8.6)		129 (16.6)	
Birth weight, g							
<750	969	731 (68.5)	<.001	335 (31.4)	<.001	485 (45.4)	<.001
750-999	1463	631 (43.10		125 (8.5)		549 (37.5)	
1000-1249	1440	348 (24.2)		52 (3.6)		311 (21.6)	
1250-1499	1426	161 (11.3)		26 (1.8)		142 (10.0)	
1500-1999	1481	117 (7.9)		22 (1.5)		96 (6.5)	
2000-2499	173	11 (6.4)		≤10		≤10	
≥2500	126	12 (9.5)		≤10		≤10	
Gestational age, wk			<.001		<.001		<.001
24-25	1055	720 (68.3)	<.001	313 (29.7)	<.001	491 (30.8)	<.001
26-27	1359	630 (46.4)		138 (10.2)		531 (39.1)	
28-29	1348	431 (24.2)		78 (4.4)		378 (21.3)	
30-31	2754	230 (7.7)		41 (1.4)		197 (6.6)	
Mother's age, y							
<20	395	110 (27.9)	.04	42 (10.6)	.18	84 (21.3)	.06
20-34	3409	1402 (29.1)		382 (7.9)		1117 (23.2)	
35-39	1080	361 (25.1)		105 (7.3)		290 (20.1)	
40-44	341	120 (26.1)		≤10		95 (20.7)	
≥45	52	18 (25.7)		≤10		11 (15.7)	
Mother's educational level[b]					<.001		
Less than high school	1642	464 (28.2)	.004	138 (8.4)	<.001	367 (22.4)	.26
High school	1677	520 (31.0)		162 (9.7)		401 (23.9)	
More than high school	3805	1008 (26.5)		262 (6.7)		817 (21.5)	
Mother's insurance			<.001				
Private	2522	643 (25.5)	<.001	365 (8.4)	.03	1008 (23.3)	.04
Uninsured	189	60 (31.8)		22 (11.6)		43 (22.8)	
Medicaid	4328	1266 (29.3)		172 (6.8)		513 (20.3)	
Other	138	42 (30.4)		11 (7.8)		33 (23.9)	
Prenatal visits[b]			<.001		<.001		<.001
0-5	2034	742 (35.6)	<.001	211 (10.4)	<.001	560 (27.5)	<.001
6-8	2059	617 (30.1)		154 (7.5)		515 (25.0)	
≥9	2816	581 (20.6)		176 (10.8)		451 (16.0)	
No. of births			<.001				
Singleton	5329	1553 (29.1)	<.001	436 (8.2)	.20	1234 (23.2)	.002
Multiple	1848	458 (24.8)		134 (7.3)		363 (19.6)	
Smoked during pregnancy							
Yes	283	79 (27.9)	.97	22 (7.8)	.92	61 (21.6)	.77
Used alcohol during pregnancy	56	12 (21.4)	.27	≤10		≤10	
Used drugs during pregnancy	82	26 (31.7)	.45	≤10		≤10	
Apgar score at 1 min			<.001		<.001		<.001
0-2	687	404 (58.8)	<.001	241 (35.1)	<.001	208 (30.3)	<.001
3-6	2379	682 (36.2)		216 (9.1)		712 (29.9)	
7-10	4090	739 (18.1)		110 (2.7)		674 (16.5)	

(continued)

Table 1. Sample Characteristics and Risk of Neonatal Morbidity or Mortality Among Very Preterm Birth Infants, New York City, NY, 2010-2014 (continued)

Variable	Total No.	Died <28 d (or <365 d if Continuously Hospitalized) or Neonatal Morbidity From Birth to Discharge, No. (%)[a]	χ^2 *P* Value	Died <28 d (or <365 d if Continuously Hospitalized), No. (%)	χ^2 *P* Value	Any Severe Morbidity, No. (%)	χ^2 *P* Value
Sex							
Male	3746	1090 (29.1)	.03	327 (8.7)	.01	848 (22.6)	.41
Female	3431	921 (26.8)		243 (7.1)		749 (21.8)	
Type of delivery							
Vaginal	2197	576 (26.2)	.02	168 (7.7)	.54	463 (21.1)	.11
Cesarean	4980	1435 (28.8)		402 (8.1)		1134 (22.8)	
BMI[b]			<.001				
Underweight (<18.5)	331	69 (20.9)	<.001	15 (4.5)	.05	56 (16.9)	<.001
Normal weight (18.5-24.9)	3200	830 (25.9)		252 (7.9)		650 (20.3)	
Overweight (25.0-29.9)	1822	557 (30.6)		160 (8.8)		433 (23.8)	
Obese (30.0-39.9)	1455	436 (30.0)		105 (7.2)		365 (25.1)	
Morbidly obese (≥40)	263	90 (34.2)		27 (10.3)		73 (27.8)	
Parity[b]			<.001				
Nulliparous	3193	950 (29.8)	<.001	256 (8.0)	.34	771 (24.2)	.002
Multiparous	3961	2057 (26.7)		314 (7.9)		822 (20.8)	
Nativity							
US born	4156	1125 (27.1)	.04	325 (7.8)	.65	884 (21.3)	.02
Non-US born	3021	886 (29.3)		245 (8.1)		713 (23.6)	
Maternal complications							
Placental abruption	579	158 (27.3)	.68	65 (11.2)	.002	108 (18.7)	.03
Pregestational diabetes	178	54 (30.3)	.49	15 (8.4)	.81	42 (24.2)	.54
Gestational diabetes	631	152 (24.1)	.02	39 (6.2)	.09	126 (20.0)	.15
Pregestational hypertension	1562	413 (26.4)	.12	124 (7.9)	.99	332 (21.3)	.28
Gestational hypertension and/or preeclampsia	1604	405 (25.3)	.006	119 (7.3)	.39	328 (20.5)	.05
Chorioamnionitis	1036	352 (34.0)	<.001	107 (10.3)	.002	263 (25.4)	.009
Premature rupture of the membranes	2349	641 (27.3)	.34	187 (8.0)	.97	502 (21.4)	.21
Precipitous labor	315	98 (31.1)	.21	38 (12.1)	.006	72 (22.9)	.79
Year							
2010	1530	459 (30.0)	.32	121 (7.9)	.71	367 (24.0)	.37
2011	1503	423 (28.1)		119 (7.9)		339 (22.6)	
2012	1459	406 (27.8)		127 (8.7)		314 (21.5)	
2013	1352	367 (27.1)		107 (7.9)		286 (21.2)	
2014	1333	356 (26.7)		96 (7.2)		291 (21.8)	

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

[a] Some infants experienced both morbidity and mortality; hence, the number of deaths and morbidities exceeds the combined outcome.

[b] Column totals for covariates may not sum to 7177 because of missing values that are not presented in the table.

white infants for 32.0% (n = 190 676). Very preterm births accounted for 1.5% of total births for these years: 2.8% of black births (n = 2775), 1.5% of Hispanic births (n = 2168), and 1.0% of white births (n = 1418). Black infants accounted for 38.4%; Hispanic infants, 30.1%; and white infants, 20.1% of all VPTB infants. Table 1 shows the sociodemographic and clinical characteristics of the VPTB infants in our study sample. Of the 7177 infants, 2011 (28.0%) died or experienced serious morbidity. There were significant differences in VPTB morbidity and mortality rates for some maternal and infant characteristics. As given in Table 1, 570 infants (7.9%) died and 1597 (22.5%) experienced a serious morbidity; morbidity rates differed significantly by race/ethnicity. **Table 2** presents the results of our model fitting for neonatal morbidity and mortality using maternal and infant variables. Birth weight, gestational age, Apgar score at 1 minute, maternal body mass index, and maternal diabetes were significantly associated with neonatal morbidity and mortality composite outcome.

Hospital Risk-Standardized Morbidity and Mortality Rates

Twenty-seven of the 39 hospitals (69.2%) were private, 33 (84.6%) had level 3 or 4 nurseries, and all were teaching hospitals. Hospitals were ranked according to risk-standardized morbidity and mortality rates. Five-year risk-standardized rates

Table 2. Patient Characteristics and Odds of Neonatal Morbidity or Mortality Among Very Preterm Birth Infants, New York City, NY, 2010-2014

Characteristic	Adjusted OR (95% CI)
Unit change (g) of birth weight *z* score for gestational age	0.82 (0.77-0.89)
Unit change (wk) of gestational age	0.60 (0.58-0.63)
Mother's age, y	
<20	0.81 (0.62-1.06)
20-34	1 [Reference]
35-39	0.79 (0.67-0.93)
40-44	0.97 (0.74-1.27)
≥45	0.80 (0.40-1.57)
Mother's race/ethnicity	
Non-Hispanic black	1.21 (0.87-1.68)
Hispanic	1.15 (0.89-1.49)
Non-Hispanic white	1 [Reference]
Asian	1.02 (0.81-1.28)
Other or unknown	0.88 (0.38-2.03)
Mother's educational level	
Less than high school	1.04 (0.81-1.32)
High school	1.06 (0.90-1.26)
More than high school	1 [Reference]
Mother's insurance	
Private	1 [Reference]
Medicaid	0.98 (0.82-1.18)
Uninsured	0.99 (0.71-1.38)
Other	0.65 (0.31-1.39)
Prenatal visits	
0-5	1 [Reference]
6-8	1.12 (0.91-1.38)
≥9	0.81 (0.61-1.07)
No. of births	
Singleton	1 [Reference]
Multiple	1.03 (0.89-1.20)
Smoked during pregnancy[a]	0.98 (0.68-1.42)
Used alcohol during pregnancy[a]	0.66 (0.30-1.42)
Used drugs during pregnancy[a]	1.09 (0.60-1.98)
Apgar score at 1 min	
0-2	2.36 (1.77-3.14)
3-6	1.28 (1.06-1.55)
7-10	1 [Reference]
Male	1.21 (1.07-1.37)
Type of delivery	
Vaginal	1 [Reference]
Cesarean	0.89 (0.72-1.09)
BMI	
Underweight (<18.5)	0.68 (0.52-0.88)
Normal weight (18.5-24.9)	1 [Reference]
Overweight (25.0-29.9)	1.14 (0.97-1.35)
Obese (30.0-39.9)	1.04 (0.88-1.23)
Morbidly obese (≥40)	1.14 (0.81-1.62)
Parity	
Nulliparous	1.05 (0.91-1.21)
Multiparous	1 [Reference]
Nativity	
US born	1 [Reference]
Non-US born	1.13 (0.97-1.33)
Maternal complications[a]	
Placental abruption	0.91 (0.75-1.10)
Pregestational diabetes	1.75 (1.10-2.80)
Gestational diabetes	1.26 (0.96-1.65)
Pregestational hypertension	1.15 (0.86-1.52)
Gestational hypertension and/or preeclampsia	0.88 (0.73-1.06)
Chorioamnionitis	1.02 (0.84-1.23)
Premature rupture of the membranes	0.81 (0.69-0.95)
Precipitous labor	1.01 (0.83-1.24)
Year	
2010	1 [Reference]
2011	0.92 (0.73-1.16)
2012	0.87 (0.68-1.11)
2013	0.78 (0.63-0.97)
2014	0.80 (0.62-1.04)

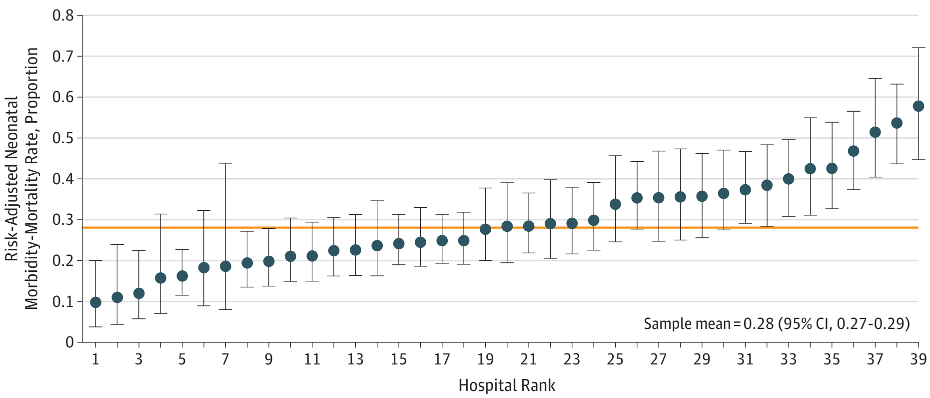
Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

[a] Reference group did not have the condition.

ranged from 9.7% (95% CI, 3.8-20.0) to 57.7% (95% CI, 44.7-72.1) (**Figure**). The cumulative distribution of deliveries among hospitals ranked from lowest to highest morbidity and mortality rates differed for black vs white mothers (*P* < .001) and for Hispanic vs white mothers (*P* < .001) (eFigure 1 in the Supplement). We divided the hospitals in tertiles based on hospital ranking, and the adjusted morbidity and mortality risk for very preterm infants differed for infants born in low- (0.16; 95% CI, 0.14-0.18), middle- (0.25; 95% CI, 0.22-0.27), and high- (0.40; 95% CI, 0.38-0.41) morbidity and mortality hospitals. There was no racial/ethnic difference in adjusted risk for morbidity and mortality composite outcome within the low-, middle-, or high-morbidity and mortality tertiles as shown in **Table 3**. However, 1204 of 2775 black (43.4%), 746 of 2168 Hispanic (34.4%), and 325 of 1418 white (22.9%) VPTB infants were born in the highest morbidity and mortality tertile of hospitals (*P* < .001). The risk difference for black compared with white very preterm infants was 20% (95% CI, 18%-23%); for Hispanic very preterm infants compared with white very preterm infants, it was 11% (95% CI, 9%-14%).

Sensitivity analyses using mortality only as the outcome produced very similar rankings of hospitals and racial/ethnic distributions among hospitals (eFigures 2 and 3 in the Supplement). When we excluded 6 hospitals with level 2 nurseries, the racial/ethnic differences in distributions were similar, with 1174 of 2717 black (43.2%), 695 of 2060 Hispanic (33.7%), and 321 of 1392 white (23.1%) VPTB infants (*P* < .001) born in the highest morbidity and mortality tertile of hospitals (eFigure 4 in the Supplement). Sensitivity analysis excluding Apgar score from the risk-adjustment model produced similar results (eFigure 5 in the Supplement).

Figure. Hospital Rankings for Risk-Adjusted Neonatal Morbidity and Mortality, New York City, NY, 2010-2014



Error bars indicate 95% CI; horizontal line, the sample mean (0.28; 95% CI, 0.27-0.29).

Table 3. Adjusted Risk for Neonatal Morbidity and Mortality by Race/Ethnicity in Hospitals of Low–, Middle–, and High–Morbidity and Mortality Rank

Race/Ethnicity	Low Morbidity and Mortality		Middle Morbidity and Mortality		High Morbidity and Mortality	
	Distribution of Births, No. (%)[a]	Adjusted Risk (95% CI)	Distribution of Births, No. (%)[a]	Adjusted Risk (95% CI)	Distribution of Births, No. (%)[a]	Adjusted Risk (95% CI)
Non-Hispanic black	560 (20.2)	0.14 (0.12-0.17)	1011 (36.4)	0.23 (0.21-0.26)	1204 (43.4)	0.41 (0.39-0.43)
Hispanic	541 (25.0)	0.16 (0.13-0.19)	881 (40.6)	0.25 (0.23-0.27)	746 (34.4)	0.42 (0.39-0.45)
Non-Hispanic white	290 (20.5)	0.18 (0.13-0.22)	803 (56.6)	0.25 (0.22-0.27)	325 (22.9)	0.38 (0.33-0.42)
All races/ethnicities	1572 (100)	0.16 (0.14-0.18)	3183 (100)	0.25 (0.24-0.26)	2422 (100)	0.40 (0.38-0.41)

[a] Kolmogorov-Smirnov test to test difference in cumulative racial/ethnic distribution of deliveries: black vs white, $P < .001$; Hispanic vs non-Hispanic white, $P < .001$.

Table 4 shows that 49.8% of the explained black-white disparity can be attributed to differences in infants' health risks between black and white VPTB infants, and 39.9% can be attributed to the fact that white mothers received care at better-performing hospitals than black mothers. The contributions of black mothers' health and socioeconomic status were negligible. Similarly, 48.4% of the explained Hispanic-white disparity can be attributed to differences in infant health risks between Hispanic and white VPTB infants, and 29.5% can be attributed to the fact that white mothers receive care at better-performing hospitals than Hispanic mothers.

Discussion

Black and Hispanic VPTB infants are more likely to be born in New York City hospitals with higher risk-adjusted neonatal morbidity and mortality rates than are white VPTB infants. Our data document that these disparate patterns of utilization explain 40% of the black-white racial disparity and nearly one-third of the Hispanic-white disparity in VPTB neonatal morbidity rates in New York City. Despite more than 10 years of quality improvement, poor performance at hospitals where black and Hispanic mothers deliver is an important and likely modifiable cause of racial and ethnic disparities in neonatal outcomes.

Our study is one of few to investigate hospital quality and racial and ethnic disparities in severe neonatal morbidity. In our analyses, observed racial and ethnic disparities in VPTB neonatal morbidity and mortality rates were driven by higher rates of severe neonatal morbidities among black and Hispanic VPTB infants. These morbidities are important adverse neonatal outcomes and are associated with additional diagnostic, therapeutic, and surgical interventions; increasing length of stay; risk for rehospitalization; and costs.[3,22] In addition, they have major implications for disparities over the life course, as they are associated with long-term neurodevelopmental disabilities.[3,9] These early disparities set a trajectory for later life, as health differences in the short term can persist and be amplified over the long term.[23-27]

Our results that black, Hispanic, and white VPTB infants are born in different hospitals are similar to findings by previous studies from more than a decade ago documenting that differences in where black and white babies were born contributed to black-white disparities in mortality rates of very low-birth-weight neonates.[10,11] The study by Howell et al[10] concluded that improving outcomes at the lowest-performing hospitals would result in a significant narrowing of disparities. During the past few decades, a large body of research from pediatrics and other areas of medicine has documented that black patients often receive care in a concentrated set of hospitals and that these hospitals have poorer quality of care and higher mortality rates.[28,29]

Why black and Hispanic women deliver their infants in poorer-performing hospitals is not known. Factors including distance to the hospital, insurance, hospital structural characteristics, patterns of racial segregation, community factors, physician referral, risk perception, patient choice, access, and the management of medical emergencies during pregnancy likely all contribute

Table 4. Contributing Factors to Racial/Ethnic Disparities in Neonatal Morbidity and Mortality Among Very Preterm Birth Infants

	% (95% CI)	
Observed Outcome	Non-Hispanic Black vs Non-Hispanic White	Hispanic vs Non-Hispanic White
White morbidity and mortality	22.5 (20.3 to 24.7)	22.5 (20.3 to 24.7)
Non-Hispanic black or Hispanic morbidity and mortality	32.2 (30.4 to 33.9)	28.1 (26.2 to 30.0)
Difference	9.7 (6.9 to 12.5)[a]	5.6 (2.8 to 8.5)[a]
Estimated effect of contributing factors		
A. Infant's health risk[b]	5.6 (4.9 to 6.2)[a]	2.3 (1.8 to 2.9)[a]
B. Choice of hospital	4.5 (2.8 to 6.1)[a]	1.4 (0.2 to 2.6)[c]
C. Mother's socioeconomic status[d]	0.3 (−0.7 to 1.3)	0.5 (−0.7 to 1.7)
D. Mother's health risk[e]	0.8 (−0.1 to 1.7)	0.6 (−0.2 to 1.4)
E. Total explained difference	11.2 (9.0 to 13.4)	4.8 (2.9 to 6.8)
Percentage of total attributed to hospital (B/E)	39.9 (29.7 to 50.1)[f]	29.5 (9.6 to 49.3)[f]
Percentage of total attributed to infant health risk (A/E)	49.8 (39.9 to 59.6)[a]	48.4 (28.9 to 67.8)[a]

[a] $P < .001$.

[b] Infant health risk includes birth weight, gestational age, sex, and multiple births.

[c] $P < .01$.

[d] Mother's socioeconomic status includes educational level, insurance, and an indicator for non–US born.

[e] Mother's health risk includes age, parity, delivery type, smoking status, body mass index, pregnancy complications, and comorbidities.

[f] $P < .05$.

to why women deliver at specific hospitals.[10,30] Previous research found that distance did not explain why black women were more likely to deliver at hospitals in New York City with higher risk-adjusted neonatal mortality.[31]

In the present study, we used a common decomposition tool from the literature[21] and found that a significant proportion of both the black-white and the Hispanic-white VPTB disparities in neonatal morbidity and mortality could be attributed to infant factors, whereas maternal social and demographic factors did not explain these differentials. Although these maternal factors are strongly related to the probability of preterm birth, previous research has not found them to be predictors of very preterm outcomes in the NICU.[32] In contrast, a significant proportion of the explained disparity could be attributed to birth hospital, suggesting that hospital quality does contribute to racial and ethnic VPTB morbidity and mortality gaps. Given the expanding body of literature associating hospital-level variables, such as volume of deliveries and nurse staffing ratios, with neonatal outcomes,[17] more research is needed to elucidate the mechanisms by which these hospital characteristics may contribute to disparities.

Limitations

Our analysis has some limitations. Both vital statistics and SPARCS data have limitations with the reliability of specific variables.[33-35] However, we combined both sources as recommended to optimize validity.[16] We could not identify morbidity after transfer to another hospital, but sensitivity analyses removing hospitals with a higher proportion of transfers did not affect our results. We conducted a decomposition analysis and estimated the extent to which hospital of birth may contribute to observed racial disparities. However, we were unable to account for unmeasured factors that are associated with both race and VPTB neonatal mortality. Although we adjusted for some social factors likely associated with infant outcomes, others (eg, crime, neighborhood poverty, and environmental toxins) were not available in our data set.[36] Furthermore, our cross-sectional data could not evaluate trends and did not include fetal deaths. Nevertheless, we conducted a population-based study based on linked data and were able to construct a robust risk-adjustment model that included important social and clinical confounders and documented that racial/ethnic disparities in hospital of birth continue. Our results may be generalizable to other large diverse urban areas.

Conclusions

We found that black and Hispanic VPTB babies are more likely than white VPTB babies to be born at hospitals with worse neonatal outcomes, and these differences in site of care contribute to disparities in VPTB neonatal morbidity and mortality in New York City. Disparities in severe neonatal morbidity are consequential, as these morbidities are major determinants of severe impairments, such as cerebral palsy, neurocognitive developmental delays, and mental health problems, and therefore perpetuate health and socioeconomic disparities across the life course.[9] These disparities, coupled with the wide variation in hospital NICU performance across New York City hospitals, are alarming. Given the significant improvements in neonatal care over the past decade, it is time to direct these quality efforts to reduce racial and ethnic disparities in neonatal outcomes.

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