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Racial and Ethnic Disparities in Maternal Morbidity and Obstetric Care

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Abstract

Objective—To evaluate whether racial and ethnic disparities exist in obstetric care and adverse outcomes.

Methods—We analyzed data from a cohort of women who delivered at 25 hospitals across the United States over a 3-year period. Race and ethnicity was categorized as Non-Hispanic white, Non-Hispanic black, Hispanic, or Asian. Associations between race and ethnicity and severe postpartum hemorrhage (PPH), peripartum infection, and severe perineal laceration at spontaneous vaginal delivery, as well as between race and ethnicity and obstetric care (eg, episiotomy) relevant to the adverse outcomes, were estimated by univariable analysis and multivariable logistic regression.

Results—Of 115,502 studied women, 95% were classified by one of the race and ethnicity categories. Non-Hispanic white women were significantly less likely to experience severe PPH

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(1.6% non-Hispanic white vs. 3.0% Non-Hispanic black vs. 3.1% Hispanic vs. 2.2%Asian) and peripartum infection (4.1% non-Hispanic white vs. 4.9% Non-Hispanic black vs. 6.4% Hispanic vs. 6.2% Asian) than others (P < 0.001 for both). Severe perineal laceration at spontaneous vaginal delivery was significantly more likely in Asian women (2.5% non-Hispanic white vs. 1.2% Non-Hispanic black vs. 1.5% Hispanic vs. 5.5% Asian) P< 0.001). These disparities persisted in multivariable analysis. Many types of obstetric care examined also were significantly different according to race and ethnicity in both univariable and multivariable analysis. There were no significant interactions between race and ethnicity and hospital of delivery.

Conclusion—Racial and ethnic disparities exist for multiple adverse obstetric outcomes and types of obstetric care, and do not appear to be explained by differences in patient characteristics or by delivery hospital.

Racial and ethnic disparities in health care have been defined as differences in the quality of care received by particular groups who have similar health insurance and the same access to a doctor when there are no differences between these groups in their preferences and needs for treatment. (1) In their report on health disparities, the Institute of Medicine indicated that racial and ethnic minorities in the United States are less likely to receive needed procedures, more likely to receive less useful procedures, and overall experience a lower quality of health services. (1) For example, black men and women in the United States have been shown to have higher mortality related to coronary heart disease but lower rates of receiving coronary angioplasty and bypass surgery than their white counterparts. (2)

Health disparities also have been documented in reproductive health. (3) Many studies have demonstrated the marked black-white difference that exists in both infant and maternal mortality. (4–6) These differences do not appear to be related solely to a greater prevalence or severity of obstetric complications. Both Tucker et. al. and Rosenberg et. al., for example, have shown that black women are more likely to have pregnancy-associated mortality even after accounting for severity of the complication. (7,8)

It has been less well documented whether disparities exist with regard to significant maternal morbidities. Some studies have suggested that white women are less likely to experience postpartum hemorrhage, infection, and severe perineal laceration than other racial and ethnic groups. (9–12) However, these studies typically have utilized administrative databases, and have therefore not been able to adequately adjust for potential differences in other patient characteristics (e.g., age, body mass index) that might account for the differences. Also, these studies, as well as the ones that have evaluated maternal mortality, have not been able to assess whether there are corresponding differences in the obstetric care that were received by women of different racial and ethnic status.

In this study, we have utilized data from an observational obstetric cohort designed to evaluate the quality of obstetric care in an effort to determine whether there are racial and ethnic differences in the frequency of three significant maternal morbidities (severe postpartum hemorrhage, peripartum infection, and severe perineal laceration), as well as differences in related obstetric care.

Materials and Methods

Between 2008 and 2011, investigators at 25 medical centers of the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development Maternal-Fetal Medicine Units (MFMU) Network assembled an observational obstetric cohort (i.e., the Assessment of Perinatal EXcellence (APEX) study) that included detailed information collected by trained and certified nurses on patient characteristics, intrapartum events, and pregnancy outcomes. Institutional review board approval for the study and a waiver of informed consent was obtained at all centers. Full details of the technique of data collection have been described previously (13,14).

Racial and ethnic status, as documented in patients' charts, was recorded in the database. The present analysis excludes those women who had no race or ethnicity recorded, or whose race and ethnicity was categorized as "other." All other women in the registry were included in the analysis, and had race and ethnicity categorized as Non-Hispanic white, Non-Hispanic black, Hispanic, or Asian. Characteristics of the population by race and ethnicity were assessed in univariable analysis using the chi-square test.

The frequency of severe postpartum hemorrhage (defined as estimated blood loss ≥ 1500cc at delivery or the immediate postpartum period, a blood transfusion, or a hysterectomy for hemorrhage, placenta accreta or atony), peripartum infection (defined as chorioamnionitis, endometritis, wound cellulitis requiring antibiotics, wound re-opened for fluid collection or infection, or wound dehiscence during the delivery hospitalization), and severe perineal laceration at spontaneous vaginal delivery (defined as a third or fourth degree laceration) were compared among the racial and ethnic groups. These outcomes were chosen given that they were the primary maternal morbidity outcomes in the APEX study, are acknowledged to be important health outcomes, and, as they may be modified by care within the health care system, have a conceptually plausible relationship with regard to racial disparities. In order to determine whether any noted racial and ethnic differences could be related to differences in demographic and historical characteristics other than race and ethnicity, we utilized multivariable logistic regression, with non-Hispanic white women as the referent, to adjust for patient characteristics, and to estimate whether the association between race and ethnicity and each outcome, presented as odds ratios with 95% confidence intervals, persisted. The multivariable models including patient factors were based on risk-adjusted models previously developed, using derivation and validation datasets, for the three maternal adverse outcomes (13). Another possible explanation for differences in morbidity could be that women of different race and ethnicity disproportionately receive care at certain institutions with different patterns of care or different frequencies of health outcomes (15,16). In order to evaluate this possibility, the hospital of delivery was added to the multivariable logistic regression models. In addition, the interaction between hospital of delivery and race and ethnicity was evaluated. Odds ratios and 95% confidence intervals for the association between race and ethnicity again were re-estimated.

Lastly, the association between types of obstetric care provided (e.g., episiotomy) and race and ethnicity was explored. Previous analyses in this cohort have demonstrated that, even after adjusting for patient, provider, and institutional factors, several types of obstetric care

are associated with postpartum hemorrhage, peripartum infection, and severe perineal laceration (14). The frequencies of these types of obstetric care were compared among the different racial and ethnic groups. Multivariable logistic regression was used to estimate the odds ratio and 95% confidence interval for the association between race and ethnicity and types of obstetric care, after controlling for differences in patient characteristics and hospital of delivery.

All tests were two tailed, $p < .05$ was used to define statistical significance for descriptive analyses, and $p < .001$ was used to account for multiple hypothesis testing of adverse maternal outcomes and types of obstetric care. No imputation for missing data was performed. All analyses were performed with SAS (SAS Institute, Cary, NC).

Results

During the study, 115,502 women delivered and their data were collected for the APEX study. Of these, 109,208 (95%) were classified according to one of the defined race and ethnicity categories and included in the present analysis. The study population was 48% (N = 52,040) non-Hispanic white, 22% (n = 23,878) non-Hispanic black, 25% (n = 27,291) Hispanic, and 5% (n = 5,999) Asian. There were multiple differences among women of different race and ethnicity with regard to their patient characteristics and medical history (table 1).

The frequency of adverse maternal outcomes, stratified by race and ethnicity, is presented in table 2. For each outcome, disparities by race and ethnicity existed, with non-Hispanic white women being least likely to experience severe postpartum hemorrhage or peripartum infection, and Asian women most likely to experience a severe perineal laceration at spontaneous vaginal delivery (P <.001 for all).

These racial and ethnic differences largely persisted after controlling for other differences in patient characteristics and hospital of delivery (table 2). Non-Hispanic black, Hispanic, and Asian women all had significantly greater odds of experiencing a severe postpartum hemorrhage or peripartum infection than non-Hispanic white women. Moreover, as the adjusted odds ratios demonstrate, the magnitude of the differences for severe postpartum hemorrhage and peripartum infection did not notably change from their unadjusted esimate even after patient characteristics and delivery hospital were included in the regression.

Disparities in the frequency of severe perineal laceration similarly persisted after adjustment, although the pattern of difference among the groups, as in the univariable analysis, was different than that observed for severe postpartum hemorrhage and peripartum infection. Compared with non-Hispanic white women, Asian women had significantly higher odds of laceration, while non-Hispanic black women had significantly lower odds of laceration. Of note, differences in patient characteristics appeared to explain some, but not all of the disparity, as the difference between non-Hispanic white and Hispanic women was no longer present, and the magnitude of the difference between non-Hispanic white and non-Hispanic black women was attenuated and no longer significant at the $p < .001$ level after

adjustment for these characteristics. Interaction terms between each delivery hospital and race and ethnicity were examined and all were non-significant.

Racial and ethnic differences existed not only for adverse maternal outcomes, but for types of obstetric care previously shown (14) to be associated with these outcomes (table 3). The frequency of every type of care that was assessed varied, sometimes widely, among the different race and ethnicity groups. For example, Asian women were most likely to receive an episiotomy. Also, non-Hispanic white women were more likely to undergo labor induction compared with all the other race and ethnicity groups. The associations between race and ethnicity and types of care received generally persisted despite adjustment for patient characteristics or delivery hospital.

Discussion

In this analysis, we have demonstrated that racial and ethnic differences exist in the frequency of significant maternal morbidities. Specifically, severe postpartum hemorrhage and peripartum infection are least common among non-Hispanic white women while severe perineal lacerations are most common among Asian women. These differences do not appear to be explained by differences in other patient characteristics, such as parity, age, body mass index, or socioeconomic indicators such as insurance status. The differences also do not appear to be related to the possibility that women of a particular race and ethnicity are more likely to be admitted to hospitals with higher rates of these adverse outcomes. Indeed, as the non-significance of the interaction terms between race and ethnicity and hospitals demonstrate, the racial and ethnic differences are similar among all hospitals studied.

There has been a large body of work that has demonstrated racial and ethnic differences in obstetric mortality (3,7,8). There has been much less research into differences in maternal morbidities. The studies that do exist have demonstrated racial and ethnic differences in outcomes that are similar to the ones noted in the present analysis. As prior studies largely have been derived from administrative databases, which have not allowed detailed patient risk-adjustment or adjustment for admitting hospital, the potential for confounding for the racial and ethnic differences has remained (9–12). The present analysis, which has utilized data collected by direct chart abstraction by trained research personnel, suggests that the racial and ethnic differences in maternal morbidities that were observed cannot easily be explained by differences in other patient characteristics or the hospital in which care was provided.

This study also has shown that it is not just outcomes that differ among women of different race and ethnicity, but the frequencies of certain types of obstetric care as well. As one example, the frequency of receiving an episiotomy was significantly higher for Asian women. The reasons for this increased utilization are not clear, as other patient characteristics, such as BMI and parity, did not account for this difference. It is notable, however, that use of episiotomy has been associated with a greater chance of severe perineal lacerations (14,17,18) – which, in the present study, were most likely to be experienced by Asian women as well. The racial and ethnic differences in outcomes, the inability to explain these differences based on case-mix, and the observed differences in care processes that

have been related to those outcomes suggest that differences in care may be one explanation for the racial and ethnic differences in outcomes that was observed.

Nevertheless, the reason that there are racial differences in obstetric care is uncertain. Unlike cardiac catheterization, for which there are well-established guidelines with regard to the appropriateness of the procedure (1,2,16), many obstetric interventions (e.g., episiotomy, vaginal exams, delayed pushing) do not have guidelines that are as clear. Accordingly, whether these procedures were truly under or over utilized for a given group cannot be known. It is possible that our risk adjustment models did not include all observable patient characteristics that could confound the association between race and ethnicity and the outcome. Yet, these models were developed using derivation and validation datasets, considered a wide variety of factors plausibly related the outcomes, and produced area-under-the curves of the receiver-operating characteristic curves that are similar to other accepted risk-adjustment models (13). Also, it is possible that there are differences in patient preferences or in unmeasured and non-modifiable patient factors that could explain the observed associations. Finally, it was not specified in patients' charts how race and ethnicity was assigned and it remains unknown, for example, whether all assignments were based on self-identification. It is unknown whether further information about the method by which race and ethnicity was assigned would alter our findings.

Correspondingly, determining the origin of the racial and ethnic differences in maternal care and morbidity should be a priority. Maternal mortality has been rising in the United States and a persistent racial and ethnic gap remains (3,19). Obstetric morbidity, however, is much more frequent than obstetric mortality and can serve as a more readily accessible measure to identify quality improvement targets (20). Similarly, unexplained variation in health care processes (such as the frequency of admission in early labor or the delay in pushing in the second stage) may serve to highlight areas where determination of best practices and corresponding guidelines would be helpful. Such an approach may not only result in reductions in maternal morbidity, but ultimately, in maternal mortality as well.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table 1

Patient Characteristics by Race and Ethnicity

	No. (%) in Non-Hispanic white n=52040	No. (%) in Non-Hispanic black n=23878	No. (%) in Hispanic n=27291	No. (%) in Asian n=5999	P-Value
Maternal characteristics					
Age, y					<.001
< 20	2180 (4.2)	4147 (17.4)	3305 (12.1)	76 (1.3)	
20–24.9	7911 (15.2)	7550 (31.6)	7194 (26.4)	433 (7.2)	
25–29.9	14531 (27.9)	5735 (24.0)	7528 (27.6)	1714 (28.6)	
30–34.9	16781 (32.3)	3970 (16.6)	5759 (21.1)	2344 (39.1)	
≥35	10637 (20.4)	2476 (10.4)	3505 (12.8)	1432 (23.9)	
Body mass index at delivery, kg/m^2[a]					<.001
< 25	6983 (13.6)	2719 (11.5)	2405 (9.2)	1346 (22.8)	
25–29.9	20411 (39.7)	6640 (28.1)	8889 (34.1)	2962 (50.2)	
30–34.9	14033 (27.3)	6349 (26.8)	8718 (33.5)	1232 (20.9)	
35–39.9	6016 (11.7)	4090 (17.3)	3939 (15.1)	266 (4.5)	
≥40	3974 (7.7)	3861 (16.3)	2089 (8.0)	91 (1.5)	
Cigarette use during pregnancy	6366 (12.3)	3708 (15.6)	865 (3.2)	90 (1.5)	<.001
Cocaine or methamphetamine use during pregnancy	417 (0.8)	278 (1.2)	99 (0.4)	2 (0.0)	<.001
Insurance status					<.001
Uninsured or self-pay	1291 (2.5)	1253 (5.3)	8754 (32.5)	306 (5.1)	
Government-assisted	11176 (21.6)	16440 (69.1)	13976 (51.8)	1016 (17.0)	
Private	39199 (75.9)	6100 (25.6)	4230 (15.7)	4645 (77.8)	
Prenatal care[a]	49114 (98.9)	21472 (95.7)	25637 (97.9)	5647 (99.1)	<.001

	No. (%) in Non-Hispanic white n=52040	No. (%) in Non-Hispanic black n=23878	No. (%) in Hispanic n=27291	No. (%) in Asian n=5999	P-Value
Obstetric history					<.001
Nulliparous	23106 (44.4)	9363 (39.2)	8312 (30.5)	3078 (51.3)	
Prior vaginal delivery only	21019 (40.4)	10573 (44.3)	13785 (50.5)	2062 (34.4)	
Prior cesarean only	3939 (7.6)	1447 (6.1)	2541 (9.3)	466 (7.8)	
Prior cesarean and vaginal	3966 (7.6)	2486 (10.4)	2644 (9.7)	393 (6.6)	
Any hypertension	5701 (11.0)	3915 (16.4)	2706 (9.9)	336 (5.6)	<.001
Diabetes mellitus					<.001
None	48751 (93.7)	22231 (93.2)	24674 (90.5)	5262 (87.8)	
Gestational	2607 (5.0)	1153 (4.8)	2154 (7.9)	665 (11.1)	
Pregestational	660 (1.3)	483 (2.0)	442 (1.6)	68 (1.1)	
Anticoagulant use during pregnancy	568 (1.1)	190 (0.8)	91 (0.3)	22 (0.4)	<.001
Multiple gestation	1603 (3.1)	497 (2.1)	370 (1.4)	145 (2.4)	<.001
Polyhydramnios	478 (0.9)	195 (0.8)	183 (0.7)	45 (0.8)	.003
Placenta previa	227 (0.4)	70 (0.3)	85 (0.3)	44 (0.7)	<.001
Placenta accreta	80 (0.2)	28 (0.1)	29 (0.1)	7 (0.1)	.29
Placental abruption	415 (0.8)	191 (0.8)	189 (0.7)	68 (1.1)	.006
PROM or PPROM[a]	2792 (5.5)	1399 (6.0)	1162 (4.3)	271 (4.6)	<.001
GBS status					<.001
Negative	34774 (66.8)	11623 (48.7)	14299 (52.4)	4158 (69.3)	
Positive	11080 (21.3)	7077 (29.6)	3866 (14.2)	1060 (17.7)	
Unknown	6186 (11.9)	5178 (21.7)	9126 (33.4)	781 (13.0)	

	No. (%) in Non-Hispanic white n=52040	No. (%) in Non-Hispanic black n=23878	No. (%) in Hispanic n=27291	No. (%) in Asian n=5999	P-Value
Neonatal characteristics (on maternal level, according to first born in multiple gestations)					
Presentation at delivery					<.001
Vertex	49106 (94.7)	22813 (95.8)	26110 (95.8)	5699 (95.3)	
Breech	2525 (4.9)	857 (3.6)	946 (3.5)	242 (4.1)	
Non breech malpresentation	249 (0.5)	154 (0.7)	190 (0.7)	40 (0.7)	
Gestational age at delivery, weeks					<.001
23^0–27^6	412 (0.8)	382 (1.6)	180 (0.7)	33 (0.6)	
28^0–33^6	1589 (3.1)	1054 (4.4)	602 (2.2)	105 (1.8)	
34^0–36^6	3984 (7.7)	2202 (9.2)	1881 (6.9)	407 (6.8)	
37^0–37^6	4496 (8.6)	2497 (10.5)	2385 (8.7)	509 (8.5)	
38^0–38^6	8564 (16.5)	4250 (17.8)	5251 (19.2)	1207 (20.1)	
39^0–39^6	17941 (34.5)	6833 (28.6)	8706 (31.9)	2095 (34.9)	
40^0–40^6	10760 (20.7)	4681 (19.6)	5757 (21.1)	1294 (21.6)	
41^0–41^6	4087 (7.9)	1851 (7.8)	2260 (8.3)	331 (5.5)	
≥ 42^0	207 (0.4)	128 (0.5)	269 (1.0)	18 (0.3)	
Birthweight, g					<.001
< 2500	4328 (8.3)	3318 (13.9)	1870 (6.9)	480 (8.0)	
2500–3999	42586 (81.8)	19522 (81.8)	23112 (84.7)	5244 (87.4)	
≥4000	5121 (9.8)	1032 (4.3)	2303 (8.4)	274 (4.6)	
Size for gestational age					<.001
Small	4868 (9.4)	2191 (9.2)	2395 (8.8)	669 (11.2)	
Appropriate	43153 (82.9)	19965 (83.6)	22446 (82.3)	4974 (82.9)	

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	No. (%) in Non-Hispanic white n=52040	No. (%) in Non-Hispanic black n=23878	No. (%) in Hispanic n=27291	No. (%) in Asian n=5999	P-Value
Large	4014 (7.7)	1716 (7.2)	2444 (9.0)	355 (5.9)	

PROM = premature rupture of membranes; PPROM = preterm prematrure rupture of membranes; GBS = group B streptococcus.

[a] N = 107,013 with body mass index data; N = 104,009 with prenatal care visit data; N = 107,312 with PROM/PPROM data.

Table 2

Associations Between Race and Ethnicity and Adverse Maternal Outcomes*

	Non-Hispanic white	Non-Hispanic black	Hispanic	Asian
Postpartum hemorrhage[a]				
N (%)	805 (1.6)	702 (3.0)	827 (3.1)	130 (2.2)
Unadjusted OR (95% CI)	1.00 (ref)	**1.89 (1.70–2.09)**	**1.94 (1.76–2.14)**	**1.38 (1.15–1.67)**
Adjusted OR (95% CI)[b]	1.00 (ref)	**1.87 (1.65–2.12)**	**2.07 (1.83–2.36)**	**1.49 (1.21–1.84)**
Adjusted OR (95% CI)[c]	1.00 (ref)	**1.71 (1.49–1.96)**	**1.51 (1.31–1.74)**	**1.54 (1.24–1.91)**
Peripartum infection[a]				
N (%)	2119 (4.1)	1169 (4.9)	1744 (6.4)	374 (6.2)
Unadjusted OR (95% CI)	1.00 (ref)	**1.21 (1.13–1.31)**	**1.61 (1.51–1.72)**	**1.57 (1.40–1.75)**
Adjusted OR (95% CI)[d]	1.00 (ref)	1.13 (1.03–1.23)	**1.69 (1.56–1.85)**	**1.59 (1.41–1.79)**
Adjusted OR (95% CI)[c]	1.00 (ref)	**1.25 (1.14–1.38)**	**1.45 (1.32–1.59)**	**1.62 (1.43–1.84)**
Severe perineal laceration at SVD[e]				
N (%)	780 (2.5)	174 (1.2)	256 (1.5)	189 (5.5)
Unadjusted OR (95% CI)	1.00 (ref)	**0.47 (0.40–0.56)**	**0.57 (0.49–0.66)**	**2.26 (1.92–2.67)**
Adjusted OR (95% CI)[f]	1.00 (ref)	0.79 (0.65–0.95)	0.84 (0.70–1.01)	**1.97 (1.66–2.34)**
Adjusted OR (95% CI)[c]	1.00 (ref)	0.76 (0.62–0.93)	0.86 (0.70–1.05)	**2.06 (1.72–2.47)**

SVD = spontaneous vaginal delivery

* Odds ratios significant at P<.001 are indicated in bold.

[a] In all patients.

[b] Adjusted for patient characteristics (age, diabetes mellitus, any hypertension, birthweight, prenatal care, obstetric history, multiple gestation, abruption, previa, accreta, anticoagulant use during pregnancy, insurance status)

[c] Adjusted for patient characteristics and hospital (fixed)

[d] Adjusted for patient characteristics (age, body mass index at delivery, diabetes mellitus, premature rupture of membranes or preterm prematrure rupture of membranes, cigarette use during pregnancy, gestational age at delivery, obstetric history, group B streptococcus status, insurance status)

[e] In patients with a singleton delivery and no shoulder dystocia or placenta previa.

[f] Adjusted for patient characteristics (age, body mass index at delivery, cigarette use during pregnancy, bithweight, prior vaginal delivery, insurance status)

Table 3

Associations Between Race and Ethnicity and Types of Obstetric Care*

	Non-Hispanic white	Non-Hispanic black	Hispanic	Asian
Labor induction[a]				
N (%)	16400 (32.1)	6597 (28.3)	6123 (23.0)	1389 (23.7)
Unadjusted OR (95% CI)	1.00 (ref)	**0.83 (0.80–0.86)**	**0.63 (0.61–0.65)**	**0.66 (0.62–0.70)**
Adjusted OR (95% CI)[b]	1.00 (ref)	**0.83 (0.80–0.87)**	**0.68 (0.65–0.71)**	**0.68 (0.64–0.73)**
Adjusted OR (95% CI)[c]	1.00 (ref)	**0.88 (0.84–0.92)**	**0.67 (0.64–0.70)**	**0.74 (0.69–0.80)**
Dilation ≤2 cm at admission[d]				
N (%)	2804 (15.4)	1451 (14.6)	1534 (11.7)	425 (16.3)
Unadjusted OR (95% CI)	1.00 (ref)	0.94 (0.88–1.01)	**0.73 (0.68–0.78)**	1.07 (0.95–1.19)
Adjusted OR (95% CI)[b]	1.00 (ref)	1.12 (1.04–1.22)	0.93 (0.85–1.01)	0.98 (0.87–1.10)
Adjusted OR (95% CI)[c]	1.00 (ref)	1.10 (1.00–1.21)	0.87 (0.79–0.96)	**0.80 (0.71–0.91)**
Maximum oxytocin ≥20 mU/min[e]				
N (%)	5582 (20.2)	2853 (23.1)	2342 (19.5)	443 (14.5)
Unadjusted OR (95% CI)	1.00 (ref)	**1.19 (1.13–1.25)**	0.96 (0.91–1.01)	**0.67 (0.60–0.75)**
Adjusted OR (95% CI)[b]	1.00 (ref)	0.97 (0.91–1.03)	**0.84 (0.79–0.90)**	**0.73 (0.65–0.81)**
Adjusted OR (95% CI)[c]	1.00 (ref)	0.90 (0.84–0.96)	**0.79 (0.73–0.85)**	**0.80 (0.71–0.90)**
≥80% of labor augmented with oxytocin[f]				
N (%)	3043 (12.1)	1415 (11.0)	1363 (8.5)	390 (11.2)
Unadjusted OR (95% CI)	1.00 (ref)	0.90 (0.84–0.96)	**0.67 (0.63–0.72)**	0.92 (0.82–1.02)
Adjusted OR (95% CI)[b]	1.00 (ref)	0.95 (0.87–1.02)	0.89 (0.81–0.97)	0.97 (0.86–1.09)
Adjusted OR (95% CI)[c]	1.00 (ref)	0.91 (0.84–1.00)	0.91 (0.83–1.00)	1.11 (0.98–1.26)
≥1 hour between complete dilation and initiation of pushing[g]				
N (%)	3111 (11.4)	685 (6.2)	854 (6.5)	476 (14.7)
Unadjusted OR (95% CI)	1.00 (ref)	**0.51 (0.47–0.55)**	**0.54 (0.50–0.58)**	**1.34 (1.21–1.49)**
Adjusted OR (95% CI)[h]	1.00 (ref)	**0.67 (0.61–0.74)**	**0.82 (0.74–0.90)**	**1.23 (1.10–1.37)**
Adjusted OR (95% CI)[c]	1.00 (ref)	0.85 (0.76–0.94)	0.92 (0.83–1.02)	1.13 (1.00–1.27)
<1 vaginal examination per every 3 hours in first stage[i]				
N (%)	6578 (17.7)	3999 (23.7)	3574 (19.0)	846 (19.3)
Unadjusted OR (95% CI)	1.00 (ref)	**1.44 (1.38–1.51)**	1.09 (1.04–1.14)	1.11 (1.03–1.20)
Adjusted OR (95% CI)[b]	1.00 (ref)	**1.42 (1.34–1.50)**	**1.30 (1.22–1.38)**	1.15 (1.05–1.25)
Adjusted OR (95% CI)[c]	1.00 (ref)	1.03 (0.97–1.10)	**0.81 (0.76–0.86)**	0.90 (0.83–0.99)
Vaginal delivery[j]				
N (%)	35632 (68.5)	16075 (67.3)	19234 (70.5)	3993 (66.6)
Unadjusted OR (95% CI)	1.00 (ref)	0.95 (0.92–0.98)	**1.10 (1.07–1.14)**	0.92 (0.87–0.97)

	Non-Hispanic white	Non-Hispanic black	Hispanic	Asian
Adjusted OR (95% CI)[b]	1.00 (ref)	**0.84 (0.80–0.88)**	0.96 (0.91–1.01)	**0.83 (0.78–0.89)**
Adjusted OR (95% CI)[c]	1.00 (ref)	**0.87 (0.83–0.91)**	1.06 (1.01–1.12)	0.96 (0.89–1.03)
Episiotomy[k]				
N (%)	4690 (13.6)	767 (4.9)	996 (5.3)	936 (24.0)
Unadjusted OR (95% CI)	1.00 (ref)	**0.33 (0.30–0.36)**	**0.36 (0.33–0.38)**	**2.02 (1.86–2.19)**
Adjusted OR (95% CI)[b]	1.00 (ref)	**0.49 (0.45–0.54)**	**0.62 (0.57–0.68)**	**1.78 (1.63–1.94)**
Adjusted OR (95% CI)[c]	1.00 (ref)	**0.62 (0.56–0.68)**	**0.63 (0.58–0.70)**	**1.39 (1.26–1.54)**
General anesthesia at cesarean[l]				
N (%)	733 (4.5)	659 (8.5)	396 (4.9)	79 (3.9)
Unadjusted OR (95% CI)	1.00 (ref)	**1.97 (1.77–2.20)**	1.10 (0.97–1.25)	0.88 (0.69–1.11)
Adjusted OR (95% CI)[h]	1.00 (ref)	**1.41 (1.24–1.61)**	0.95 (0.81–1.10)	1.05 (0.82–1.34)
Adjusted OR (95% CI)[c]	1.00 (ref)	1.19 (1.04–1.37)	0.87 (0.73–1.03)	1.08 (0.83–1.39)

[*] Odds ratios significant at P<.001 are indicated in bold

[a] In patients with no previa and no history of classical, T, or J cesarean.

[b] Adjusted for patient characteristics (age, body mass index at delivery, diabetes mellitus, premature rupture of membranes or preterm prematrure rupture of membranes, cigarette use during pregnancy, gestational age at delivery, obstetric history, group B streptococcus status, insurance status)

[c] Adjusted for patient characteristics and hospital (fixed)

[d] In patients at term with intact membranes and spontaneous intended labor with no previa and cervical dilation measured within one hour before or after L&D admission.

[e] In patients who received oxytocin in labor.

[f] In patients with spontaneous intended labor admitted to L&D before delivery.

[g] In patients who reached complete after intended labor.

[h] Adjusted for patient characteristics (age, diabetes mellitus, any hypertension, birthweight, prenatal care, obstetric history, multiple gestation, abruption, previa, accreta, anticoagulant use during pregnancy, insurance status).

[i] In patients with intended labor managed in hospital for greater than 1 hour during first stage.

[j] In all patients.

[k] In patients with a vaginal delivery and no shoulder dystocia.

[l] In patients with a cesarean delivery.