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Maternal Morbidity during Childbirth Hospitalization in California

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Abstract

Objective—To determine the incidence and risk factors for maternal morbidity during childbirth hospitalization.

Methods—Maternal morbidities were determined using ICD9-CM and vital records codes from linked hospital discharge and vital records data for 1,572,909 singleton births in California, 2005-2007. Sociodemographic, obstetric, and hospital volume risk factors were estimated using mixed effects logistic regression models.

Results—The maternal morbidity rate was 241/1000 births. The most common morbidities were episiotomy, pelvic trauma, maternal infection, postpartum hemorrhage, and severe laceration. Preeclampsia (Adjusted Odds Ratio [AOR] 2.96; 95% CI 2.8,3.13), maternal age over 35 years, (AOR 1.92; 1.79,2.06), vaginal birth after cesarean, (AOR 1.81; 1.47,2.23), and repeat cesarean birth (AOR 1.99; 1.87,2.12) conferred the highest odds of severe morbidity. Non-white women were more likely to suffer morbidity.

Conclusions—Nearly one in four California women experienced complications during childbirth hospitalization. Significant health disparities in maternal childbirth outcomes persist in the United States.

Keywords

Childbirth hospitalization; maternal morbidity; risk factors

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INTRODUCTION

Maternal health during childbirth is an international priority presently under increased focus in the United States (US) in light of escalating overall maternal mortality and racial disparities in maternal mortality.[1-4] Recent death certificate coding changes in the US only partially explain the observed increase in maternal mortality.[2,5] Furthermore, many more women and families are affected by maternal morbidity during childbirth; severe maternal morbidity often may represent a "near miss"[4] with significant utility as an indicator of maternal health and clinical quality.

Contemporary reports of maternal morbidity during childbirth hospitalization in the US are either not population based, or use a sampling strategy of administrative survey data to estimate rates.[6-8] Administrative data often do not accurately reflect patient race/ethnicity, particularly for non-Whites, and may underestimate racial disparities.[9-11] Previous studies have not assessed hospital volume, a factor implicated in morbidity and mortality for certain surgeries and conditions such as neonatal mortality for premature infants.[12,13]

The purpose of this study was to evaluate the incidence of maternal morbidity during childbirth hospitalization in a large US population-based cohort of singleton births and assess risk factors for morbidity, including race/ethnicity and hospital volume. By combining birth certificate and administrative data, we incorporated variables that may have not been captured using hospital administrative data alone.

MATERIALS & METHODS

We evaluated maternal morbidity during childbirth hospitalization using data linked from California Vital Statistics records and state-wide hospital discharge data from the Office of State Wide Planning and Development (OSHPD). This linked data set contains maternal education level, race, ethnicity, insurance status, estimate of prenatal care, mode of birth, and diagnosis and procedure codes from the birth hospitalization for virtually all inpatient live births in California. The study period included all births in 2005, 2006, and 2007, which were the most recent years with available linked records at the time of the data request. We limited analysis to singleton births, due to the very different risk profile for the small fraction of births from multi-fetal pregnancy.

Data were linked using a probabilistic matching algorithm for large public health data sets as described by Jaro.[14,15] Linkage between Vital Statistics and hospital discharge data was established for greater than 96% of records. Linkage variables included baby's birth date, birth hospital, delivery mode, mother's birth date, and other maternal information. We excluded the records of 31,884 births (2.0% of total records) that occurred in military hospitals and freestanding birth centers that do not report hospital discharge data. Hospital identifiers were masked to protect privacy. The California Perinatal Quality Care Collaborative developed and executed the linkage strategy under grant support from the March of Dimes. Institutional Review Boards at Stanford University and University of California San Francisco approved the study.

We identified maternal morbidity using International Classification of Diseases, 9th Revision (ICD-9-CM) diagnosis and procedure codes[7,8,16-20] supplemented with birth certificate data.[21] (Supplementary Digital Content S1) After determining crude rates of morbidities for each year we classified women as having "pelvic floor morbidity," "non-pelvic floor morbidity," and "severe morbidity." Mothers were considered positive for "pelvic floor morbidity" if they had ICD-9 codes for episiotomy, 3rd or 4th degree laceration, vulvar or perineal hematoma or other trauma; or indication of 3rd or 4th degree laceration on the birth certificate. Mothers were considered positive for "non-pelvic floor morbidity" if

they had ICD-9 diagnosis codes for postpartum hemorrhage, maternal infection, pelvic trauma, deep vein thrombosis, wound complication, pulmonary embolus, uterine rupture, anesthetic complication, severe anesthetic complication, respiratory failure, maternal shock, maternal sepsis, heart failure, renal failure, puerperal cerebral vascular accident (CVA), or disseminated intravascular coagulation (DIC), or ICD-9 procedure codes for blood transfusion, dilatation and curettage, hysterectomy, or ventilation. Indications of these maternal morbidities from birth certificate fields were also included where applicable. Discharge dispositions of death or birth certificate indication of maternal death during labor and delivery were also included (n = 118).

We evaluated pelvic floor morbidity because severe lacerations can have significant negative consequences for women, and episiotomy increases the risk of 3rd and 4th degree laceration.[22] There is some controversy about whether cesarean birth should be considered a morbidity in contemporary obstetrics.[6,17] We calculated morbidity rates including and excluding cesarean birth. When included, cesarean accounted for 53% of overall morbidity. We determined that mode of birth is best considered a risk factor for morbidity, and excluded cesarean from our final composite indicators.

We defined “severe morbidity” following the methods of Kuklina[7] and Callaghan.[8] Cases with a length of stay ≥90th percentile for mode of birth and an ICD-9 or birth certificate code for severe postpartum hemorrhage, maternal sepsis, deep vein thrombosis, pulmonary embolism, uterine rupture, respiratory failure, heart failure, puerperal CVA, severe anesthetic complication, maternal shock, DIC, or renal failure, were classified as severe. When ICD-9 or birth certificate codes indicated the woman had hysterectomy, ventilation, unplanned return to operating room, transfer to intensive care, or maternal death, these events were classified as severe morbidity regardless of length of stay.

We conducted unadjusted and multivariable analyses to examine associations between predictor variables and maternal morbidity. Predictor variables included year of birth, maternal socio-demographic factors, selected maternal co-morbidities, mode of birth, and hospital level factors. For unadjusted analyses, we used chi-square test for group comparisons with significance level $p<0.05$. Socio-demographic factors were included based on reports of substantial socio-demographic disparities in maternal health outcomes.[1,22,23] Maternal age, education, race, ethnicity, insurance status, and adequacy of prenatal care[24] were determined from birth certificate data. Maternal co-morbidities evaluated were diabetes, preeclampsia/eclampsia, and chronic hypertension, determined by ICD-9 codes. These co-morbidities, especially hypertensive disorders, reasonably could be classified as either risk factors or maternal morbidities. We chose to evaluate them as risk factors for birth-related morbidity.

We categorized hospital volume by number of annual births in each facility during each year of the study period: <1000, 1000-3000, and >3000.[2] To account for clustering of births within hospitals, we used mixed effects logistic regression models for the multivariable analyses, with individual hospitals as a random effect, and predictor variables as fixed effects. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) were estimated using PROC GLIMMIX in SAS 9.2 (SAS Institute, Cary, NC).

RESULTS

During 2005 to 2007, there were 1,572,909 live singleton births in California with linked records. Socio-demographic and pregnancy characteristics are reported in Table 1. The overall rate of maternal morbidity excluding cesarean was 241/1000 births. The morbidity rate declined 11% over the study period from 256/1000 in 2005 to 241/1000 in 2006 and

227/1000 in 2007 (p<.001). The most common morbidities were episiotomy, pelvic trauma, maternal infection, postpartum hemorrhage, and 3rd or 4th degree laceration, all of which were slightly lower in 2007 than in 2005. (Table 2) While postpartum hemorrhage overall was 9% lower in 2007 than in 2005, blood transfusion increased by 21% and severe postpartum hemorrhage increased by 10% (p<0.001). Although rare, hysterectomy increased by 27% over the study period (p=0.004). While pelvic floor morbidity and non-pelvic morbidity were 14% and 8% lower in 2007, respectively (p<0.001), severe morbidity was 9% higher in 2007 than in 2005 (p=0.02). Unadjusted relationships between potential risk factors and morbidity are shown in supplementary digital content (S2). Adjusted relationships are shown in Table 3.

Pelvic Floor Morbidity

The overall rate of pelvic floor morbidity was 156/1000 births. In unadjusted analyses, women had higher rates of pelvic floor morbidity if they were under age 18 (279/1000), age 18-25 (181/1000), Asian (238/1000), Non-Hispanic (165/1000), uninsured (191/1000), more educated (some college 164/1000; some post-graduate 183/1000) or primiparous (255/1000). Women had higher rates of pelvic floor morbidity with vaginal birth (222/1000) than with vaginal birth after cesarean (VBAC) (172/1000), or if they gave birth in a higher volume hospital (>3000 births 162/1000). Inadequate prenatal care was associated with lower pelvic floor morbidity (141 vs 160/1000). Women who reported being Black, American Indian/Alaskan Native, and Hawaiian/Pacific Islander or who had hypertensive disorders had lower rates of pelvic floor morbidity (S2).

In the multivariable analysis VBAC remained strongly associated with pelvic floor morbidity (Table 3). Asian race, higher education, and age (<18 and >36 years of age) were also associated with increased odds of pelvic floor morbidity. Odds for pelvic floor morbidity were lower for women who gave birth at low volume hospitals or had chronic hypertension, were multiparous, or were Black, American Indian/Alaskan Native, Hawaiian/Pacific Islander, or Hispanic. Lack of insurance was not significantly associated with pelvic floor morbidity.

Non-Pelvic Floor Morbidity

The overall rate of non-pelvic floor morbidity was 97/1000 births. In unadjusted analysis, women under age 26 had higher rates of non-pelvic floor morbidity (<18, 128/1000; 18-25 106/1000), as did women who were primiparous (133/1000), had preeclampsia (144/1000) or chronic hypertension (137/1000), or gave birth by VBAC or primary cesarean (130/1000 and 135/1000, respectively). Hawaiian/Pacific Islander (126/1000) or other non-White race, and inadequate prenatal care were also risk factors for non-pelvic floor morbidity (S2). Mothers with Medi-Cal/government insurance had lower rates of non-pelvic floor morbidity (93/1000) compared to mothers with private insurance (101/1000), no insurance or self-pay (98/1000). Mothers who gave birth by repeat cesarean also had lower non-pelvic floor morbidity rates. In multivariable analysis Hawaiian/Pacific Islander and other non-white races, Hispanic ethnicity, non-private or no insurance, hypertensive disorders, VBAC, and primary cesarean birth were associated with higher non-pelvic floor morbidity (Table 3). Repeat cesarean section births, mulitparity, and postgraduate education were associated with lower rates of non-pelvic floor morbidity.

Severe Morbidity

The overall rate of severe morbidity during the study period was 5.8/1000 births. Severe morbidity was higher in women who had the co-morbidities of chronic hypertension (24/1000) and preeclampsia (20/1000) than those who did not (5.7/1000 and 4.9/1000, respectively), and was elevated in women with diabetes (9.3/1000 vs. 5.6/1000) (S2).

Compared to vaginal birth, the rate of severe morbidity was higher in repeat cesarean (8.1/1000) and VBAC (8.5/1000), and more than doubled in primary cesarean birth (9.4/1000).

In crude analysis for severe morbidity, Black, American Indian/Alaskan Native, and Hawaiian/Pacific Islander women had higher rates of severe morbidity (9.4, 7.4 and 6.9/1000, respectively) compared to White women (5.5/1000), with Black women bearing a high burden of serious morbidities (Supplementary digital content S3). Women under 18 and over 35 had higher rates of severe morbidity (7.3 and 9.3) than women 18-25 (5.0/1000). Women who gave birth in higher volume hospitals had lower rates of severe morbidity.

In the multivariable analysis, post-graduate education and multiparity were associated with lower severe morbidity (Table 3). Odds for severe morbidity were increased in women over 35. Odds for severe morbidity were significantly higher in Black, Asian, and Hispanic women and women without private insurance, giving birth in hospitals with <3000 annual births, and giving birth by VBAC or cesarean section. Preeclampsia, maternal age over 35 years, VBAC and cesarean birth conferred the highest odds of severe morbidity.

DISCUSSION

Nearly one in four California women giving birth during the study period experienced morbidity during their childbirth hospitalization. As would be expected, hypertensive disorders were associated with increased risk of non-pelvic and severe morbidity, and preeclampsia was the strongest risk factor for severe morbidity. Black women had increased risk for severe morbidity. Women of Asian race had increased risk for all types of morbidity, though the risk was highest for pelvic floor morbidity. Women of all other non-White races had lower risk of pelvic floor morbidity but increased risk of non-pelvic floor morbidity. While cesarean birth had virtually no risk for pelvic floor involvement, primary cesarean birth conferred increased odds of both non-pelvic floor and severe morbidity; repeat cesarean birth was also significantly associated with severe morbidity. Women who gave birth by VBAC accounted for only 1% of births and had a morbidity pattern similar to Asian women, with increased risk for all types of morbidity and highest risk for pelvic floor morbidity.

Declining overall morbidity during the study period stands in contrast to reports of increasing maternal mortality;[4] however the rate of severe morbidity increased. In our study 379,345 women (241/1000 births) had morbidity. A substantial portion of morbidity was due to episiotomy, 3rd or 4th degree laceration, pelvic trauma, and postpartum hemorrhage, suggesting that much of this morbidity may be preventable.

An overarching goal of Healthy People 2020 is to reduce health disparities.[23] Substantial differences in pelvic floor morbidity in Asian women are consistent with a recent study of perineal trauma that suggests risk factors for perineal trauma may be mostly non-modifiable.[22] However, others have reported successful interventions for lowering severe laceration rates,[26] suggesting that like central line infections, perineal trauma may be more preventable than previously believed. Higher risk for severe morbidity in Black women is consistent with their much higher rates of maternal mortality in the US population.[1,2] This pressing public health problem has persisted over the past five decades.[1,2,27] We found that among women with childbirth morbidities, serious morbidities such as pulmonary embolus, respiratory failure, shock, and death were more common in Black mothers than in other racial groups. Focused exploration of the reason for conditions disproportionally affecting Black mothers could aid efforts to reduce maternal mortality in Black women.

Hospital volume was a risk factor for morbidity. Our finding of greater risk for severe morbidity in smaller volume hospitals is consistent with literature on decreased morbidity with higher volumes for certain conditions.[12,13] This may be due to having fewer resources to address serious complications when they occur without time for transfer to a higher level of care, and is a concerning finding considering that in 2008, 58% of US hospitals providing obstetrical care had a volume of less than 1000 annual births.[28] Circumstances leading to severe morbidity and requiring complex coordinated perinatal care may be similar to some surgical conditions in which lower volume is associated with increased mortality.[13] Unfortunately interventions to improve care coordination are challenging to replicate in disparate contexts, and measuring their efficacy is difficult.

The significant association between primary cesarean and morbidity after controlling for demographic and obstetric risk factors is similarly quite concerning. Some factors that may have led to a cesarean birth could also lead to morbidity, and our study design cannot determine causality. However, contrary to public health goals,[3] the primary cesarean rate is increasing, without demonstrated benefit to mother or infant.[29,30] For our primary analysis, we classified cesarean birth as a predictor rather than an outcome given its prevalence[6] and concerns that cesarean birth may best be considered a process rather than an outcome indicator.[17,25] If cesarean births were included they would account for more than half of childbirth morbidity and the overall morbidity rate would be 52%, substantially higher than the estimate of 48.5% for a national sample of birth hospitalizations in 2001-2005.[6] The association between primary cesarean and severe morbidity, particularly, lends urgency to efforts to reevaluate practices regarding primary cesarean. This urgency is reinforced by the association of severe morbidity with both VBAC and repeat cesarean, modes of birth that can only be avoided through prevention of primary cesarean.

We acknowledge the inherent limitations of hospital discharge data and vital statistics data including the time lag between the provision of services and data analysis. If there is a systematic bias in the coding of administrative data, it is likely to be toward under-reporting of some morbidities.[16,19,20] There is also likely to be some misclassification of co-morbidities when assessed by ICD-9 codes. We note that variation in reported education levels across the three years in our study is greater than expected, and there may have been misclassification of education levels in 2006 due to changes in California reporting requirements [21]. Furthermore, the social determinants of maternal health are complex. Education level and insurance status represent a fairly crude approximation of socioeconomic status. However, compared to hospital discharge data alone, the linkage of vital statistics data with administrative discharge data provides an improved level of analysis of socio-demographic risk, and is a strength of this study. While there are limitations to analyzing the data from a single state, particularly in relation to racial and ethnic population representativeness, approximately one in seven US births occur in California, and our three years of data provide a cohort size that allows for analysis of rare outcomes. We were not able to evaluate the contribution of body mass index, behavioral risk factors, or labor interventions to maternal morbidity, and these are important areas of investigation. California began reporting mother’s pre-pregnancy weight, delivery weight, height, and smoking status in electronically collected vital records data in 2007.

Our mixed effects model and volume analysis account for hospital characteristics to some degree, but do not illuminate specifically what is most important at the hospital level. Continued research is needed to better understand the range of factors contributing to observed racial and ethnic differences in maternal morbidity and mortality. While some disparities may be attributable to biologic factors that are difficult to control at the time of birth, some could potentially be addressed through targeted interventions to reduce specific morbidities.

In summary, maternal morbidity at the time of birth is common, and while affecting women from all socioeconomic strata, it is more common and more consequential in specific high-risk groups. Our findings regarding the association between severe morbidity and low birth volume hospitals and between primary cesarean births and non-pelvic and severe morbidity suggest opportunities for improving care. Establishing and simulating the implementation of emergency protocols could help facilities with more limited resources respond quickly and effectively to serious complications when they arise. Reducing maternal morbidity and reducing cesarean births among low-risk women are public health priorities.[3] Renewed attention to reducing use of cesarean birth could have a synergistic effect on maternal morbidity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Maternal Characteristics, by Year

	2005 %	2006 %	2007 %	Total
Education [a]				
Less than High School	28.4	38	28.2	481498
High School	28.3	18.1	27.3	374847
Some college	31.9	36.4	37	536326
Some post-graduate	11.4	7.5	7.6	134259
Maternal age				
<18	3.3	3.3	3.3	51653
18-25	34.4	34.7	34.4	542198
26-35	49.4	48.9	49.1	772772
>35	13	13.1	13.2	206285
Race				
White	78.9	78.4	77.3	1229313
Black	5.2	5.3	5.2	82760
American Indian/Alaskan Native	0.5	0.5	0.5	7586
Asian	11.4	11.4	11.9	181534
Hawaiian/Pacific Islander	0.5	0.5	0.5	7298
Other/Multirace	3.5	4	4.7	64418
Ethnicity				
Non-Hispanic	46.5	45.7	45.5	722099
Hispanic	52.2	52.9	53.2	830122
Unknown	1.2	1.4	1.3	20688
Payor				
None/self	2.9	2.8	2.8	44361
Medi-cal/government	49.5	50	50.5	784487
Private	47.7	47.2	46.7	739983
Parity				
Primiparous	39.2	39.5	39.8	620782
Multiparous	60.8	60.5	60.2	951130
Prenatal care [b]				
Inadequate	19.5	19.4	21.6	317364
Adequate	80.5	80.6	78.4	1255545
Co-Morbidities				
Diabetes				
No	93.6	93.2	92.6	1464614
Yes	6.4	6.8	7.4	108295
Preeclampsia				
No	94.2	94	94	1479681
Yes	5.8	6.0	6.0	93228

	2005 %	2006 %	2007 %	Total
Chronic Hypertension				
No	99.1	99	99	1557890
Yes	0.9	1	1	15019
Mode of Birth				
Vaginal	70	69.4	68.7	1091172
VBAC	0.8	0.7	0.7	11477
Primary Cesarean	16.3	16.6	16.8	260363
Repeat Cesarean	12.9	13.3	13.8	209897

Abbreviation: VBAC, Vaginal Birth after Cesarean

[a]Number of years of education were reported prior to 2006, rather than degree information. In 2006-2007 there was a transition of reporting education levels were according to new 2003 US standard birth certificate specifications. Categories reported here were developed to account for education level across the three years of data.

[b]Kotelchuck Adequacy of Prenatal Care Utilization Index[24]

Table 2

Births and Morbidity Rates, by Year

	2005	2006	2007	Total Period		
Number of singleton births	512869	527632	532408	1572909		
	Morbidities per 1000 births				**Events**	
Composite Morbidities	**2005**	**2006**	**2007**	**Total Period**	**n**	
Pelvic floor morbidity[a]	169	153	146	156	245095	
Non-pelvic floor morbidity[b]	99	100	91	97	152089	
Any pelvic or non-pelvic floor morbidity	256	241	227	241	379345	
Cesarean birth counted as an additional morbidity	516	508	504	516	800836	
Severe morbidity[c]	5.6	5.8	6.1	5.8	9190	
Individual Morbidities	**2005**	**2006**	**2007**	**Total Period**	**n**	**% of women with non-pelvic floor morbidity [b]**
Episiotomy	148	133	125	136	213229	-
Pelvic trauma	33.1	34.1	29.3	32.2	50593	33.3
Maternal infection	28.4	28.0	26.3	27.5	43312	28.5
Postpartum hemorrhage	28.3	28.3	25.7	27.4	43124	28.4
3rd or 4th degree laceration	26.2	23.8	22.0	24.0	37759	-
Blood transfusion	5.7	6.4	6.9	6.3	9961	6.6
Severe postpartum hemorrhage	4.8	4.9	5.3	5.0	7854	5.2
Anesthetic complication	3.6	3.6	3.3	3.5	5548	3.6
Wound complication	3.4	3.7	3.3	3.5	5493	3.6
Heart failure	3.8	2.9	2.7	3.1	4897	3.2
Other pelvic floor	3.3	3.5	6.1	4.3	6766	-
Dilatation & curretage	2.7	2.5	2.7	2.6	4154	2.7
Disseminated intravascular coagulation	1.2	1.1	1.3	1.2	1890	1.2
Uterine rupture	1.0	1.0	1.1	1.0	1628	1.1
Maternal Sepsis	0.9	0.9	1	0.9	1486	1
Hysterectomy	0.7	0.8	0.8	0.8	1195	0.8
Respiratory failure	0.6	0.6	0.7	0.6	1006	0.7
Ventilation	0.5	0.5	0.5	0.5	761	0.5
Maternal shock	0.4	0.4	0.5	0.4	702	0.5
Deep vein thrombosis	0.3	0.3	0.3	0.3	502	0.3
Severe anesthetic complication	0.3	0.3	0.3	0.3	476	0.3
Renal failure	0.3	0.2	0.3	0.3	407	0.3
Puerperal cardiovascular accident	0.2	0.2	0.2	0.2	313	0.2
Pulmonary embolus	0.2	0.1	0.2	0.2	264	0.2

	2005	2006	2007	Total Period		
Maternal death during childbirth hospitalization	0.08	0.09	0.05	0.07	118	0.08

[a]Pelvic floor morbidity includes episiotomy, 3-4th degree laceration, and vulvar or perineal hematoma or other trauma to vulva or perineum.

[b]Cesarean birth without other morbidity not counted in “any morbidity” composite. Total of individual morbidities greater than 100% as some women had more than one complication.

[c]Severe morbidity = ICD9-CM or birth certificate codes present for hysterectomy, ventilation, unplanned return to operating room, transfer to intensive care, or maternal death, OR an ICD9-CM or birth certificate code for severe postpartum hemorrhage, maternal sepsis, deep vein thrombosis, pulmonary embolism, uterine rupture, respiratory failure, heart failure, hysterectomy, puerperal CVA, severe anesthetic complication, maternal shock, DIC, or renal failure and length of stay ≥90th percentile for mode of birth.

Table 3
Adjusted Maternal Morbidity, by Risk Factors

Predictor Variable	Adjusted Odds Ratio[a] (95% Confidence Interval)		
	Pelvic floor morbidity	Non-pelvic floor morbidity	Severe morbidity
Education			
Less than HS	0.97 (0.95, 0.98)	0.99 (0.98, 1.01)	1.05 (0.99, 1.12)
High school	1 reference	1 reference	1 Reference
Some college	1.1 (1.08, 1.12)	0.98 (0.96, 0.99)	0.95 (0.89,1.01)
Some post-graduate	1.24 (1.21, 1.27)	0.92 (0.9, 0.94)	0.81 (0.74, 0.89)
Maternal Age			
<18	1.12 (1.09, 1.15)	1 (0.97, 1.03)	1.2 (1.07, 1.34)
18-25	1 reference	1 reference	1 Reference
26-35	1.04 (1.03, 1.06)	0.94 (0.93, 0.95)	1.22 (1.15, 1.29)
>35	1.16 (1.13, 1.18)	1 (0.98, 1.02)	1.92 (1.79, 2.06)
Race			
White	1 reference	1 reference	1 reference
Black	0.59 (0.57, 0.60)	1.11 (1.08, 1.14)	1.47 (1.34, 1.60)
American Indian/Alaskan Native	0.76 (0.70, 0.82)	1.12 (1.04, 1.21)	1.30 (0.99, 1.71)
Asian	1.60 (1.57, 1.62)	1.18 (1.16, 1.2)	1.16 (1.08, 1.26)
Hawaiian/Pacific Islander	0.81 (0.74, 0.88)	1.37 (1.27, 1.47)	1.19 (0.90, 1.59)
Other/Multi-race	0.83 (0.80, 0.85)	1.04 (1.01, 1.08)	1.06 (0.94, 1.21)
Ethnicity			
Hispanic	0.83 (0.81, 0.84)	1.15 (1.14, 1.17)	1.11 (1.04, 1.18)
Non-Hispanic	1 reference	1 reference	1 Reference
Unknown	0.96 (0.85, 1.09)	1.08 (0.95, 1.22)	1.24 (0.80, 1.93)
Payor			
Medi-Cal/Govt/Other	0.97 (0.96, 0.99)	1.06 (1.04, 1.08)	1.24 (1.16, 1.32)
None/Self	1.03 (0.997, 1.06)	1.13 (1.09, 1.17)	1.29 (1.12, 1.48)
Private	1 Reference	1 reference	1 Reference
Parity			
Primiparous	1 Reference	1 reference	1 reference
Multiparous	0.21 (0.21, 0.22)	0.57 (0.56, 0.58)	0.64 (0.61, 0.68)
Prenatal care [b]			
Inadequate	1.0 (0.99, 1.02)	1.03 (1.01, 1.04)	1.03 (0.98, 1.09)
Adequate	1 Reference	1 reference	1 Reference
Co-Morbidities			
Diabetes			
Yes	0.98 (0.96, 1.00)	0.94 (0.92, 0.96)	1.08 (1.01, 1.16)
No	1 reference	1 reference	1 Reference
Preeclampsia			
Yes	0.93 (0.91, 0.96)	1.27 (1.24, 1.3)	2.96 (2.8, 3.13)

	Adjusted Odds Ratio[a] (95% Confidence Interval)		
Predictor Variable	**Pelvic floor morbidity**	**Non-pelvic floor morbidity**	**Severe morbidity**
No	1 reference	1 reference	1 Reference
Chronic Hypertension			
Yes	0.77 (0.72, 0.84)	1.1 (1.05, 1.16)	1.45 (1.29, 1.63)
No	1 reference	1 reference	1 Reference
Hospital volume			
< 1000	0.78 (0.7, 0.86)	0.97 (0.89, 1.05)	1.27 (1.06, 1.52)
1000-3000	0.93 (0.91, 0.96)	1.05 (1.01, 1.1)	1.15 (1.02, 1.31)
> 3000	1 reference	1 reference	1 Reference
Mode of Birth			
Vaginal	1 reference	1 reference	1 Reference
VBAC	2.16 (2.04, 2.27)	1.51 (1.42, 1.59)	1.81 (1.47, 2.23)
Primary Cesarean	0.004 (0.003, 0.004)	1.36 (1.34, 1.38)	1.59 (1.51, 1.67)
Repeat Cesarean	0.004 (0.003, 0.005)	0.88 (0.86, 0.9)	1.99 (1.87, 2.12)

Abbreviation: VBAC, Vaginal Birth after Cesarean.

[a]Mixed effects logistic regression model with individual hospital as random effect and predictor variables as fixed effects.

[b]Kotelchuck Adequacy of Prenatal Care Utilization Index[24]