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# Mothers at Risk

## *Factors Affecting Maternal Postpartum Length of Stay*

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**ABSTRACT**

Perinatal complications linked to maternal comorbidities contribute to increased healthcare utilization through an extended postpartum length of stay (LOS). Understanding factors influencing postpartum LOS may minimize the adverse effects associated with comorbidities and complications. The purpose of this study was to identify risk factors with the greatest odds of increasing postpartum LOS. Linked 2008-2009 hospital discharge and birth certificate data were used to examine comorbidities and complication codes in 1 015 424 births. The overall rate for an extended LOS (vaginal: >5 days/cesarean: >6 days) was 3.63 per 1000 live births. Complications were present in 17% of pregnancies; multiple complications were seen in 1%. Chronic hypertension was associated with an extended stay for both vaginal and cesarean births (odds ratio [OR] = 5.89 [95% CI, 4.39-7.88]; OR = 3.57 [95% CI, 3.05-4.17], respectively). Puerperal infections (OR = 6.86 [95% CI, 5.73-8.21]), eclampsia (OR = 17.07 [95% CI, 13.76-21.17]), and transfusions (OR = 11.66 [95% CI, 9.20-14.75]) occurred most frequently and conferred the highest odds of an extended stay for vaginal births. Cerebrovascular conditions (OR = 15.32 [95% CI, 11.90-19.60]) and infection (OR = 15.35 [95% CI, 10.11-23.32]) conferred the highest odds of an extended LOS for cesarean births. The earlier risk factors are recognized, the sooner processes can be initiated to optimize organizational preparation, thus decreasing adverse maternal outcomes and extended hospital stays.

**Key Words:** maternal morbidity, postpartum length of stay, risk factors

In the United States, nearly 4 million women give birth annually, making childbirth the most common reason for hospitalization in adults 18 to 44 years of age and one of the main contributors to overall healthcare utilization and cost.[1,2] The majority of pregnant women remain low risk, with minimal, if any, significant adverse outcomes. Unfortunately, despite improved resources in women's health, a substantial number of pregnancies begin or end with complications. In 2014, US data showed a 26.6% increase in maternal mortality between 2000 (18.8 per 100 000 live births) and 2014 (23.8 per 100 000 live births); notably, 2 to 3 women die from pregnancy-related complications per day.[3–6] These rates are in direct contrast to the global decrease in maternal mortality rates by more than a third from 2000 to 2015.

The process of pregnancy and birth, albeit a major life event, is a natural, developmental, physiological stage. Although a woman's body goes through extraordinary physical changes to adapt to the needs of the growing fetus, the majority of women do so without medical concern. For a small percentage of women, the changes that occur trigger a cascade of events, which can lead to tragic results including maternal morbidity and mortality.[7] Complications during pregnancy can pose a serious risk to both maternal and fetal health. Consequently, recent research in obstetrics has focused on finding answers to the questions of who is at risk and how do healthcare professionals recognize and minimize the effects of these risks.

The number of high-risk pregnancies due to maternal comorbidities and complications has significantly

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increased, leading to an increased number of adverse maternal health outcomes postdelivery requiring increased length of stay.[7–10] Berg and associates[11] compared 2 time periods (1993-1997 and 2001-2005) and found the overall rate of complications remained unchanged at 28.6%, but the prevalence of preexisting medical conditions at delivery increased from 4.1% to 4.9%. The percentage of delivery hospitalizations with postpartum hemorrhage, severe preeclampsia, transient hypertension of pregnancy, postpartum fever of unknown origin, gestational diabetes, preexisting diabetes mellitus, and asthma increased significantly. Women with previous or current complications are 3 to 4 times more likely to be admitted to the intensive care unit with higher rates of eclampsia, acute renal failure, and placental abruption.[12,13] Pourat et al[14,15] note that accrued inpatient days dramatically increase the costs associated with adverse maternal outcomes that are often preventable with improved access to care and appropriate resources.

Identifying the risk factors for an extended length of stay for both vaginal and cesarean births could serve as an important quality indicator when assessing perinatal care. Estimating the potential impact of individual and group risk profiles could also facilitate the development of policies on early identification and appropriate care to decrease risk. The purpose of this study was to identify risk factors with the greatest odds of increasing length of postpartum hospitalization. Recognizing elements influencing the hospitalization period may help decrease the length of hospital stay, reduce costs, and improve efficiency of obstetric units.

## LITERATURE REVIEW

### Maternal morbidity and mortality

Possible factors affecting the increase in morbidity and mortality rates may include changes in the underlying risk profiles of women (ie, age, parity, obesity, previous cesarean birth) and changes in clinical practice (ie, inductions and cesarean birth). Risk factors for severe maternal morbidity are identifiable during the antepartum, intrapartum, and postpartum periods.[16] Research findings indicate that women with severe maternal morbidity were more likely to be older (35-39 years), of nonwhite race/ethnicity, unmarried, of lower level of education, at the extremes of parity (ie, nulliparous or 3+ pregnancies), have a preexisting medical condition, and on Medicaid, as compared with controls.[16,17] Women older than 34 years and non-Hispanic black women were disproportionally represented among patients with morbidity or mortality.[17] Women with severe morbidity were also more likely to have multiple-fetus births, a cesarean birth, a low-birth-weight or preterm infant, and received adequate prenatal care.[16] The most common severe maternal morbidities were transfusion, hysterectomy, respiratory failure, disseminated intravascular coagulation, acute liver disease, acute respiratory distress syndrome, and acute heart failure.[16,17] One or more of these complications were present in 68.4% of the patients.[17] Indeed, women with comorbidities had 2 times the risk of having severe maternal morbidity than those without any risk factors.[16] Findings indicate that most of the near-miss morbidity events occurred in patients with high-risk conditions, generally identifiable at the time of admission to the labor unit.[17] Opportunities to improve outcomes may exist by triaging high-risk women to delivery centers with increased capacity to deliver intensive antepartum and peripartum care.

Kuklina et al[10] examined trends in the rates of severe maternal complications and the potential contribution of these complications to cesarean birth rates and maternal age. The prevalence of deliveries complicated by at least 1 severe obstetric complication increased from 0.64% to 0.81%, including renal failure, pulmonary embolism, adult respiratory distress syndrome, shock, blood transfusion, and mechanical ventilation. An increase in the number of women with multiple-fetus pregnancy, hypertension, diabetes, and cesarean delivery was also noted. Adjustment for maternal age had no effect on the increased risk, but adjustment for cesarean birth explained a majority of the increase in risks of renal failure, adult respiratory syndrome, and need for mechanical ventilation. More recently, previous estimates of severe maternal morbidity during both delivery and postpartum hospitalizations were updated. Compared with 1998-1999, severe complications during delivery hospitalization increased by 75% and by 114% during postpartum hospitalization in the period 2008-2009.[7] Blood transfusion was the leading reason for being classified as having severe morbidity across all time periods for both delivery and postpartum hospitalizations. Increases in many complications including acute renal failure, shock, thrombotic pulmonary embolisms, respiratory distress syndrome, acute myocardial infarction, aneurysms, and operations of the heart and pericardium were noted. During the study period, increases in the cesarean delivery rate and in the proportion of pregnant women with chronic conditions, postpartum hemorrhage, obesity, multiple-fetus births, and advanced maternal age were documented. Lyndon et al[18] further support the risks of age, minority status, inadequate prenatal care, and comorbidities including hypertension, preeclampsia, and diabetes as being associated with higher morbidity.

Substantial disparities in maternal morbidity across racial-ethnic groups may further influence maternal morbidity. Guendelman et al[19] found that black women

experienced more combined morbidities than white women (24.2% vs 21.3%, respectively); Asian women are at a higher risk of deliveries with major lacerations, postpartum hemorrhage, and major puerperal infections. From 2006 to 2008, black women in California were almost 4 times more likely to die from pregnancy-related causes, with 46.1 deaths per 100 000 live births, compared with 12.8 for Hispanic women, 12.4 for white women, and 9.3 for Asian women.[20] These rates have often been associated with demographic variables such as age, educational level, marital status, and residence. Other explanations for these racial health disparities include the higher rates of preexisting medical conditions in black women including obesity, hypertension, and diabetes, as well as decreased healthcare access due to poverty.[20]

Adverse maternal outcomes are often preventable with improved access to care and appropriate resources.[21–24] Forty percent of pregnancy-related deaths are potentially preventable depending on the cause of death.[25] For example, deaths due to hemorrhage and complications of chronic diseases were determined to be preventable with earlier identification and rapid, aggressive treatment. Changes in several areas including preconception care, patient actions, system factors, and quality of care contribute to the preventability of death. In additional studies, it was noted that among women with complications, the most common types of preventable events were related to inadequate diagnosis/recognition of high-risk status by the provider, inappropriate treatment primarily due to delay in treatment, and inadequate documentation.[17,21,22]

### Postpartum length of stay

As complications related to pregnancy, labor, and delivery increase, the likelihood of longer postpartum stays due to more extensive care will increase. Factors with the greatest influence on maternal length of stay have been identified.[26] Notably, the mean length of stay increased in an approximately linear fashion with the number of risk factors identified. A significant increase in length of stay was noted among women whose infants required specialized neonatal care, women with certain social problems, and women with obstetric or medical complications. Women with primarily obstetric complications were the most likely to have an extended length of stay. In a study examining prepregnancy obesity and excess pregnancy weight gain, Mamun et al[27] found that mothers with excess prepregnancy body mass index (BMI) and mothers who gained excess weight during pregnancy were at greater odds of pregnancy complications and cesarean delivery and had excess length of stay. Most recently, Blumenfeld et al[28] identified risk factors for prolonged postpartum length of stay after cesarean delivery. The authors noted that women with perioperative complications such as general anesthesia, uterine atony, hysterectomy, intraoperative or postpartum transfusion, wound complication, ileus, or endometritis had the highest risk for a prolonged postpartum length of stay. Several antepartum and neonatal variables were also associated with longer hospitalization including BMI of more than 40, diabetes, asthma, chronic hypertension, multiple-fetus pregnancy, pregnancy-associated hypertension, gestational age, and neonatal birth weight.

## METHODS

### Design and source of data

A retrospective cohort study design was used that linked data from several sources. Applying probabilistic linkage techniques that allow for the identification of records most likely to be matches, (*a*) maternal discharge procedure, (*b*) diagnostic *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes, and (*c*) hospital length of stay were extracted from hospital discharge records and linked to (*a*) time of birth, (*b*) maternal sociodemographic and (*c*) birth features contained in the birth statistical master file.[18,29] Birth certificate data included reported educational level, race/ethnicity, mother's birth date, parity, pre- and postpregnancy weights, initiation of prenatal care, comorbidities, gestational age, and birth weight. The linkage between these 2 databases has been studied previously and has been found to be 97% to 100% accurate.[30] The California Office of Statewide Health Planning and Development created and executed the linkage strategy. This study was approved by the State of California and Stanford University/University of San Diego institutional review boards.

### Study sample and variables

The study population consisted of women in California delivering infants from January 2008 to December 2009, which were the most recent years available at the time the analysis was performed. The *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) diagnostic and procedural codes were used to identify various diagnoses and outcomes.[11,16,31] Postpartum length of stay, the primary outcome, was calculated by subtracting the infant date of birth from the discharge date of the mother. Because postpartum length of stay varies by birth type, the data were first stratified into mode of birth (vaginal/assisted vs cesarean birth). An expected length of stay, as defined by law, is up to 2 days for a vaginal birth and 4 days for a cesarean birth.[32] To take into account additional hospital days due to minor maternal events such

as anemia, transient hypertension, or postpartum fever of unknown origin, the dependent variable of a clinically significant extended length of stay was defined as 5 or more days for vaginal birth and 6 or more days for cesarean birth. These arbitrary cut points were based on published research and the authors' clinical experience.[7,10] Predictor variables for increased odds ratios (ORs) of an extended length of stay were chosen on the basis of the availability within the existing data set and categorized to include maternal and obstetric characteristics, as well as comorbidities and complications. Maternal characteristics included age, level of education, race, payer source, trimester of initiation of prenatal care, parity, and BMI. The BMI was calculated using maternal height and weight prior to pregnancy. Although marital status and smoking have been shown to increase maternal risk, these items are inconsistently reported and were not included in this study. Obstetric characteristics included multiple-fetus gestation, previous cesarean birth, gestational hypertension and/or diabetes, placenta previa, birth weight, and gestational age at birth.

Mothers were considered positive for comorbidities if they had *ICD-9* diagnosis codes for depression, substance use, asthma, chronic hypertension, coagulation disorders, diabetes, lupus, or cardiac, renal, or liver conditions. Women were regarded as positive for complications if *ICD-9* diagnosis codes for hemorrhage, puerperal infections, mild preeclampsia, severe preeclampsia/eclampsia, cerebrovascular disorders, other puerperal complications, respiratory failure, obstetric shock, cardiac events, renal failure, or infection or *ICD-9* procedure codes for transfusion, hysterectomy, mechanical ventilation, or hemodynamic monitoring were identified.

Data were available on a total of 1 079 318 live births occurring during the study years. Records from facilities that did not report hospital discharge data (military hospitals and freestanding birth centers, $N = 36\,449$; 3.4% of total records) were excluded. Two percent of linked records ($n = 21\,428$) were also excluded for the following reasons: duplicate mothers (mothers of multiples), nonbirthing facilities, missing insurance status, parity, maternal place of birth, invalid postpartum length of stay (negative values), maternal age less than 11 years or more than 59 years, height extremes (<48 in or >84 in), gestational age less than 17 weeks or more than 47 weeks, birth weight less than 227 g or more than 8165 g, and/or hospitals with fewer than 50 births. An additional 0.5% of linked records ($N = 6017$) from births that fell between the defined expected and extended lengths of stay were also excluded. As noted in Figure 1, the final study sample contained 1 015 424 linked records.

### Statistical methods

The statistical analyses consisted of 2 parts. First, a 2-way table was constructed that contained frequencies of cases for each level of the predictor variables, stratified by method of birth (vaginal/assisted vs cesarean birth) and length of stay (expected vs extended). Pearson $\chi^2$ tests were computed to test equality of proportions for each predictor variable within each birth method. Second, a binary logistic regression was employed to model the odds in favor of an extended length of stay. Separate regressions were fitted for vaginal/assisted and for cesarean births. In the final multivariable logistic models, only predictors significantly associated with the extended length of stay at the less than .05 level of significance were retained. Data analysis was conducted by the California Perinatal Quality Care Collaborative/California Maternal Quality Care Collaborative data center. Analyses were performed with SAS 9.2 (SAS Institute Inc, Cary, North Carolina).

## RESULTS

The total number of mothers in the final data set who experienced an extended length of stay was 3707, with an overall rate of 3.63 per 1000 live births. The rate of an extended length of stay was higher among mothers who gave birth by cesarean birth than by vaginal birth (7.90/1000 live births vs 1.54/1000 live births, respectively). Percentage distribution for maternal sociodemographic/obstetric characteristics and comorbidities/complications for the expected and extended length of stay populations is reported in Tables 1 and 2, respectively. Separate analyses comparing expected and extended lengths of stay were performed for women with vaginal and cesarean births, and significant $P$ values (<.01) based on the Pearson $\chi^2$ test for equality of proportions are shown.

### Maternal/obstetric characteristics

Women with an extended length of stay were more likely to be at the extremes of age (<18 or >35 years), non-Hispanic black or Pacific Islander, public insurance recipients, nulliparous, have limited high school education, and have no prenatal care compared with women with an expected length of stay. Women with an extended length of stay were also more likely to deliver a low-birth-weight or preterm infant and have obstetric conditions such as gestational diabetes, gestational hypertension, placenta previa/abruption, and/or multiple-fetus gestations. For women delivering vaginally, an extended length of stay was more frequent in overweight women (BMI = 25.0-29.9). For cesarean births, extremely obese women (obese III: BMI >40) and

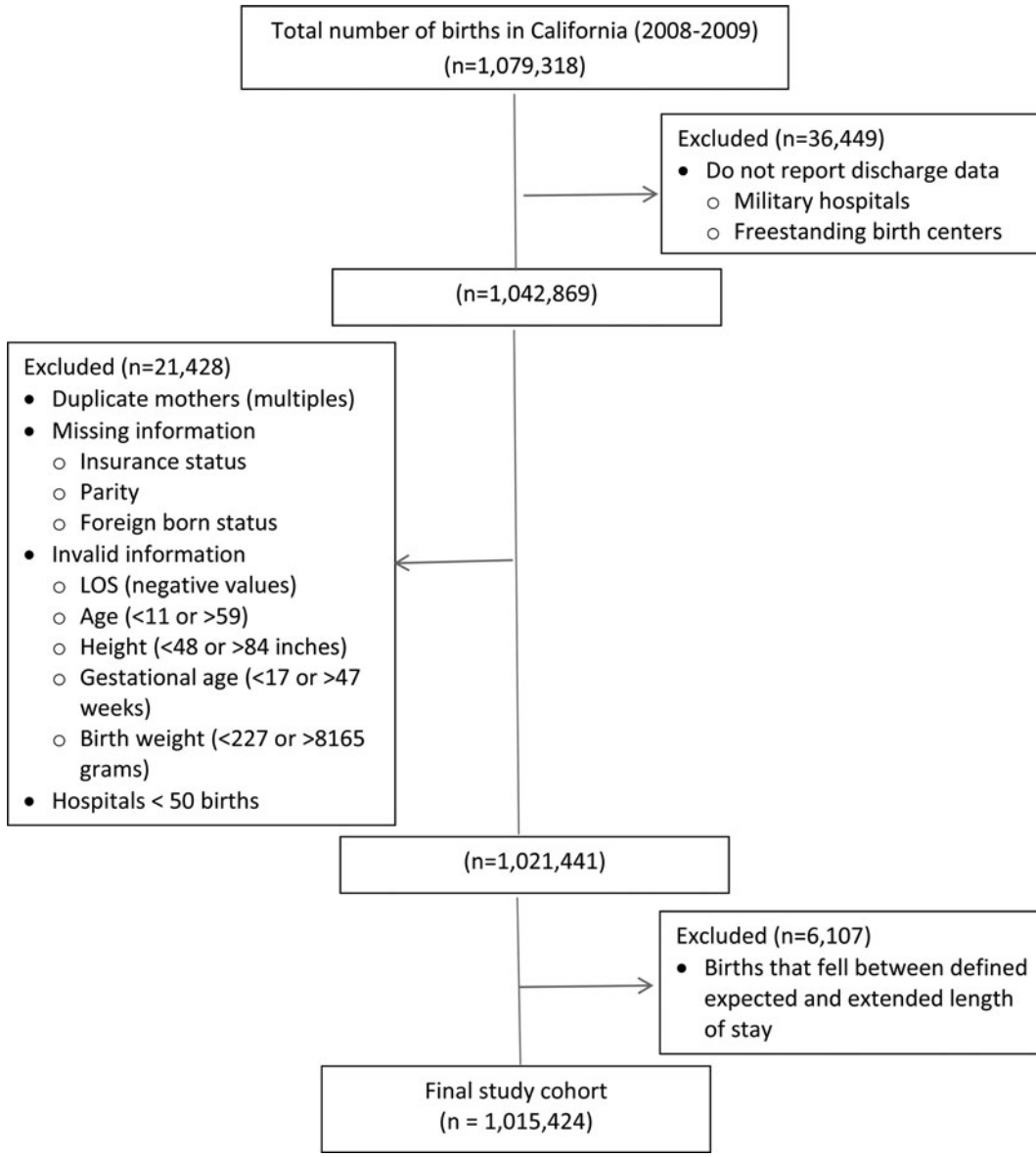


**Figure 1.** Consort diagram for study cohort. LOS indicates length of stay.

underweight women (BMI <18.5) more frequently had an extended length of stay.

### Comorbidities/complications

One comorbidity was present in 7% of all pregnancies; multiple comorbidities were seen in 1%. For women with an extended length of stay, nearly 25% had 1 comorbidity compared with 7% in women who had an expected length of stay. Nine percent of women with an extended length of stay had multiple comorbidities compared with less than 1% of women with an expected length of stay. For expected length of stay, the most common comorbidities for both modes of birth were depression, asthma, chronic hypertension, coagulation disorders, and diabetes (type 1 and 2). For women with an extended length of stay, cardiac conditions were more frequent than diabetes (type 1 and 2) for both vaginal and cesarean births. Comorbidities were higher in women delivering by cesarean birth.

In the study population, except for hemorrhage, women undergoing cesarean delivery experienced complications almost twice as frequently as did women having a vaginal birth. For women with an extended length of stay, nearly 34% had at least 1 complication and 35% had more than 1 complication compared with 8% and less than 1% in women with an expected

Table 1. **Maternal/obstetric characteristics by delivery method and length of stay**

| Characteristic | Vaginal | | Cesarean | |
|---|---|---|---|---|
| | % Normal (total) ($n = 683\,338$) | % Extended (total) ($n = 1\,058$) | % Normal (total) ($n = 328\,379$) | % Extended (total) ($n = 2\,649$) |
| *Maternal* | | | | |
| Age[a] | | | | |
| <18 y | 3.8 (25 833) | 5.0 (53) | 1.9 (6 255) | 3.3 (88) |
| 18-24 y | 30.7 (209 884) | 32.7 (346) | 22.9 (7 514) | 22.8 (605) |
| 25-29 y | 27.5 (188 031) | 19.0 (201) | 25.4 (83 478) | 20.1 (533) |
| 30-34 y | 23.3 (159 341) | 22.5 (238) | 26.4 (86 783) | 24.1 (638) |
| 35+ y | 14.7 (100 249) | 20.8 (220) | 23.4 (76 709) | 29.6 (785) |
| Race/ethnicity[a,b] | | | | |
| Non-Hispanic white | 26.7 (182 580) | 18.6 (197) | 26.9 (88 415) | 21.0 (556) |
| Non-Hispanic black | 5.4 (36 467) | 10.1 (107) | 6.3 (20 676) | 13.8 (365) |
| Asian | 9.7 (66 174) | 7.4 (78) | 9.1 (29 875) | 8.6 (229) |
| Pacific Islander | 3.2 (21 943) | 5.3 (56) | 3.6 (11 790) | 5.2 (138) |
| Hispanic | 53.1 (362 858) | 56.2 (595) | 51.9 (170 417) | 48.9 (1 294) |
| AI/Native Alaskan | 0.4 (3 029) | 0.3 (3) | 0.5 (1 469) | 0.5 (12) |
| Other | 0.1 (506) | 0.2 (2) | 0.1 (291) | 0.1 (3) |
| Payer[a] | | | | |
| Public | 48.7 (332 459) | 58.4 (618) | 47.2 (154 995) | 53.0 (1 405) |
| Private | 46.2 (315 359) | 36.1 (382) | 47.6 (156 350) | 41.6 (1 103) |
| None/uninsured | 2.0 (13 972) | 2.0 (21) | 1.9 (6 060) | 2.0 (52) |
| Other | 3.1 (21 548) | 3.5 (37) | 3.3 (10 974) | 3.4 (89) |
| Parity[a] | | | | |
| Nulliparous | 40.1 (274 424) | 51.5 (545) | 39.1 (128 471) | 50.3 (1 333) |
| 1-3 | 55.2 (377 084) | 41.4 (438) | 56.5 (185 591) | 42.7 (1 130) |
| 4+ | 4.7 (31 830) | 7.1 (75) | 4.4 (14 317) | 7.0 (186) |
| Education[b] | | | | |
| Some high school | 26.1 (178 566) | 31.8 (336) | 24.5 (80 453) | 25.5 (676) |
| High school/GED | 26.4 (180 760) | 25.7 (272) | 24.9 (81 934) | 25.2 (667) |
| Some college | 21.9 (149 378) | 20.3 (215) | 22.6 (74 251) | 23.3 (618) |
| College | 14.9 (101 516) | 10.7 (113) | 16.0 (52 542) | 13.2 (349) |
| Graduate | 7.5 (51 519) | 6.7 (71) | 8.7 (28 452) | 8.0 (211) |
| Prenatal care[b] | | | | |
| None | 0.5 (3 370) | 2.1 (22) | 0.4 (1 095) | 1.2 (31) |
| First trimester | 80.5 (550 035) | 76.1 (805) | 82.6 (271 304) | 80.5 (2 133) |
| Second trimester | 14.3 (98 179) | 15.8 (167) | 12.8 (42 046) | 12.6 (333) |
| Third trimester | 2.8 (18 884) | 3.6 (38) | 2.4 (7 948) | 2.0 (54) |
| Body mass index[a,b] | | | | |
| Underweight | 4.3 (29 102) | 4.1 (43) | 2.7 (8 875) | 3.4 (91) |
| Normal | 48.3 (330 311) | 45.3 (479) | 39.5 (129 842) | 38.0 (1 007) |
| Overweight | 22.9 (156 571) | 24.5 (259) | 24.6 (80 716) | 23.3 (616) |
| Obese I-II | 13.8 (94 113) | 13.0 (138) | 20.1 (65 969) | 18.5 (491) |
| Obese III | 1.8 (12 248) | 1.8 (19) | 4.3 (139 720) | 5.9 (155) |
| *Obstetric* | | | | |
| Multiple-fetus gestation[a] | 0.5 (3 283) | 2.3 (24) | 3.9 (12 694) | 9.3 (245) |
| Previous C-section[a] | 1.9 (12 894) | 3.6 (38) | 46.2 (151 700) | 27.4 (725) |
| Gestational HTN[a] | 2.1 (14 301) | 5.5 (58) | 3.4 (11 012) | 7.9 (209) |
| Gestational DM[a] | 5.8 (39 249) | 7.6 (80) | 9.5 (31 114) | 9.9 (262) |
| Placenta previa | 0.7 (5 038) | 2.5 (26) | 3.4 (11 065) | 9.1 (242) |
| Birth weight[a] | | | | |
| <2500 g | 4.3 (29 127) | 18.8 (199) | 8.5 (27 937) | 39.0 (1 033) |
| 2500-3999 g | 88.5 (604 967) | 74.4 (787) | 80.9 (265 495) | 54.6 (1 447) |
| >4000 g | 7.2 (49 244) | 6.8 (72) | 10.6 (34 947) | 6.4 (169) |
| Gestational age[a,b] | | | | |
| 20-29 wk | 0.4 (2 795) | 1.9 (20) | 1.0 (3 433) | 9.8 (259) |
| 30-36 wk | 5.6 (38 511) | 21.6 (229) | 9.9 (32 546) | 35.8 (948) |
| 37-40 wk | 85.4 (583 286) | 68.4 (724) | 82.0 (269 283) | 48.9 (1 297) |
| 40+ wk | 8.0 (54 942) | 7.4 (78) | 6.5 (21 257) | 4.7 (125) |

Abbreviations: AI, American Indian; DM, diabetes; HD, hemodynamic; HTN, hypertension.
[a] $P \leq .01$; [b] Total 100% includes unknown/missing data.

Table 2. **Comorbidites/complications by delivery method and length of stay**

| Characteristic | Vaginal | | Cesarean | |
|---|---|---|---|---|
| | % Normal ($n = 683\,338$) | % Extended ($n = 1\,058$) | % Normal ($n = 328\,379$) | % Extended ($n = 2\,649$) |
| Comorbidities | | | | |
| Depression[a] | 2.2 (15 164) | 6.4 (68) | 2.7 (8 747) | 7.7 (205) |
| Substance use | 0.2 (1 455) | 1.4 (15) | 0.3 (835) | 1.2 (32) |
| Asthma | 2.1 (14 363) | 4.0 (42) | 2.8 (9 227) | 5.7 (150) |
| Chronic HTN[a] | 0.9 (5 856) | 6.6 (70) | 2.2 (7 211) | 10.7 (284) |
| Coagulation disorders[a] | 0.6 (3 839) | 9.6 (101) | 1.0 (3 356) | 10.0 (266) |
| Diabetes[a] | 0.5 (3 081) | 1.9 (21) | 1.6 (5 217) | 4.2 (110) |
| Lupus[a] | 0.1 (597) | 0.9 (10) | 0.2 (540) | 1.2 (32) |
| Cardiac conditions[a] | 0.3 (2 215) | 3.2 (34) | 0.5 (1 692) | 5.7 (151) |
| Renal conditions[a] | 0.1 (855) | 1.1 (12) | 0.2 (568) | 1.7 (45) |
| Liver conditions[a] | 0.1 (518) | 0.7 (7) | 0.1 (378) | 1.2 (32) |
| Complications | | | | |
| Hemorrhage[a] | 2.7 (18 716) | 22.5 (238) | 1.7 (5 591) | 14.7 (389) |
| Puerperal infections[a] | 2.5 (2 221) | 20.7 (89) | 4.4 (14 367) | 3.1 (611) |
| Mild preeclampsia[a] | 1.5 (10 023) | 6.8 (72) | 2.6 (8 423) | 7.9 (209) |
| Preeclampsia/eclampsia[a] | 0.5 (3 261) | 15.8 (167) | 1.9 (6 266) | 18.6 (492) |
| Cerebrovascular[a] | 0.4 (2 841) | 6.1 (64) | 0.3 (912) | 8.9 (238) |
| Puerperal complications[a] | 0.3 (17 085) | 8.4 (219) | 0.7 (2 248) | 8.7 (230) |
| Respiratory failure[a] | 0.01 (59) | 6.2 (66) | 0.2 (469) | 12.1 (321) |
| Obstetric shock[a] | 0.01 (39) | 3.7 (39) | 0.03 (91) | 4.1 (109) |
| Cardiac events[a] | 0.01 (35) | 1.1 (12) | 0.1 (179) | 3.4 (90) |
| Renal failure[a] | 0.00 (30) | 2.8 (30) | 0.03 (106) | 6.4 (169) |
| Infection[a] | 0.00 (26) | 3.9 (41) | 0.02 (69) | 5.0 (133) |
| Transfusion[a] | 0.4 (2 928) | 20.9 (222) | 1.2 (4 056) | 24.2 (640) |
| Hysterectomy[a] | 0.01 (42) | 6.9 (73) | 0.1 (468) | 5.9 (157) |
| Mechanical ventilation[a] | 0.01 (40) | 4.1 (43) | 0.1 (182) | 9.3 (245) |
| HD monitoring[a] | 0.00 (25) | 0.9 (10) | 0.01 (43) | 0.8 (22) |

Abbreviations: DM, diabetes; HD, hemodynamic; HTN, hypertension.
[a] $P \leq .01$.

length of stay, respectively. The most common complications associated with an extended length of stay for vaginal births were hemorrhage, puerperal infections, severe preeclampsia/eclampsia, and transfusion. The most common complications associated with an extended length of stay for cesarean birth were similar except for respiratory failure, which was more common than puerperal infections.

### Independent risk factors for an extended length of stay

The associations of maternal sociodemographic and obstetric risk factors, comorbidities, and complications with the risk of an extended length of stay, estimated by a binary logistic regression analysis, considered all the significant characteristics, comorbidities, and complications. The reference level for each categorical variable was chosen to reflect the most commonly expected norm for obstetrics. Tables 3 and 4 display the results of this analysis.

Women (aged >30 years) were at an increased risk of an extended length of stay compared with women aged 25 to 29 years for both vaginal and cesarean births. Non-Hispanic black and Pacific Islander women were at a highest risk for an extended length of stay, with black women at twice the risk compared with non-Hispanic whites. Women with public insurance coverage were at a greater risk of an extended length of stay than privately covered women. Multiparous women were at a lower risk for an extended length of stay (vaginal: OR = 0.68 [95% CI, 0.58-0.79]; cesarean birth: OR = 0.87 [95% CI, 0.77-0.98]) than primiparous women. Although extremely obese women delivering by cesarean birth experienced an extended length of stay more frequently than not, the OR for this population did not show significant risk (OR = 0.93 [95% CI, 0.76-1.14]).

Women delivering infants less than 2500 g were at an increased risk of an extended length of stay compared with women with infants more than 2500 g (vaginal: OR = 1.41 [95% CI, 1.12-1.79]; cesarean birth: OR = 1.55

Table 3. **Maternal/obstetric risk factors associated with an extended postpartum length of stay**

| Risk factors | Vaginal Extended aOR [95% CI] | Cesarean Extended aOR [95% CI] |
|---|---|---|
| *Maternal* | | |
| Maternal age | | |
| <18 y | 1.15 [0.82-1.59] | 1.36 [1.05-1.77][a] |
| 18-24 y | 1.12 [0.92-1.36] | 1.00 [0.87-1.14] |
| 25-29 y | 1.00 Reference | 1.00 Reference |
| 30-34 y | 1.49 [1.21-1.82][a] | 1.21 [1.07-1.38][a] |
| 35+ y | 1.77 [1.43-2.19][a] | 1.60 [1.41-1.82][a] |
| Race/ethnicity | | |
| Non-Hispanic white | 1.00 Reference[a] | 1.00 Reference |
| Non-Hispanic black | 2.00 [1.54-2.60] | 2.06 [1.76-2.39][a] |
| Asian | 0.83 [0.62-1.12] | 1.19 [1.01-1.43][a] |
| Pacific Islander | 1.68 [1.21-2.32][a] | 1.36 [1.10-1.68][a] |
| Hispanic | 1.40 [1.16-1.69][a] | 1.17 [1.03-1.32][a] |
| AI/Native Alaskan | 0.77 [0.29-2.20] | 0.94 [0.52-1.67] |
| Payer | | |
| Public | 1.69 [1.44-1.99][a] | 1.40 [1.27-1.55][a] |
| Private | 1.00 Reference | 1.00 Reference |
| None/uninsured | 0.99 [0.59-1.68] | 1.08 [0.78-1.49] |
| Other | 1.43 [0.97-2.11] | 1.32 [1.04-1.68][a] |
| Parity | | |
| Nulliparous | 1.00 Reference | 1.00 Reference |
| Multiparous[b] | 0.68 [0.58-0.79][a] | 0.87 [0.77-0.98][a] |
| Body mass index | | |
| Underweight | 0.89 [0.63-1.26] | 1.28 [1.02-1.63][a] |
| Normal | 1.00 Reference | 1.00 Reference |
| Overweight | 1.02 [0.86-1.20] | 1.29 [1.02-1.63][a] |
| Obese I | 0.89 [0.70-1.12] | 0.86 [0.75-0.99][a] |
| Obese II, III | 0.79 [0.58-1.05] | 1.00 [0.86-1.16] |
| *Obstetric* | | |
| Multiple-fetus gestation[c] | 1.56 [0.98-2.49] | 1.02 [0.87-1.19] |
| Previous C-section[c] | 1.74 [1.21-2.49][a] | 0.78 [0.69-0.88][a] |
| Gestational HTN[c] | 2.47 [1.85-3.28][a] | 2.59 [2.21-3.05][a] |
| Gestational DM[c] | 0.97 [0.75-1.26] | 0.86 [0.75-0.99][a] |
| Birth weight | | |
| <2500 g | 1.41 [1.12-1.79][a] | 1.55 [1.35-1.78][a] |
| 2500-3999 g | 1.00 Reference | 1.00 Reference |
| >4000 g | 1.17 [0.90-1.52] | 0.89 [0.75-1.06] |
| Gestational age | | |
| 20-29 wk | 1.02 [0.57-1.81] | 3.78 [3.08-4.64][a] |
| 30-36 wk | 2.16 [1.75-2.66][a] | 2.40 [2.11-2.74][a] |
| 37-40 wk | 1.00 Reference | 1.00 Reference |
| 40+ wk | 1.09 [0.85-1.4] | 0.93 [0.76-1.14] |

Abbreviations: AI, American Indian; DM, diabetes; HTN, hypertension.
[a] $P \leq .05$.
[b] Multiparous categories were combined, as no significance was found in parity of 1 to 3
[c] Reference variable was absence of risk factor/comorbidity/complication.

[95% CI, 1.35-1.78]). In addition, women delivering between 30 and 36 weeks' gestation were twice as likely to experience an extended length of stay as those delivering at 37 and 40 weeks' gestation (vaginal: OR = 2.16 [95% CI, 1.75-2.66]; cesarean birth: OR = 2.40 [95% CI, 2.11-2.74]). Women delivering by cesarean birth at 20 to 29 weeks' gestation were at approximately 4 times increased risk of an extended length of stay (OR = 3.78 [95% CI, 3.08-4.64]). For several risk factors, including women younger than 18 years, Asian, and underweight/overweight women, those delivered by cesarean birth were at a 20% to 30% increased risk for an extended length of stay compared with those delivered vaginally.

The majority of the comorbidities were associated with an extended length of stay for both modes of birth.

Table 4. **Comorbidities/complications associated with an extended postpartum length of stay**

| Risk factors | Vaginal, Extended aOR [95% CI] | Cesarean, Extended aOR [95% CI] |
|---|---|---|
| Comorbidities[a] | | |
| Depression | 1.69 [1.26-2.25][b] | 1.89 [1.59-2.26][b] |
| Chronic HTN | 5.94 [4.44-7.94][b] | 3.57 [3.05-4.17][b] |
| Coagulation disorders | 1.82 [1.31-2.53][b] | 1.40 [1.15-1.71][b] |
| Diabetes | 1.64 [1.01-2.67][b] | 1.38 [1.10-1.73][b] |
| Lupus | 3.19 [1.48-6.89][b] | 2.11 [1.33-3.33][b] |
| Cardiac conditions | 3.04 [1.92-4.81][b] | 3.38 [2.66-4.31][b] |
| Renal conditions | 3.61 [1.70-7.66][b] | 3.06 [1.99-4.71][b] |
| Liver conditions | 2.34 [0.81-6.73] | 2.26 [1.31-3.89][b] |
| Complications[a] | | |
| Hemorrhage | 1.58 [1.26-1.97][b] | 1.52 [1.27-1.80][b] |
| Puerperal infections | 6.86 [5.73-8.21][b] | 6.07 [5.41-6.80][b] |
| Mild preeclampsia | 3.99 [3.08-5.18][b] | 3.26 [2.78-3.83][b] |
| Preeclampsia/eclampsia | 17.07 [13.76-21.17][b] | 5.10 [4.47-5.82][b] |
| Cerebrovascular | 9.25 [6.57-13.01][b] | 15.32 [11.9-19.6][b] |
| Puerperal complications | 12.50 [9.51-16.41][b] | 5.16 [4.27-6.25][b] |
| Respiratory failure | 30.94 [16.58-57.75][b] | 6.49 [4.99-8.43][b] |
| Obstetric shock | 6.11 [2.66-14.04][b] | 1.87 [1.15-3.04][b] |
| Cardiac events | 1.12 [0.38-3.28] | 0.39 [0.25-0.63][b] |
| Renal failure | 15.07 [6.67-34.03][b] | 7.75 [5.36-11.19][b] |
| Infection | 129.60 [66.93-250.94][b] | 15.35 [10.11-23.32][b] |
| Transfusion | 11.66 [9.20-14.75][b] | 6.07 [5.28-6.97][b] |
| Hysterectomy | 52.90 [31.21-89.67][b] | 5.66 [4.29-7.48][b] |
| Mechanical ventilation | 3.18 [1.31-7.79][b] | 4.27 [3.03-6.03][b] |
| HD monitoring | 17.65 [4.53-68.67][b] | 1.05 [0.44-2.49] |

Abbreviations: aOR, adjusted odds ratio; HD, hemodynamic; HTN, hypertension.
[a]Reference variable was absence of risk factor/comorbidity/complication.
[b]$P \leq .05$.

Odds ratios for an extended length of stay for women with any comorbidity delivering vaginally ranged from 1.64 [95% CI, 1.01-2.67] for women with diabetes to 5.94 [95% CI, 4.44-7.94] for women with chronic hypertension. Odds ratios for an extended length of stay for women with a cesarean birth were slightly lower and ranged from 1.38 [95% CI, 1.10-1.73] for women with diabetes to 3.57 [95% CI, 3.05-4.17] for women with chronic hypertension. Although depression and diabetes carried less odds of an extended length of stay, they presented more frequently than other conditions (ie, cardiac, renal, and liver) at 3 times greater risk.

The majority of complications were associated with an extended length of stay; the effect of the complication depended upon its extent of risk and frequency. Overall, except for cerebrovascular disorders and mechanical ventilation, women delivering by cesarean birth had more frequent complications but were at lower odds of an extended length of stay than women delivering vaginally. Odds ratios for an extended length of stay for women with any complication delivering vaginally ranged from 1.58 [95% CI, 1.26-1.97] for women with hemorrhage to 129.60 [95% CI, 66.93-250.94] for women with infections. Although hemorrhage was the most frequent complication in vaginal deliveries, it carried the least amount of risk for an extended length of stay. Odds ratios for an extended length of stay for women with a cesarean birth were also slightly lower, ranging from 1.52 [95% CI, 1.27-1.80] for women with hemorrhage to 15.35 [95% CI, 10.11-23.32] for women with infections. Severe preeclampsia/eclampsia and puerperal infections were also associated with a significant risk of an extended length of stay for both modes of birth.

Women delivering vaginally with respiratory failure (OR = 30.94 [95% CI, 16.58-57.75]), hysterectomy (OR = 52.90 [95% CI, 21.21-89.67]), or receiving a transfusion (OR = 11.66 [95% CI, 9.20-14.75]) were at a significantly higher risk for an extended length of stay than women delivering by cesarean birth (OR = 6.49 [95% CI, 4.99-8.43]; OR = 5.66 [95% CI, 4.29-7.48]; OR = 6.07 [95% CI, 5.28-6.97], respectively). The frequency of procedures related to intensive care (ventilation, hemodynamic monitoring) was minimal. Nonetheless, women with mechanical ventilation were at 3 to 4 times greater risk for an extended length of stay in both

modes of delivery and 17 times greater risk for an extended length of stay with hemodynamic monitoring in vaginal births.

## DISCUSSION

The purpose of this study was to identify risk factors associated with increased postpartum length of stay. The major finding from this study was that women with certain risk factors including maternal demographics as well as prepregnancy, pregnancy, and birth complications are at increased odds for an extended length of stay regardless of delivery mode. Multiple risk factors in a single pregnancy increased the potential for longer postpartum hospitalizations. The predictors of postpartum length of stay are multidimensional and complex. Although many of the risk factors carried adjusted ORs of less than 2, they can be used to identify women who would benefit from increased vigilance and monitoring during pregnancy, especially when more than 1 risk factor is present. Risk factors with an OR greater than 2 may not be amenable to change in the intrapartum period but are still useful in the identification of women who require added vigilance during the labor and birth process, as well as during the postpartum period.

In general, these conditions are identifiable at the time of admission to the labor or postpartum unit, suggesting that opportunities exist to improve outcomes by triaging high-risk women and transporting to a facility or unit better equipped to care for them if necessary. Recognizing the adverse effects of risk factors can improve the response necessary to minimize those effects. In fact, the American College of Obstetricians and Gynecologists recommend the development of a rapid response team to improve response time and reduce or prevent the severity of maternal complications.[33] Rapid response teams bring critical care expertise to the bedside and can work collaboratively to improve outcomes. Utilization of hospital-based patient safety bundles for hemorrhage, preeclampsia, and venous thromboembolism prevention can improve care and further reduce overall maternal morbidity. Recently, Main and associates[34] published findings indicating that implementing a national patient safety bundle improving response to hemorrhage is beneficial in reducing maternal morbidity. Similar support for the use of a consensus bundle on severe hypertension during pregnancy and the postpartum period to reduce hypertension-related complications through timely and appropriate treatment can be found in the literature.[35]

While most perinatal complications can be cared for adequately at any facility providing obstetric care, for some pregnant women, a higher level of care is required and transport is necessary. As this study indicates, many of the high-risk factors prompting an extended length of stay are identifiable prior to birth. An understanding of these risks can help identify strategies to minimize adverse effects. The earlier these factors are recognized, the sooner the provider can initiate the decision-making process to mitigate the risk. Access to prenatal care, although vital to identify and minimize risks prior to birth, was not a significant factor in an extended length of stay, indicating many of the comorbidities and complications identified may increase or occur during the labor and/or birth period. Women with identifiable risk factors, especially those with multiple risk factors, would benefit from increased vigilance and prompt treatment to minimize adverse outcomes, as well as decrease cost. Although this study identifies an extended length of stay as a possible marker for maternal risk-appropriate care and supports the benefit of a scoring system for pregnant women at an increased risk for complications during labor/birth, further research is needed to develop such a scoring system and examine the practicality of its use in decision making. A more formal analysis of risk ratio may be beneficial and should be addressed in future studies.

### Implications for practice

Several opportunities for improving obstetric healthcare practice exist. Healthcare professionals need to develop and utilize a system of risk scoring for pregnant women at an increased risk for complications during labor/birth to inform planning decisions. Assessments and screening strategies can assist healthcare professionals in identifying risk factors and preventing potential medical complications of high-risk pregnant women by matching these women, providers, and birth sites to level of need, available resources, and capacity to provide risk-appropriate care. The adequate exposure to gain the expertise and competency required for early identification of at-risk mothers is limited because of the overall small number of adverse outcomes. Tailored education programs including simulation with standardized patients and drills are needed to increase perinatal staff awareness of risk factors to identify triggers and intervene quickly to address the specific needs of this low-volume, high-risk population. Maintaining the readiness of the unit and staff through ongoing skills training can optimize outcomes for pregnant and postpartum women.

Improving collaboration and communication between professionals in obstetric and intensive care departments to ensure prompt response to emergencies is crucial. In addition, developing guidelines for the systematic identification of women at risk and ensuring the availability of appropriate resources required

to provide care can mitigate the potential for adverse outcomes. Policies that support recommended criteria for transport and enhanced communication between referring and receiving institutions are recommended. Maternal morbidity and mortality can be reduced if facilities are prepared for at-risk pregnant women and obstetric emergencies.

### Limitations

Although the sample size for this study included more than 1 million postpartum cases, lending credence to the findings, there are several limitations that must be considered. First, the use of retrospective administrative databases can undermine the data quality. Data quality depended on the accuracy and completeness of the information recorded on the certificates and the quality control procedures employed in the coding process. Therefore, bias is inevitable due to misclassification and underreporting by the healthcare facility. Second, socioeconomic and marital statuses, which are essential in identifying associations, were not contained within the data sets; medical record review to abstract these data was not available. In addition, prepregnancy BMI was used to establish weight risk factors. Although prepregnancy obesity incurs the highest risk, it unfortunately does not capture those women who gained more than the recommended weight during pregnancy. Third, previous studies have indicated that maternal outcomes are also affected by provider and healthcare system factors, which this study did not address.[11] Although *ICD-9-CM* codes were used to identify comorbidities and complications, these codes do not fully assess the severity of these conditions. Nonetheless, the outcome variable of extended length of stay as operationally defined could act as a proxy for severity with the assumption that only women with severe complications required continuous hospitalization and care. Although women undergoing cesarean birth experienced more frequent comorbidities and complications than women with vaginal birth, the comorbidities and complications were not necessarily the result of the mode of delivery itself but rather may have influenced the decision to deliver by cesarean birth. Finally, the results indicate that the ORs for an extended length of stay for several complications (respiratory failure, hysterectomy, and transfusion) were higher for vaginal than for cesarean births. It is important to note that this does not necessarily mean these complications are inherently more dangerous (eg, confer a higher degree of morbidity) in women with vaginal birth. Instead, these may be due, in part, to the availability of anesthesia/intubation during cesarean birth and better control of hemorrhage due to uterine atony. The use of a cutoff of greater than 5 days for vaginal birth and greater than 6 days for cesarean birth may affect this comparison. Therefore, these results should be used with caution when using length of stay as a proxy for morbidity. Despite these limitations, the results of this study provide new knowledge in our understanding of factors that affect postpartum length of stay.

## CONCLUSIONS

Perinatal complications linked to maternal comorbidities contribute to increased healthcare utilization through an extended postpartum length of stay. The analysis of more than 1 million births illustrates the importance of quantifying risk factors to improve overall care of mothers. The earlier these factors are recognized, the sooner the healthcare team can initiate the decision-making process to mitigate the risk.

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