

Racial and Ethnic Disparities in Maternal Outcomes and the Disadvantage of Peripartum Black Women: A Multistate Analysis, 2007–2014

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Abstract

Objective Racial and ethnic disparities in obstetric care and delivery outcomes have shown that black women experience high rates of pregnancy-related mortality and morbidity, along with high rates of cesarean delivery, compared with other racial and ethnic groups. We aimed to quantify these disparities and test the effects of race/ethnicity in stratified statistical models by insurance payer and socioeconomic status, adjusting for comorbidities specific to an obstetric population.

Study Design We analyzed maternal outcomes in a sample of 6,872,588 delivery records from California, Florida, Kentucky, Maryland, and New York from 2007 to 2014 from the State Inpatient Databases, Healthcare Cost and Utilization Project. We compared present-on-admission characteristics of parturients by race/ethnicity, and estimated logistic regression and generalized linear models to assess outcomes of in-hospital mortality, cesarean delivery, and length of stay.

Results Compared with white women, black women were more likely to die in-hospital (odds ratio [OR]: 1.90, 95% confidence interval [CI]: 1.47–2.45) and have a longer average length of stay (incidence rate ratio: 1.10, 95% CI: 1.09–1.10). Black women also were more likely to have a cesarean delivery (OR: 1.12, 95% CI 1.12–1.13) than white women. These results largely held in stratified analyses.

Conclusion In most insurance payers and socioeconomic strata, race/ethnicity alone is a factor that predicts parturient outcomes.

Keywords

- ▶ racial/ethnic disparities
- ▶ in-hospital maternal mortality
- ▶ cesarean delivery
- ▶ administrative database
- ▶ outcomes research
- ▶ maternal length of stay

Racial and ethnic disparities in obstetric care and delivery outcomes have been previously reported, showing black women experience disproportionately higher rates of mortality and morbidity associated with pregnancy than all other racial and ethnic groups.^{1–9} In the United States, black women are two to four times more likely than white women to die in the peripartum period due to cardiovascular, cerebrovascular, and pulmonary complications.^{1,3,10–15}

In addition, studies have identified black parturients to be more likely than women from other racial and ethnic groups to have a cesarean delivery, even when controlling for

comorbidities.^{1,16–25} Cesarean delivery is more deleterious to maternal health than vaginal deliveries due to an increased risk of poor outcomes with subsequent pregnancies, longer recovery times, and longer hospital lengths of stay (LOS).^{26,27} Black women are also more likely to be readmitted after cesarean and vaginal delivery²⁸ and have longer postpartum hospital LOS.⁷

The disproportionately poor maternal outcomes experienced by black women have been attributed to the cumulative effects of structural racism.^{29–36} Demographically, black women are more likely to live in socioeconomically

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disadvantaged areas³⁷ and are less likely to have private insurance as their primary insurance payer than white women.³⁸ These factors result in poorer access to quality of care than other racial and ethnic groups.³⁹ Additionally, providers' internalized views of their patients' racial or ethnic identity potentially result in implicit bias leading to a further layer of substandard care.^{33,35,40} These forces interact in a lived experience of race and ethnicity that affects obstetric care and influences maternal health outcomes.⁴¹

Although previous studies have controlled for income and insurance payer as confounders of maternal outcomes, none have examined them as effect measure modifiers of race and ethnicity.^{7,21} Research utilizing data from large, representative data sets is needed to determine if these differences in outcomes by race and ethnicity, along with the disadvantage experienced by black women, are due to the unique experience of race and ethnicity alone, or if the effects of race and ethnicity are modified by primary insurance type and/or socioeconomic status.^{42,43}

Using administrative discharge records of more than 6.8 million singleton and multiple deliveries in five states in the United States over an 8-year period, we aimed to expand upon existing literature by quantifying differences in maternal outcomes between racial and ethnic groups by in-hospital mortality, delivery mode, and hospital LOS. To accomplish this task, we used data from the State Inpatient Database (SID), Healthcare Cost and Utilization Project (HCUP), and Agency for Healthcare Quality and Research (AHRQ); a multistate database that approximates a census of inpatient hospital discharges in participating states.⁴⁴ We hypothesized that racial and ethnic differences exist in outcomes in a population of peripartum patients, and that black patients experience poorer outcomes as compared with white patients. In particular, we hypothesized that these differences result in increased rates of in-hospital mortality, cesarean deliveries, and longer LOS, despite controlling for potential confounders such as present-on-admission comorbidities or when assessing effect modification (through stratified statistical models) by insurance payer and socioeconomic status. Our efforts update numbers on outcomes in a peripartum population, as well as assess the homogeneity of the effects of race/ethnicity on these outcomes by levels of insurance payer and socioeconomic status.

Materials and Methods

We conducted a retrospective analysis of inpatient singleton and multiple deliveries from patients aged ≥ 18 years (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM]) using data from the SIDs (SID, HCUP, AHRQ) from the years 2007 to 2011 for California, and years 2007 to 2014 for Florida, New York, Maryland, and Kentucky.⁴⁴ The SID is an administrative database that contains information on comorbidities, diagnoses, procedures, and complications of procedures (all of which are identified by ICD-9-CM codes); an indicator to distinguish present-on-admission comorbidities and diagnoses, hospital characteristics; patient demographics; dates of admission

and discharge; hospital LOS; and disposition at discharge.⁴⁴ Records are by hospital admission.

Singleton deliveries were identified by ICD-9-CM codes V27.0 and V27.1, and multiple births were identified by ICD-9-CM codes V27.2–8. Deliveries were categorized into cesarean (ICD-9-CM 74.0–74.2, 74.4, 74.99), operative vaginal (ICD-9-CM 72.0–72.9, 73.3), or normal vaginal deliveries. Ectopic and molar pregnancies, as well as terminated pregnancies, were excluded from analysis (ICD-9-CM 630–639, 69.01, 75.0).

The Institutional Review Board at Weill Cornell Medicine determined this research to be exempt from review due to its retrospective nature and lack of patient identifiers.

Outcome Measures

The primary outcome of our study was maternal inpatient mortality. Secondary outcomes included cesarean delivery versus a vaginal or operative vaginal delivery (i.e., forceps or vacuum-assisted) and hospital LOS.

Patient and Hospital Variables

The primary variable of interest was race/ethnicity, which was coded as white, black (Black or African American), Hispanic, and Other (including Asian, Native Hawaiian or Other Pacific Islander, Native American, and more than one race/ethnicity). Other patient demographics examined included parturient age; primary payer status (including Medicare, Medicaid, private insurance, uninsured [including self-pay and no charge], and Other [including Worker's Compensation, CHAMPUS, CHAMP-VA, Title V, and other government programs]); delivery type (vaginal, operative vaginal [including forceps and vacuum deliveries], cesarean); socioeconomic status (operationalized as the median household income quartile for the patient's ZIP code); hospital state; hospital delivery volume quartile; and year of delivery.

Present-on-admission comorbidities included the index developed by Bateman et al,⁴⁵ a validated comorbidity score for use in obstetric populations.⁴⁶ The Bateman index includes weighted measures that predict maternal end-organ injury or death, including severe preeclampsia or eclampsia, chronic congestive heart failure, congenital heart disease, pulmonary hypertension, chronic ischemic heart disease, sickle cell disease, multiple gestation, cardiac valvular disease, systemic lupus erythematosus, human immunodeficiency virus, mild or unspecified preeclampsia (without severe preeclampsia or eclampsia), drug abuse, placenta previa, chronic renal disease, preexisting hypertension, previous cesarean delivery, gestational hypertension, alcohol abuse, asthma, preexisting diabetes mellitus, and maternal age older than 35 (categorized as ages 35–39, 40–44, and 45+).

Statistical Analyses

Descriptive statistics by racial/ethnic group and delivery type were calculated separately. Variables were compared in unadjusted analyses using the appropriate parametric and nonparametric tests for categorical and ordinal or continuous variables: Pearson's chi-square test, Fisher's exact test, one-way analysis of variance, Mann-Whitney *U*-test, or Kruskal-Wallis test.

Multivariate Models

We fit multivariate logistic regression models to predict the outcomes of in-hospital mortality and cesarean deliveries. We fit multivariate generalized linear models with a log link that followed a negative binomial distribution to predict the count outcome of LOS.

Predictor variables in all multivariate models were chosen a priori; all were significantly different between racial/ethnic groups at $\alpha \leq 0.05$: race (reference: white), primary payer (reference: private insurance), median household income quartile (reference: first quartile), patient age as a linear term, the maternal comorbidity index as defined by Bateman,⁴⁵ hospital state (reference: Florida), delivery year (reference: 2007), and hospital delivery volume (reference: first quartile).

For each multivariate model, only observations with nonmissing covariate data were included. For each outcome, a model was run containing the aforementioned predictor variables. Each model contained only these predictor variables; a variable indicating delivery type (reference: vaginal delivery) was additionally included in models for the outcomes of inpatient mortality and LOS.

Subsequent stratified multivariate models for each outcome were run by subpopulations of social determinants of health: primary insurance payer and quartile of median income for the patient's residential ZIP code. These models contained all of the variables present in the main models, save for the variable by which they were stratified. Stratified models were used to assess potential heterogeneity in the effects of race/ethnicity between the main models and within each category of insurance payer and median income quartile.

For dichotomous outcomes, the area under the receiver operating characteristic curve was calculated to assess model discrimination. Assumptions regarding the distribution of the LOS were assessed graphically.

Data are expressed as *n* (percent), mean (standard deviation), median (interquartile range [IQR]) in bivariate analyses; odds ratio (OR, 95% confidence interval, CI) for logistic regression models; or incidence rate ratio (IRR, 95% CI) for generalized linear models with negative binomial distributions. All *p*-values are two-sided, and statistical significance is evaluated at the 0.05 α level. Data analysis was conducted in SAS 9.4 (SAS Institute, Cary, NC) and in Stata SE 15 (StataCorp, College Station, TX).

Results

Sample Attrition

There were 7,109,892 records in the database with an identified singleton or multiple birth. After dropping cases with missing values on age, the sample size decreased to 7,097,656. Following the exclusion criteria of Cheesman et al, we omitted cases of ectopic and molar pregnancies, abortions, dilation and curettage for termination of pregnancy, aspiration curettage for termination of pregnancy, hysterectomy to terminate pregnancy, and intra-amniotic injections for abortions, which reduced the sample size to

7,097,179.⁴⁷ The sample was further reduced to include only patients 18 years or older (6,893,416), with a nonmissing value on gender (6,875,717), a nonmissing final disposition (6,875,593), nonmissing data on primary insurance payer (6,874,806), and with no more than one type of preeclampsia coded on the record (including no preeclampsia). This resulted in a final sample size of 6,872,588.

Descriptive Statistics

A total of 6,872,588 patients were included in the sample; 2,922,680 (42.5%) were white, 1,930,270 (28.1%) were Hispanic, 957,513 (13.9%) were black, and 871,624 (12.7%) were of another race/ethnicity (►Table 1). In addition, 190,501 (2.8%) of the sample had missing values on race/ethnicity. Black women had the highest percentage of cesarean deliveries, at 38.3%, followed by Hispanic women, white women, and women of other races/ethnicities.

Hispanic women had the highest proportion of vaginal deliveries (excluding forceps or vacuum deliveries), at 60.8%, followed by white women, women of other races/ethnicities, and black women. Black women were most likely to live in the lowest quartile of median income, and women of other races/ethnicities were most likely to live in the top quartile of median income. Two-thirds of Hispanic women were insured by Medicaid, along with nearly the same percentage of black women. Approximately one-third of women of other races/ethnicities and white women were insured by Medicaid. White women had the highest proportion of all racial/ethnic groups of private insurance.

Each racial/ethnic group had the same median scores on the Bateman comorbidity index, which ranged in values from 0 to 21 (data not shown).

The largest proportion of cesarean deliveries in a population of black parturients were among those with Medicare or private insurance (45.2 and 42.6%, respectively, unpublished data), compared with black women insured by Medicaid (36.4%), with other types of insurance (37.8%), or uninsured (33.6%). By comparison, the largest proportion of cesarean deliveries in a population of white patients was with patients insured by Medicare (45.1%), followed by private insurance (36.4%), other insurance (32.2%), Medicaid (32.1%), and uninsured (29.6%). In a Hispanic patient population, the highest proportion of those having a cesarean delivery were also on Medicare (46.5%), followed by private insurance (38.2%), other insurance (34.6%), Medicaid (34.1%), and uninsured (32.1%). Finally, in a patient population of those from other races, 42.7% of Medicaid patients had cesarean delivery, followed by 35.5% of patients with private insurance, 31.8% with Medicaid, 34.1% with other types of insurance, and 30.9% of uninsured.

The rate of cesarean deliveries increased with each successive increase in median income quartile in a black patient population: 37.3% in the first quartile, 39.2% in the second quartile, 40.1% in the third quartile, and 41.2% in the fourth quartile. For white patients, the rate of cesarean deliveries followed approximately the same pattern: 32.8% in the first quartile, 34.2% in the second, 34.8% in the third, and 37.2% in

Table 1 Descriptive statistics by racial and ethnic group

Characteristic	Racial or ethnic group						Total	p-Value
	White	Black	Hispanic	Other	Missing	Total		
Total	2,922,680 (42.5)	957,513 (13.9)	1,930,270 (28.1)	871,624 (12.7)	190,501 (2.8)	6,872,588 (100.0)		
Age in years							< 0.0001	
Mean (standard deviation)	29.11 (5.88)	27.34 (6.12)	27.71 (5.94)	30.26 (5.56)	28.33 (5.84)	28.59 (5.97)		
Delivery type							< 0.0001	
Vaginal delivery	1,771,410 (60.6)	559,875 (58.5)	1,173,464 (60.8)	524,081 (60.1)	118,153 (62.0)	4,146,983 (60.3)		
Operative delivery	132,089 (4.5)	30,641 (3.2)	76,534 (4.0)	53,031 (6.1)	10,106 (5.3)	302,401 (4.4)		
Cesarean delivery	1,019,181 (34.9)	366,997 (38.3)	680,272 (35.2)	294,512 (33.8)	62,242 (32.7)	2,423,204 (35.3)		
Year							< 0.0001	
2007	410,157 (14.0)	127,018 (13.3)	349,142 (18.1)	129,047 (14.8)	80,739 (42.4)	1,096,103 (15.9)		
2008	444,927 (15.2)	132,896 (13.9)	334,990 (17.4)	136,837 (15.7)	25,246 (13.3)	1,074,896 (15.6)		
2009	431,493 (14.8)	132,176 (13.8)	322,959 (16.7)	134,240 (15.4)	23,155 (12.2)	1,044,023 (15.2)		
2010	422,804 (14.5)	129,814 (13.6)	317,772 (16.5)	124,554 (14.3)	22,829 (12.0)	1,017,773 (14.8)		
2011	416,470 (14.2)	128,537 (13.4)	308,151 (16.0)	134,059 (15.4)	21,591 (11.3)	1,008,808 (14.7)		
2012	266,118 (9.1)	103,250 (10.8)	97,495 (5.1)	73,616 (8.4)	3,711 (1.9)	544,190 (7.9)		
2013	262,354 (9.0)	101,506 (10.6)	101,005 (5.2)	68,658 (7.9)	5,269 (2.8)	538,792 (7.8)		
2014	268,357 (9.2)	102,316 (10.7)	98,756 (5.1)	70,613 (8.1)	7,961 (4.2)	548,003 (8.0)		
State							< 0.0001	
California	749,996 (25.7)	124,694 (13.0)	1,152,781 (59.7)	327,362 (37.6)	88,633 (46.5)	2,443,466 (35.6)		
Florida	771,684 (26.4)	356,888 (37.3)	389,102 (20.2)	111,575 (12.8)	21,405 (11.2)	1,650,654 (24.0)		
Kentucky	292,165 (10.0)	30,044 (3.1)	13,679 (0.7)	14,008 (1.6)	51,349 (27.0)	401,245 (5.8)		
Maryland	245,526 (8.4)	161,971 (16.9)	60,226 (3.1)	54,505 (6.3)	9,937 (5.2)	532,165 (7.7)		
New York	863,309 (29.5)	283,916 (29.7)	314,482 (16.3)	364,174 (41.8)	19,177 (10.1)	1,845,058 (26.8)		
Median household income state quartile for patient ZIP code							< 0.0001	
First quartile	587,060 (20.1)	420,715 (43.9)	682,947 (35.4)	181,310 (20.8)	45,822 (24.1)	1,917,854 (27.9)		
Second quartile	709,064 (24.3)	214,684 (22.4)	535,036 (27.7)	178,808 (20.5)	46,802 (24.6)	1,684,394 (24.5)		
Third quartile	769,849 (26.3)	168,368 (17.6)	417,674 (21.6)	205,542 (23.6)	48,371 (25.4)	1,609,804 (23.4)		
Fourth quartile	795,561 (27.2)	93,112 (9.7)	229,905 (11.9)	240,172 (27.6)	45,368 (23.8)	1,404,118 (20.4)		
Missing	61,146 (2.1)	60,634 (6.3)	64,708 (3.4)	65,792 (7.5)	4,138 (2.2)	256,418 (3.7)		
Payer							< 0.0001	
Medicare	15,552 (0.5)	8,950 (0.9)	4,702 (0.2)	1,971 (0.2)	947 (0.5)	32,122 (0.5)		
Medicaid	931,436 (31.9)	596,250 (62.3)	1,276,399 (66.1)	325,625 (37.4)	79,932 (42.0)	3,209,642 (46.7)		
Private insurance	1,845,467 (63.1)	299,659 (31.3)	559,854 (29.0)	474,649 (54.5)	94,355 (49.5)	3,273,984 (47.6)		

Table 1 (Continued)

Characteristic	Racial or ethnic group							Total	p-Value
	White	Black	Hispanic	Other	Missing	Total	p-Value		
Other	77,149 (2.6)	14,945 (1.6)	21,466 (1.1)	14,112 (1.6)	9,570 (5.0)	137,242 (2.0)			
Self-pay/No charge	53,076 (1.8)	37,709 (3.9)	67,849 (3.5)	55,267 (6.3)	5,697 (3.0)	219,598 (3.2)			
Disposition at discharge							< 0.0001		
Routine	2,869,876 (98.2)	938,663 (98.0)	1,908,193 (98.9)	854,707 (98.1)	187,884 (98.6)	6,759,323 (98.4)			
Transfer to short-term hospital	2,344 (0.1)	687 (0.1)	879 (0.0)	489 (0.1)	159 (0.1)	4,558 (0.1)			
Home health care	46,739 (1.6)	15,320 (1.6)	19,183 (1.0)	15,301 (1.8)	2,195 (1.2)	98,738 (1.4)			
Died	148 (0.0)	134 (0.0)	134 (0.0)	59 (0.0)	13 (0.0)	488 (0.0)			
Transfer to other, against medical advice, or destination unknown	3,573 (0.1)	2,709 (0.3)	1,881 (0.1)	1,068 (0.1)	250 (0.1)	9,481 (0.1)			
Hospital volume							< 0.0001		
First quartile	832,507 (28.5)	164,167 (17.1)	498,229 (25.8)	144,982 (16.6)	70,441 (37.0)	1,710,326 (24.9)			
Second quartile	657,688 (22.5)	222,636 (23.3)	571,696 (29.6)	224,414 (25.7)	49,574 (26.0)	1,726,008 (25.1)			
Third quartile	690,346 (23.6)	289,395 (30.2)	475,672 (24.6)	221,621 (25.4)	40,636 (21.3)	1,717,670 (25.0)			
Fourth quartile	742,139 (25.4)	281,315 (29.4)	384,673 (19.9)	280,607 (32.2)	29,850 (15.7)	1,718,584 (25.0)			
Bateman et al (2013) comorbidities									
Alcohol abuse	3,665 (0.1)	1,685 (0.2)	1,243 (0.1)	415 (0.0)	111 (0.1)	7,119 (0.1)	< 0.0001		
Asthma	108,244 (3.7)	55,663 (5.8)	48,648 (2.5)	20,121 (2.3)	2,964 (1.6)	235,640 (3.4)	< 0.0001		
Cardiac valvular disease	16,974 (0.6)	2,895 (0.3)	3,354 (0.2)	2,284 (0.3)	347 (0.2)	25,854 (0.4)	< 0.0001		
Chronic congestive heart failure	33 (0.0)	40 (0.0)	14 (0.0)	14 (0.0)	< 11 (< 0.0)	< 112 (< 0.0)	< 0.0001		
Chronic ischemic heart disease	359 (0.0)	150 (0.0)	125 (0.0)	71 (0.0)	13 (0.0)	718 (0.0)	< 0.0001		
Chronic renal disease	6,680 (0.2)	2,622 (0.3)	4,184 (0.2)	1,669 (0.2)	180 (0.1)	15,335 (0.2)	< 0.0001		
Congenital heart disease	2,477 (0.1)	515 (0.1)	945 (0.0)	478 (0.1)	54 (0.0)	4,469 (0.1)	< 0.0001		
Drug abuse	54,310 (1.9)	23,706 (2.5)	12,990 (0.7)	3,929 (0.5)	1,396 (0.7)	96,331 (1.4)	< 0.0001		
Gestational hypertension	93,051 (3.2)	31,657 (3.3)	39,398 (2.0)	15,650 (1.8)	2,566 (1.3)	182,322 (2.7)	< 0.0001		
Human immunodeficiency virus	1,351 (0.0)	6,455 (0.7)	1,336 (0.1)	737 (0.1)	76 (0.0)	9,955 (0.1)	< 0.0001		
Mild or unspecified preeclampsia	69,605 (2.4)	38,218 (4.0)	45,143 (2.3)	17,150 (2.0)	2,556 (1.3)	172,672 (2.5)	< 0.0001		
Multiple gestation	57,638 (2.0)	17,740 (1.9)	22,338 (1.2)	13,462 (1.5)	1,671 (0.9)	112,849 (1.6)	< 0.0001		
Placenta previa	17,023 (0.6)	5,548 (0.6)	11,335 (0.6)	8,298 (1.0)	835 (0.4)	43,039 (0.6)	< 0.0001		
Preexisting diabetes mellitus	22,092 (0.8)	12,441 (1.3)	19,237 (1.0)	7,127 (0.8)	819 (0.4)	61,716 (0.9)	< 0.0001		
Preexisting hypertension	50,718 (1.7)	41,760 (4.4)	26,277 (1.4)	12,522 (1.4)	1,807 (0.9)	133,084 (1.9)	< 0.0001		

(Continued)

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Table 1 (Continued)

Characteristic	Racial or ethnic group								Total	p-Value
	White	Black	Hispanic	Other	Missing	Other	Hispanic	Black		
Previous cesarean delivery	469,708 (16.1)	174,964 (18.3)	363,407 (18.8)	134,408 (15.4)	20,185 (10.6)	1,162,672 (16.9)				< 0.0001
Pulmonary hypertension	439 (0.0)	520 (0.1)	394 (0.0)	157 (0.0)	26 (0.0)	1,536 (0.0)				< 0.0001
Severe preeclampsia	32,371 (1.1)	19,765 (2.1)	24,263 (1.3)	9,429 (1.1)	1,480 (0.8)	87,308 (1.3)				< 0.0001
Sickle cell disease	3,413 (0.1)	5,292 (0.6)	1,257 (0.1)	4,243 (0.5)	258 (0.1)	14,463 (0.2)				< 0.0001
Systemic lupus erythematosus	3,480 (0.1)	1,760 (0.2)	1,964 (0.1)	1,044 (0.1)	102 (0.1)	8,350 (0.1)				< 0.0001
Bateman et al (2013) comorbidity index										< 0.0001
Median (Q1; Q3)	0 (0; 1)	0 (0; 1)	0 (0; 1)	0 (0; 1)	0 (0; 1)	0 (0; 1)				
In-hospital death	148 (0.0)	134 (0.0)	134 (0.0)	59 (0.0)	13 (0.0)	488 (0.0)				< 0.0001
30-d readmission	25,492 (1.1)	15,668 (2.1)	15,719 (1.3)	7,012 (1.0)	734 (0.6)	64,625 (1.3)				< 0.0001
Length of stay										< 0.0001
Median (Q1; Q3)	2 (2; 3)	3 (2; 3)	2 (2; 3)	2 (2; 3)	2 (2; 3)	2 (2; 3)				
Total charges in 2016 dollars										< 0.0001
Median (Q1; Q3)	12,204 (7,808; 19,063)	12,243 (7,977; 19,705)	15,465 (10,240; 23,129)	14,375 (9,137; 22,284)	11,896 (7,691; 19,247)	13,366 (8,533; 20,783)				
Cardiovascular complications grouped variable	589 (0.0)	379 (0.0)	391 (0.0)	180 (0.0)	27 (0.0)	1,566 (0.0)				< 0.0001
Pulmonary complications grouped variable	3,658 (0.1)	3,064 (0.3)	3,003 (0.2)	1,634 (0.2)	195 (0.1)	11,554 (0.2)				< 0.0001
Infectious complications grouped variable	3,440 (0.1)	2,504 (0.3)	2,983 (0.2)	1,331 (0.2)	144 (0.1)	10,402 (0.2)				< 0.0001
Intraoperative complication grouped variable	1,196 (0.0)	604 (0.1)	890 (0.0)	368 (0.0)	36 (0.0)	3,094 (0.0)				< 0.0001
Digestive system complication	333 (0.0)	320 (0.0)	208 (0.0)	108 (0.0)	12 (0.0)	981 (0.0)				< 0.0001
Any complication	8,680 (0.3)	6,358 (0.7)	6,987 (0.4)	3,425 (0.4)	377 (0.2)	25,827 (0.4)				< 0.0001

Abbreviations: IQR, interquartile range; SD, standard deviation.

Note: Percents may not sum to 100 due to rounding and missing values. Continuous variables analyzed using analysis of variance; categorical variables analyzed using Pearson's chi-square test or Fisher's exact test. Data provided as n (%), mean (SD), or median (IQR), as appropriate.

Table 2 Descriptive statistics by delivery type

Characteristic	Delivery type				p-Value
	Vaginal delivery	Operative vaginal	Cesarean delivery	Total	
Total	4,146,983 (60.3)	302,401 (4.4)	2,423,204 (35.3)	6,872,588 (100.0)	
Age in years					< 0.0001
Mean (standard deviation)	28.02 (5.81)	27.96 (5.98)	29.66 (6.07)	28.59 (5.97)	
Race					< 0.0001
White	1,771,410 (42.7)	132,089 (43.7)	1,019,181 (42.1)	2,922,680 (42.5)	
Black	559,875 (13.5)	30,641 (10.1)	366,997 (15.1)	957,513 (13.9)	
Hispanic	1,173,464 (28.3)	76,534 (25.3)	680,272 (28.1)	1,930,270 (28.1)	
Other	524,081 (12.6)	53,031 (17.5)	294,512 (12.2)	871,624 (12.7)	
Missing	118,153 (2.8)	10,106 (3.3)	62,242 (2.6)	190,501 (2.8)	
Year					< 0.0001
2007	665,124 (16.0)	55,559 (18.4)	375,420 (15.5)	1,096,103 (15.9)	
2008	651,081 (15.7)	51,370 (17.0)	372,445 (15.4)	1,074,896 (15.6)	
2009	627,856 (15.1)	47,569 (15.7)	368,598 (15.2)	1,044,023 (15.2)	
2010	614,343 (14.8)	45,596 (15.1)	357,834 (14.8)	1,017,773 (14.8)	
2011	609,179 (14.7)	44,496 (14.7)	355,133 (14.7)	1,008,808 (14.7)	
2012	325,432 (7.8)	20,088 (6.6)	198,670 (8.2)	544,190 (7.9)	
2013	322,713 (7.8)	18,978 (6.3)	197,101 (8.1)	538,792 (7.8)	
2014	331,255 (8.0)	18,745 (6.2)	198,003 (8.2)	548,003 (8.0)	
State					< 0.0001
California	1,492,973 (36.0)	135,345 (44.8)	815,148 (33.6)	2,443,466 (35.6)	
Florida	949,901 (22.9)	56,154 (18.6)	644,599 (26.6)	1,650,654 (24.0)	
Kentucky	232,667 (5.6)	20,936 (6.9)	147,642 (6.1)	401,245 (5.8)	
Maryland	323,229 (7.8)	24,849 (8.2)	184,087 (7.6)	532,165 (7.7)	
New York	1,148,213 (27.7)	65,117 (21.5)	631,728 (26.1)	1,845,058 (26.8)	
Median household income state quartile for patient ZIP code					< 0.0001
First quartile	1,178,675 (28.4)	77,658 (25.7)	661,521 (27.3)	1,917,854 (27.9)	
Second quartile	1,018,750 (24.6)	76,674 (25.4)	588,970 (24.3)	1,684,394 (24.5)	
Third quartile	966,701 (23.3)	73,424 (24.3)	569,679 (23.5)	1,609,804 (23.4)	
Fourth quartile	817,882 (19.7)	65,452 (21.6)	520,784 (21.5)	1,404,118 (20.4)	
Missing	164,975 (4.0)	9,193 (3.0)	82,250 (3.4)	256,418 (3.7)	
Payer					< 0.0001
Medicare	16,489 (0.4)	1,150 (0.4)	14,483 (0.6)	32,122 (0.5)	
Medicaid	2,000,245 (48.2)	129,712 (42.9)	1,079,685 (44.6)	3,209,642 (46.7)	
Private insurance	1,903,782 (45.9)	155,997 (51.6)	1,214,205 (50.1)	3,273,984 (47.6)	
Other	84,793 (2.0)	6,403 (2.1)	46,046 (1.9)	137,242 (2.0)	
Self-pay/No charge	141,674 (3.4)	9,139 (3.0)	68,785 (2.8)	219,598 (3.2)	
Disposition at discharge					< 0.0001
Routine	4,083,569 (98.5)	297,727 (98.5)	2,378,027 (98.1)	6,759,323 (98.4)	
Transfer to short-term hospital	1,483 (0.0)	149 (0.0)	2,926 (0.1)	4,558 (0.1)	
Home health care	56,371 (1.4)	4,200 (1.4)	38,167 (1.6)	98,738 (1.4)	
Died	110 (0.0)	12 (0.0)	366 (0.0)	488 (0.0)	
Transfer to other, against medical advice, or destination unknown	5,450 (0.1)	313 (0.1)	3,718 (0.2)	9,481 (0.1)	
Hospital volume					< 0.0001
First quartile	1,047,978 (25.3)	82,577 (27.3)	579,771 (23.9)	1,710,326 (24.9)	
Second quartile	1,034,357 (24.9)	81,453 (26.9)	610,198 (25.2)	1,726,008 (25.1)	

(Continued)

Table 2 (Continued)

Characteristic	Delivery type				p-Value
	Vaginal delivery	Operative vaginal	Cesarean delivery	Total	
Third quartile	1,048,627 (25.3)	68,085 (22.5)	600,958 (24.8)	1,717,670 (25.0)	
Fourth quartile	1,016,021 (24.5)	70,286 (23.2)	632,277 (26.1)	1,718,584 (25.0)	
Bateman et al (2013) comorbidities					
Alcohol abuse	4,384 (0.1)	226 (0.1)	2,509 (0.1)	7,119 (0.1)	< 0.0001
Asthma	132,142 (3.2)	7,927 (2.6)	95,571 (3.9)	235,640 (3.4)	< 0.0001
Cardiac valvular disease	13,627 (0.3)	1,120 (0.4)	11,107 (0.5)	25,854 (0.4)	< 0.0001
Chronic congestive heart failure	24 (0.0)	< 11 (< 0.0)	72 (0.0)	< 107 (< 0.0)	< 0.0001
Chronic ischemic heart disease	260 (0.0)	39 (0.0)	419 (0.0)	718 (0.0)	< 0.0001
Chronic renal disease	7,727 (0.2)	552 (0.2)	7,056 (0.3)	15,335 (0.2)	< 0.0001
Congenital heart disease	2,192 (0.1)	302 (0.1)	1,975 (0.1)	4,469 (0.1)	< 0.0001
Drug abuse	58,905 (1.4)	3,352 (1.1)	34,074 (1.4)	96,331 (1.4)	< 0.0001
Gestational hypertension	97,410 (2.3)	8,126 (2.7)	76,786 (3.2)	182,322 (2.7)	< 0.0001
Human immunodeficiency virus	3,845 (0.1)	96 (0.0)	6,014 (0.2)	9,955 (0.1)	< 0.0001
Mild or unspecified preeclampsia	74,957 (1.8)	6,517 (2.2)	91,198 (3.8)	172,672 (2.5)	< 0.0001
Multiple gestation	21,207 (0.5)	3,135 (1.0)	88,507 (3.7)	112,849 (1.6)	< 0.0001
Placenta previa	5,829 (0.1)	399 (0.1)	36,811 (1.5)	43,039 (0.6)	< 0.0001
Preexisting diabetes mellitus	20,426 (0.5)	1,557 (0.5)	39,733 (1.6)	61,716 (0.9)	< 0.0001
Preexisting hypertension	53,498 (1.3)	3,319 (1.1)	76,267 (3.1)	133,084 (1.9)	< 0.0001
Previous cesarean delivery	89,409 (2.2)	8,230 (2.7)	1,065,033 (44.0)	1,162,672 (16.9)	< 0.0001
Pulmonary hypertension	475 (0.0)	100 (0.0)	961 (0.0)	1,536 (0.0)	< 0.0001
Severe preeclampsia	24,111 (0.6)	2,151 (0.7)	61,046 (2.5)	87,308 (1.3)	< 0.0001
Sickle cell disease	7,748 (0.2)	613 (0.2)	6,102 (0.3)	14,463 (0.2)	< 0.0001
Systemic lupus erythematosus	3,978 (0.1)	271 (0.1)	4,101 (0.2)	8,350 (0.1)	< 0.0001
Bateman et al (2013) comorbidity index					< 0.0001
Median (Q1; Q3)	0 (0; 1)	0 (0; 1)	1 (0; 2)	0 (0; 1)	
In-hospital death	110 (0.0)	12 (0.0)	366 (0.0)	488 (0.0)	< 0.0001
30-d readmission	27,486 (0.9)	2,308 (1.1)	34,831 (1.9)	64,625 (1.3)	< 0.0001
Length of stay					< 0.0001
Median (Q1; Q3)	2 (2; 3)	2 (2; 3)	3 (3; 4)	2 (2; 3)	
Total charges in 2016 dollars					< 0.0001
Median (Q1; Q3)	10,986 (7,414; 16,100)	12,693 (8,308; 18,675)	19,788 (12,765; 28,280)	13,366 (8,533; 20,783)	
Cardiovascular complications grouped variable	451 (0.0)	52 (0.0)	1,063 (0.0)	1,566 (0.0)	< 0.0001
Pulmonary complications grouped variable	1,547 (0.0)	204 (0.1)	9,803 (0.4)	11,554 (0.2)	< 0.0001
Infectious complications grouped variable	3,574 (0.1)	327 (0.1)	6,501 (0.3)	10,402 (0.2)	< 0.0001
Intraoperative complication grouped variable	306 (0.0)	28 (0.0)	2,760 (0.1)	3,094 (0.0)	< 0.0001
Digestive system complication	53 (0.0)	< 11 (< 0.0)	921 (0.0)	< 985 (< 0.0)	< 0.0001
Any complication	5,653 (0.1)	568 (0.2)	19,606 (0.8)	25,827 (0.4)	< 0.0001

Abbreviations: IQR, interquartile range; SD, standard deviation.

Note: Percents may not sum to 100 due to rounding and missing values. Continuous variables analyzed using analysis of variance; categorical variables analyzed using Pearson's chi-square test or Fisher's exact test. Data provided as *n* (%), mean (SD), or median (IQR), as appropriate.

the fourth. Among Hispanic patients, 35.2% of the first income quartile, 35.0% in the second, 35.2% in the third, and 37.6% in the fourth had cesarean deliveries. Finally, those in other races/ethnicities had the lowest rates of cesarean deliveries across the board: 31.6% of the first quartile of

median income, 34.4% of the second, 34.7% of the third, and 35.1% of the fourth.

Patients with vaginal or operative deliveries had a median score of 0 (IQR: 0; 1) on the Bateman comorbidity index, while cesarean deliveries had a 1 (IQR: 0; 2) (► **Table 2**).

Less than 1% of the women in the entire sample died in-hospital (►Table 1). In an overall sample, black women had the longest LOS of all racial/ethnic groups.

Multivariate Results

In-Hospital Mortality

After adjustment for patient-level (race [reference: white], primary payer [reference: private insurance], median household income quartile [reference: first quartile], patient age as a linear term, the maternal comorbidity index as defined by Bateman,⁴⁵ and delivery type [reference: vaginal]) and hospital-level variables (hospital state [reference: Florida], delivery year [reference: 2007], and hospital delivery volume [reference: first quartile]), black patients were 90% more likely to die in-hospital when compared with white women (►Table 3). Each incremental increase on the Bateman comorbidity index resulted in a 45% increase in the likelihood of in-hospital maternal mortality (OR: 1.45, 95% CI: 1.39–1.51, $p < 0.001$, data not shown). Stratified subgroup analysis by insurance status showed that black women with Medicaid insurance and black women with private insurance had increased odds of in-hospital death when compared with white women with those respective insurances. In a sample of Medicaid patients only, black women were 61% more likely than white women to die in-hospital; black women and women of other races/ethnicities (individually) were more than 100% more likely than white women to die in-hospital in a sample of patients with private insurance. In

a population of patients with other insurance, Hispanic women were more than four times as likely as white women to die in-hospital.

In populations of the lowest and highest income quartiles, respectively, no racial/ethnic group was significantly more or less likely to die in-hospital as compared with white patients, though this negative finding could be attributed to the small number of individuals in the entire sample who died in the inpatient setting.

Delivery Type

After adjustment for patient-level (race [reference: white], primary payer [reference: private insurance], median household income quartile [reference: first quartile], patient age as a linear term, the maternal comorbidity index as defined by Bateman⁴⁵) and hospital-level variables (hospital state [reference: Florida], delivery year [reference: 2007], and hospital delivery volume [reference: first quartile]), 6,872,588 women had nonmissing data on all model covariates and were included in our analysis. Black and Hispanic women were 12 and 23% more likely, respectively, when compared with white women to have undergone a cesarean delivery as compared with a vaginal delivery (►Table 4). Women of other races/ethnicities were also more likely than white women to have an increased odds of cesarean delivery. For each incremental increase on the Bateman comorbidity index, women became 2.20 times more likely to have a cesarean delivery (OR: 2.20, 95% CI: 2.20–2.20, $p < 0.001$, data not shown).

Table 3 Risk-adjusted outcomes of in-hospital mortality according to race and ethnicity

Population	White (reference)	Black	Hispanic	Other	Missing	N
Full sample	1.00	1.90 ^c (1.47, 2.45)	1.17 (0.91, 1.52)	1.33 (0.97, 1.82)	1.44 (0.81, 2.56)	6,872,588
Medicare only	1.00	0.47 (0.08, 2.62)	0.56 (0.06, 5.12)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	9,823
Medicaid only	1.00	1.61 ^b (1.15, 2.27)	0.91 (0.64, 1.30)	1.08 (0.66, 1.76)	0.75 (0.27, 2.08)	3,209,642
Private insurance only	1.00	2.52 ^c (1.65, 3.84)	1.49 (0.95, 2.34)	2.03 ^b (1.31, 3.15)	3.05 ^b (1.45, 6.43)	3,273,984
Other insurance only	1.00	1.07 (0.11, 10.08)	4.49 ^a (1.21, 16.69)	1.00 (1.00, 1.00)	1.92 (0.16, 23.38)	54,491
Uninsured only	1.00	1.38 (0.48, 3.95)	0.68 (0.23, 2.00)	0.51 (0.14, 1.90)	1.00 (1.00, 1.00)	213,901
Median income quartile 1 (lowest) only	1.00	1.45 (0.97, 2.16)	0.93 (0.61, 1.43)	0.81 (0.41, 1.59)	0.84 (0.26, 2.73)	1,917,854
Median income quartile 2 only	1.00	1.84 ^a (1.02, 3.33)	1.77 ^a (1.04, 3.01)	2.72 ^b (1.48, 4.98)	1.09 (0.25, 4.65)	1,676,265
Median income quartile 3 only	1.00	3.32 ^c (2.01, 5.49)	1.01 (0.56, 1.84)	2.12 ^a (1.18, 3.81)	1.06 (0.25, 4.50)	1,609,804
Median income quartile 4 (highest) only	1.00	0.92 (0.35, 2.46)	0.98 (0.48, 1.98)	0.51 (0.20, 1.33)	3.38 ^a (1.28, 8.91)	1,399,986

Abbreviation: CI, confidence interval.

Note: All numbers reported are odds ratios (95% CI) unless noted otherwise.

^a $p < 0.05$.

^b $p < 0.01$.

^c $p < 0.001$.

Table 4 Risk-adjusted outcomes of having a cesarean delivery (vs. vaginal or operative vaginal delivery) according to race and ethnicity

Population	White (reference)	Black	Hispanic	Other	Missing	N
Full sample	1.00	1.12 ^c (1.12, 1.13)	1.23 ^c (1.22, 1.23)	1.08 ^c (1.07, 1.08)	1.11 ^c (1.09, 1.12)	6,872,588
Medicare only	1.00	0.88 ^c (0.83, 0.93)	1.07 (0.99, 1.15)	0.94 (0.84, 1.03)	1.03 (0.89, 1.18)	32,122
Medicaid only	1.00	1.14 ^c (1.13, 1.14)	1.23 ^c (1.22, 1.24)	1.15 ^c (1.14, 1.16)	1.12 ^c (1.10, 1.14)	3,209,642
Private insurance only	1.00	1.16 ^c (1.15, 1.17)	1.20 ^c (1.19, 1.21)	1.05 ^c (1.04, 1.06)	1.09 ^c (1.07, 1.10)	3,273,984
Other insurance only	1.00	1.15 ^c (1.11, 1.20)	1.15 ^c (1.11, 1.19)	1.06 ^b (1.02, 1.10)	1.16 ^c (1.10, 1.23)	137,242
Uninsured only	1.00	1.17 ^c (1.13, 1.21)	1.26 ^c (1.23, 1.30)	1.24 ^c (1.20, 1.28)	1.07 ^a (1.00, 1.14)	219,598
Median income quartile 1 (lowest) only	1.00	1.15 ^c (1.14, 1.16)	1.28 ^c (1.27, 1.29)	1.11 ^c (1.10, 1.13)	1.11 ^c (1.09, 1.14)	1,917,854
Median income quartile 2 only	1.00	1.15 ^c (1.14, 1.16)	1.18 ^c (1.17, 1.19)	1.11 ^c (1.09, 1.12)	1.11 ^c (1.09, 1.13)	1,684,394
Median income quartile 3 only	1.00	1.20 ^c (1.18, 1.21)	1.23 ^c (1.22, 1.24)	1.10 ^c (1.09, 1.12)	1.11 ^c (1.08, 1.13)	1,609,804
Median income quartile 4 (highest) only	1.00	1.14 ^c (1.12, 1.16)	1.19 ^c (1.18, 1.20)	1.04 ^c (1.03, 1.05)	1.13 ^c (1.10, 1.15)	1,404,118

Abbreviation: CI, confidence interval.

Note: All numbers reported are odds ratios (95% CI) unless noted otherwise.

^a $p < 0.05$.

^b $p < 0.01$.

^c $p < 0.001$.

Black women, Hispanic women, and women of other races/ethnicities continued to have increased odds of cesarean delivery compared with white women when stratified subgroup analysis were performed by primary payer status for Medicaid insurance, private insurance, other insurance, and in an uninsured population. However, in a population of Medicare patients, black women had reduced odds of cesarean delivery compared with white women. Black women, Hispanic women, and women of other races/ethnicities were also individually more likely than white women to have increased odds of a cesarean delivery in each quartile of median income, with Hispanic women having the highest odds of a cesarean delivery as compared with white women in each quartile of median income.

Length of Stay

Models of LOS were interpreted using the IRR, which is the ratio of the average LOS for one group versus the average LOS for the reference group. In adjusted models (in which patient- and hospital-level variables were controlled for—including delivery type), black women had an average LOS 1.10 times greater than white women (—Table 5). This increase in average LOS was similarly significant in stratified analyses for each primary insurance payer type and quartile of median income. For each successively higher median income bracket as compared with the lowest bracket of median income, the average LOS for black as compared with white women decreased. For

each successive increase in the Bateman comorbidity index, the average LOS increased by 8% (IRR: 1.08, 95% CI: 1.08–1.08, $p < 0.001$, data not shown).

Hispanic women and women of other races/ethnicities were expected to have slightly longer LOS than white women, though these findings were not uniform in stratified analyses by insurance payer and median income quartile.

Discussion

Using comprehensive discharge data from a geographically diverse population in the United States over an 8-year period, we identified disparities by race and ethnicity in maternal mortality, delivery type, and LOS.

For each of our outcomes, race/ethnicity served as an independent predictor when controlling for patient demographics, patient comorbidities specific to an obstetric population, and hospital-level variables. In stratified models, we analyzed outcomes in subgroups of insurance payer and median income quartile to assess the homogeneity of the effect of race/ethnicity across strata. Our findings suggest that race/ethnicity is a significant predictor of in-hospital mortality, having a cesarean delivery, and having a longer expected LOS, even in many cases when testing for effect modification by insurance payer and median income category. Notably, our findings of the homogeneity of the effect of race/ethnicity in our primary outcome offer confirmatory evidence that black

Table 5 Risk-adjusted outcomes of length of stay (count outcome) according to race and ethnicity

Population	White (reference)	Black	Hispanic	Other	Missing	N
Full sample	1.00	1.10 ^c (1.09, 1.10)	1.01 ^c (1.01, 1.01)	1.04 ^c (1.04, 1.05)	1.01 ^c (1.01, 1.02)	6,872,582
Medicare only	1.00	1.10 ^c (1.07, 1.14)	1.03 (0.99, 1.07)	1.05 (1.00, 1.11)	0.98 (0.91, 1.06)	32,122
Medicaid only	1.00	1.10 ^c (1.09, 1.10)	1.03 ^c (1.02, 1.03)	1.05 ^c (1.04, 1.05)	1.02 ^c (1.01, 1.03)	3,209,640
Private insurance only	1.00	1.10 ^c (1.09, 1.10)	0.98 ^c (0.98, 0.98)	1.05 ^c (1.04, 1.05)	1.01 (1.00, 1.02)	3,273,981
Other insurance only	1.00	1.10 ^c (1.08, 1.12)	1.02 (1.00, 1.04)	1.03 ^a (1.01, 1.05)	1.00 (0.97, 1.03)	137,242
Uninsured only	1.00	1.13 ^c (1.11, 1.15)	1.06 ^c (1.04, 1.07)	1.03 ^c (1.01, 1.04)	1.03 (0.99, 1.06)	219,597
Median income quartile 1 (lowest) only	1.00	1.11 ^c (1.10, 1.12)	1.04 ^c (1.03, 1.04)	1.05 ^c (1.04, 1.06)	1.03 ^c (1.01, 1.04)	1,917,854
Median income quartile 2 only	1.00	1.09 ^c (1.09, 1.10)	1.01 ^b (1.00, 1.01)	1.05 ^c (1.04, 1.05)	1.01 ^a (1.00, 1.03)	1,684,389
Median income quartile 3 only	1.00	1.09 ^c (1.08, 1.10)	1.01 ^a (1.00, 1.01)	1.04 ^c (1.04, 1.05)	1.01 ^a (1.00, 1.02)	1,609,803
Median income quartile 4 (highest) only	1.00	1.08 ^c (1.07, 1.08)	1.00 (0.99, 1.00)	1.04 ^c (1.03, 1.04)	1.00 (0.99, 1.01)	1,404,118

Abbreviation: CI, confidence interval.

Note: All numbers reported are incidence rate ratios (95% CI) unless noted otherwise.

^a $p < 0.05$.

^b $p < 0.01$.

^c $p < 0.001$.

women across all insurance categories and quartiles of median income experience increased odds of having a cesarean delivery as compared with white women.

To our knowledge, assessing effect modification by either primary insurance payer or median income quartile in the relationship between maternal race/ethnicity and outcomes has heretofore not been performed, allowing for an important contribution to the literature. Moreover, the large, longitudinal sample in our analysis offers a generalizable insight into the effects of race/ethnicity on maternal outcomes. Perhaps most importantly, our multivariate analyses adjust for present-on-admission maternal-specific comorbidities from the Bateman index; adjustment by this index has not been done previously in a multistate analysis of data from the SID. Even when these comorbidities are taken into account, black women still experience poorer outcomes compared with white women.

In-Hospital Maternal Mortality/Length of Stay

Our results confirm the findings of a multitude of studies showing racial and ethnic differences in rates of maternal mortality, with black women being disproportionately affected.^{1-8,10-15} In our adjusted models, black women were 90% more likely than white women to die in-hospital; the same was true in stratified analyses by Medicaid and private insurance populations, with an especially strong increased likelihood of inpatient mortality in a population of black patients with private insurance. Black women were also more likely to have an expected slight increase in LOS as compared with white women,

even when controlling for delivery type in adjusted analyses. This corroborated the findings of Tanner et al, who concluded that black women were more likely than white women to have LOS longer than 3 days after a scheduled cesarean delivery.⁴⁸

Stratified analyses by payer type and median income quartile are especially advantageous in examining the relationship between race/ethnicity and LOS, noting the complexities of the contributing factors to LOS, ranging from patient, provider, and insurance payer preferences.⁴⁹

Cesarean Delivery

Consistent with the existing literature, we found differences in racial and ethnic groups in delivery type. There were small but significant differences in the prevalence of cesarean deliveries across all racial and ethnic groups, with black women having the highest percentage (38.3%, **Table 1**). In an adjusted logistic regression model, black women were significantly more likely than white women to undergo a cesarean delivery when controlling for patient-level comorbidities and hospital characteristics; these estimates were more exaggerated in a population of Hispanic women (**Table 4**). For black women, these results were maintained in stratified analyses by categories of insurance payer and median income quartile. Among Hispanic women, results of a higher likelihood of cesarean delivery as compared with white women were consistent across all stratified models, save for in a population of Medicare patients. These estimates of the effects of race/ethnicity on the likelihood of cesarean

delivery in both models with the full sample and stratified by median income quartile and insurance payer point to the importance of race/ethnicity as a predictor of delivery type.

Explanations about rates of cesarean delivery across racial and ethnic groups vary: studies have suggested that physician preference, maternal request, and clinical indications (such as nonreassuring fetal heart tracings or fetal distress) all play a role in determining the likelihood of a cesarean delivery.^{23,50,51} Roth and Henley noted the advantage of white women and more highly educated women, both of whom have better access to care and better communication with health care providers; these populations are less likely to have cesarean deliveries.²³ An additional explanation for some of the racial/ethnic disparities in rates of cesarean deliveries is based on medical need: black women are more likely to have an “unnecessary” primary cesarean delivery—when such a procedure is not medically indicated, but is preferred for financial, medico-legal, or patient demographic factors, among others.²²

The epidemiological evidence of racial and ethnic disparities is manifold.

When adjusting for patient characteristics, Chung et al concluded that black women were 75% more likely than white women to have a cesarean delivery.²⁰ In models further adding fixed effects of hospital along with random (clustering) effects of physicians, black women were 54% more likely than white women to undergo a cesarean delivery. Braveman et al found that black women were 24% more likely than white women to undergo cesarean deliveries after adjustment for sociodemographic categories and medical risk factors, as well as hospital characteristics.¹⁸ Roth and Henley added black women were 33% more likely than white women to have a primary cesarean delivery, even when adjusting for demographic and pregnancy characteristics, maternal health risks, and complications of labor and delivery.²³ Finally, in adjusted models, Aron et al found that nonwhites had higher rates of cesarean delivery (OR: 1.34; 95% CI: 1.14–1.57) than whites.¹⁶ Despite these multiple studies, contrary findings do exist. In a nationally representative sample, Witt et al discovered that there was no effect of race on the likelihood of both medically indicated and nonmedically indicated cesarean deliveries; indeed, the strongest predictor was having a previous cesarean delivery.¹⁷ At the provider level, Metz et al found no racial and ethnic differences in cesarean deliveries between providers who had low, medium, and high rates of primary cesarean deliveries.⁵² These findings suggest that clinical necessity and provider preference may be most influential in determining delivery type, though mediated by sociodemographic factors.

Limitations

The SID is an administrative database comprised of data from billing records, which subjects it to concerns of validity. Data may be inaccurately coded or incomplete. Specific to variables in this study, research to validate coding practices in administrative databases has shown that delivery type has high sensitivities and positive predictive values, though select comorbidities do not.^{53,54} Importantly, the SID does not contain physician-level data to show provider preference for

delivery type and whether this preference was clinically motivated (e.g., due to vertex presentation); the individual physician's preference has been shown to be an important factor in the likelihood of a cesarean delivery, net of hospital factors or patient comorbidities.⁵² Nor does the SID contain data on patient preference, which could also affect the likelihood of a cesarean delivery.¹⁸

The SID lacks information on the severity of comorbidities, as well as any data on medications or other markers of prenatal care. Neither does the SID contain behavioral or social measures on part of the patient or provider. These measures are potentially relevant factors in explaining the impact of race/ethnicity on our outcomes.^{55,56} In addition, body mass index, which has been shown to be a significant predictor of adverse perinatal outcomes,^{57–61} is not available in the SID.

The unit of analysis in the SID is the inpatient discharge, allowing for multiple records per patient in the database with multiple pregnancies in the included states and years.

The obstetric comorbidity index used in our multivariate analyses was designed to predict maternal death or end-organ injury,⁴⁵ although we have included it in multivariate analyses where death or end-organ injury is not the outcome. Even though this index has been validated,⁴⁶ we cannot be certain that it captures the totality of patient conditions that might contribute to each of our outcomes.

In addition, 2.8% of our sample (190,501) had missing data on race/ethnicity. Because the percentage of the total sample with missing data on race/ethnicity was below an arbitrary cutoff point of 5%, we elected not to conduct a sensitivity analysis, despite our assumption that the data on race and ethnicity were not missing at random.⁶² Finally, we were unable to conduct multilevel analyses with hospital as a clustering variable due to model nonconvergence, though we did include hospital delivery volume as a covariate in all of our multivariate models.

Strengths

In spite of these limitations, a notable strength of our study is its comprehensive sample of hospital discharges (approximating a census) over an 8-year period in five geographically diverse states in the United States. The inclusion of patient and hospital characteristics as explanatory variables controlled for the effects of preexisting conditions and for variation in hospital delivery practice.^{63,64} We also controlled for year of admission to account for changes in laws that have affected insurance payer reimbursements and coverage, such as the introduction of the Patient Protection and Affordable Care Act.⁶⁵

Conclusion

This study shows that racial and ethnic disparities in inpatient maternal mortality, delivery type, and LOS exist, even within strata of insurance payer and income in models controlling for confounding patient comorbidities and hospital characteristics. Specifically, racial and ethnic group differences in delivery type exist, with black women more likely than white women to die in-hospital regardless of primary insurance payer or

residence associated with a particular income bracket. At all levels of health care, providers should be mindful of the effects of race and ethnicity on maternal outcomes, irrespective of primary insurance payer or residence in socioeconomic category. Research into the causal mechanisms of these disparities is needed with the collection of behavioral and sociological variables in hospital administrative databases.

Conflict of Interest

None.

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