Early postpartum readmissions: identifying risk factors at birth hospitalization

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BACKGROUND: The high maternal mortality and severe morbidity rates in the United States compared with other high-income countries have received national attention. Characterization of postpartum hospital readmissions within the first days after delivery hospitalization discharge could help to identify patients who need additional preparedness for discharge.

OBJECTIVE: This study aimed to investigate conditions at birth associated with postpartum readmissions occurring within 0 to 6 days and at 7 to 29 days after discharge from the delivery hospitalization.

STUDY DESIGN: We analyzed linked vital statistics and hospital discharge records of patients who gave birth in California during 2007 to 2018. We investigated hospital readmissions within 30 days after birth hospitalization discharge. We used multivariable logistic regression to investigate factors associated with early readmission (0–6 days) and later readmission (7–29 days) compared with no readmission within 30 days (reference). The risk factors assessed included maternal medical or obstetrical conditions before and at birth, birth hospitalization length of stay, and mode of delivery. Severe maternal morbidity was defined as the presence of any of the 21 indicators recommended by the Centers for Disease Control and Prevention.

RESULTS: Among 5,248,746 pregnant patients, 23,636 (0.45%) had an early postpartum readmission, whereas 24,712 (0.47%) had a later postpartum readmission. After adjustments, early readmission was most strongly associated with sepsis (adjusted odds ratio, 4.63; 95% confidence interval, 3.87–5.53), severe maternal morbidity (adjusted odds ratio, 3.46; 95% confidence interval, 3.28–3.65) at birth hospitalization, or preeclampsia before birth hospitalization (adjusted odds ratio, 3.67; 95% confidence interval, 3.54–3.81). The associations between later readmission and sepsis and severe maternal morbidity were similar, whereas the association between preeclampsia and later readmission was less strong (adjusted odds ratio, 1.65; 95% confidence interval, 1.57–1.73).

CONCLUSION: Pregnant patients with sepsis or severe maternal morbidity during delivery hospitalization or preeclampsia before birth hospitalization were at the highest risk for readmission within 6 days of discharge. These findings may be informative for efforts to improve postpartum care.

Key words: cesarean delivery, emergency department, hospitalization, major mental health condition, postpartum, preeclampsia, readmission, sepsis, severe maternal morbidity

The high maternal mortality and severe morbidity rates in the United States compared with other high-income countries have received national attention.1–4 Maternal care quality during childbirth and within the immediate postpartum period are recognized as potential care improvement areas.5,6 To improve immediate postpartum care, the American College of Obstetricians and Gynecologists recommended in 2018 that all women should have contact with a maternal care provider within the first 3 weeks postpartum.6

More than half of maternal deaths in the United States occur during the postpartum period.4,5 In an effort to improve postpartum outcomes, information about the postpartum care utilization would be helpful. However, despite previous studies showing that the median time from discharge to postpartum readmission is 7 days (interquartile range, 2–19 days),7 the current literature on postpartum readmissions has focused mostly on factors associated with a readmission from

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Postpartum readmissions are common, with the median time for postpartum readmission being 7 days after discharge. Risk factors for readmission within the immediate postpartum period (0–6 days) are not fully understood.

Key findings
Pregnant patients with preeclampsia, sepsis, or severe maternal morbidity during birth hospitalization had a 3- to four-fold increased odds of readmission within 6 days of discharge. Patients with preterm birth <34 weeks’ gestation and those with a major mental health condition had 2-fold increased odds of early readmission.

What does this add to what is known?
This study identified groups of patients who are at increased risk for readmission within 6 days of discharge following birth hospitalization. In particular, postpartum patients who have had sepsis, severe maternal morbidity at birth, or preeclampsia might benefit from proactive care planning.

Materials and Methods
Study population
We performed a cohort study using the California birth cohorts from 2007 to 2018. For these years, the California Department of Health Care Access and Information (formerly the Office of Statewide Health Planning and Development) linked the birth and fetal death certificate records with patient hospital discharge data during pregnancy and through the postpartum period. The birth and fetal death certificates include patient and pregnancy characteristics, and the discharge data include diagnosis and procedure codes from hospitalizations.

30 to 90 days postpartum. Few studies have investigated postpartum readmissions with ≤7 days of discharge. Identification of patients at risk of immediate return to the hospital after birth hospitalization could help to identify patients needing additional preparedness for discharge.

This study aimed to investigate conditions during birth hospitalization that were associated with postpartum readmissions occurring within the first week (0–6 days) after discharge.

Postpartum readmissions
We identified postpartum readmissions based on patient discharge records from hospital inpatient readmissions that occurred after delivery hospitalization discharge. To ensure that we did not include hospital transfers as readmissions, we classified postpartum hospitalizations as transfers (not readmissions) for cases in which the (1) birth hospitalization discharge status was either within or to another hospital or the postpartum admission route was from within hospital or another hospital, and (2) time between postpartum admission and birth hospitalization discharge was ≤1 day. In the case of multiple postpartum hospitalizations for 1 patient, we selected the first occurrence for each.

We classified readmissions that occurred during 0 to 6 days after discharge from birth hospitalization as early and those that occurred during 7 to 29 days after discharge as later readmissions. These definitions were selected a priori by the investigators based on a multistate analysis showing that the median time between discharge and postpartum readmission is 7 days.

Risk factors
We sought to evaluate conditions that were present before and during the birth hospitalization that could affect the probability of a readmission. Conditions were identified using the International Classification of Diseases, Ninth and Tenth Revision, Clinical Modification (ICD-9-CM and ICD-10-CM) diagnosis codes. Conditions of interest occurring before birth hospitalization included preeclampsia, preexisting diabetes mellitus, bleeding disorders, major mental health conditions, and thyroid disorders. Conditions or events of interest occurring during birth hospitalization included severe maternal morbidity, nontransfusion severe maternal morbidity, postpartum hemorrhage, sepsis, perineal trauma, cesarean delivery, stillbirth, preterm birth, and prolonged hospitalization. Details of the ICD-9-CM, ICD-10-CM diagnosis codes and others used to define the conditions analyzed are presented in Appendix 1. Severe maternal morbidity was defined as the presence of any of the 21 indicators recommended by the Centers for Disease Control and Prevention (CDC). Following the CDC recommendations, we also investigated nontransfusion severe maternal morbidity—cases in which blood products transfusion was not the sole indicator of a severe event. Preterm birth was defined as a birth <37 weeks of gestation as reported on the birth or fetal death certificate and was categorized as 34+0/7 to 36+6/7 or <34 weeks’ gestation. Prolonged length of delivery hospitalization was defined as ≥3 days for vaginal deliveries and ≥5 days for cesarean delivery.

Confounders
We considered the following variables as potential confounders in multivariable models: maternal age at delivery, race/ethnicity, method of payment for delivery, education, parity, prepregnancy body mass index (BMI), multifetal gestation, preexisting diabetes mellitus and chronic hypertension. Prepregnancy BMI was calculated using the maternal weight and
height (kg/m²). Preexisting diabetes mellitus and chronic hypertension were identified using the patient discharge data and the other variables were collected from the birth or fetal death certificate. These variables were selected a priori from available variables based on existing knowledge and causal diagrams.\textsuperscript{7,8,10,17}

**Causes of readmission**

We also investigated the primary causes of early and later readmissions based on the primary ICD-9-CM and ICD-10-CM diagnosis code for the readmission (Appendix 2). We first categorized these into the 19 ICD-CM diagnosis code categories, which are largely organ specific.\textsuperscript{18}

We then reclassified the diagnosis codes that were in the category of “Complications of Pregnancy, Childbirth, and the Puerperium” into the organ-specific categories as appropriate. Diagnoses in the perinatal category directly related to pregnancy and birth (e.g., placental disorders) and nonspecific codes (e.g., unspecified complication of pregnancy) were kept in the category.

**Statistical analysis**

We calculated the rate of early (0–6 days) and later (7–29 days) readmission per 1000 deliveries. We conducted a series of mixed effects logistic regression models with patients nested within delivery hospital to estimate odds ratios with 95% confidence intervals (CIs) for the association between each risk factor and (1) early readmission and (2) later readmission. Models were adjusted for variables as follows: (1) models for conditions occurring before birth hospitalization were adjusted for maternal age at delivery, race/ethnicity, method of payment for delivery, education, parity, prepregnancy BMI and multifetal gestation and (2) models for conditions occurring at birth hospitalization were additionally adjusted for diabetes mellitus and chronic hypertension or preeclampsia that existed before the birth hospitalization. Odds ratios approximated risk ratios because of the rarity of the outcomes. The level of significance was set at $P<.05$. Data management was done using SAS, version 9.4 (SAS Institute, Cary, NC) and data analysis using Stata/IP, version 15.1 (College Station, TX). The Strengthening the Reporting of Observational Studies in Epidemiology guidelines for cohort studies were followed.

**Results**

**Patient characteristics**

Included in the analysis were a total of 5,248,748 pregnant patients of whom 23,636 (0.45%) had a postpartum readmission at 0 to 6 days after birth hospitalization discharge (early readmission), and 24,712 (0.47%) were readmitted 7 to 29 days after discharge following birth hospitalization (later readmission) (Figure 1). The demographics and clinical characteristics of pregnant patients
with early, later, and no readmission are presented in Table 1. Based on the frequencies observed, patients with early readmission were more likely to be Black, have college education, be nulliparous, have obesity, and have private insurance and a multifetal gestation than pregnant patients with no readmission within 30 days (Table 1). Patients with early readmission had higher frequencies of chronic hypertension and preexisting diabetes mellitus.

| Characteristics                                | Column %      | Column %      | Column %      |
|------------------------------------------------|---------------|---------------|---------------|
| Maternal age (y)                               | 29.9±6.6      | 28.3±6.6      | 28.9±6.2      |
| Race/ethnicity                                 |               |               |               |
| US-born Hispanic                               | 27.6%         | 33.6%         | 26.4%         |
| Foreign-born Hispanic                          | 15.5%         | 18.9%         | 24.4%         |
| White, non-Hispanic                            | 30.7%         | 27.3%         | 28.5%         |
| Asian or Pacific Islander, non-Hispanic        | 13.8%         | 10.5%         | 14.6%         |
| Black, non-Hispanic                            | 11.8%         | 8.8%          | 5.6%          |
| Other                                          | 0.7%          | 0.9%          | 0.5%          |
| Insurance type for delivery                    |               |               |               |
| Public (Medi-Cal or other government)          | 44.8%         | 54.4%         | 47.6%         |
| Private                                        | 52.6%         | 43.0%         | 48.2%         |
| Self-pay or other                              | 2.6%          | 2.6%          | 4.2%          |
| Maternal education                             |               |               |               |
| No high school diploma                         | 15.2%         | 20.1%         | 20.1%         |
| High school graduate                           | 25.6%         | 29.3%         | 25.8%         |
| Associate degree or some college               | 29.5%         | 28.9%         | 25.6%         |
| College graduate                               | 29.7%         | 21.7%         | 28.5%         |
| Nulliparous                                    | 47.3%         | 44.6%         | 39.2%         |
| BMI category at prepregnancya                  |               |               |               |
| Underweight                                     | 2.8%          | 3.0%          | 4.0%          |
| Normal weight                                   | 38.7%         | 36.9%         | 47.9%         |
| Overweight                                      | 25.9%         | 26.7%         | 26.1%         |
| Obese 1                                        | 16.0%         | 17.0%         | 13.2%         |
| Obese 2                                        | 8.8%          | 9.1%          | 5.6%          |
| Obese 3                                        | 7.8%          | 7.3%          | 3.3%          |
| Multifetal gestation                            | 3.9%          | 2.9%          | 1.6%          |
| Preexisting diabetes mellitus                   | 2.8%          | 2.6%          | 1.3%          |
| Chronic hypertension                            | 5.6%          | 3.3%          | 1.4%          |

The data are presented for a total of 5,248,746 pregnancies.

BMI, body mass index.

a Obese 1: BMI of 30 to <35; Obese 2: BMI of 35 to <40; Obese 3: BMI of ≥40.

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than patients without readmission within 30 days of birth hospitalization. Similarly, pregnant patients with a later readmission were more often Black or non-US born Hispanic, nulliparous, and more likely to have obesity, a multifetal gestation, preexisting diabetes mellitus, or chronic hypertension than patients without readmission. Patients with later readmission more often had public insurance and were less likely to have a college degree than those with no readmission (Table 1).

### Conditions at birth hospitalization

Among conditions or events that occurred during the birth hospitalization, we found that sepsis had the strongest association with early readmission (aOR, 4.63; 95% CI, 3.87−5.53) and later readmission (aOR, 4.92; 95% CI, 4.08−5.93). Severe maternal morbidity at birth hospitalization significantly increased the odds of an early readmission (aOR, 3.46; 95% CI, 3.28−3.65), and the association was similar for nontransfusion only severe maternal morbidity (aOR, 3.71; 95% CI, 3.45−3.98). The odds of later readmission were also increased with severe maternal morbidity (aOR, 3.27; 95% CI, 3.09−3.46) and nontransfusion severe maternal morbidity at birth (aOR, 3.51; 95% CI, 3.24−3.81) (Table 3). Other notable birth hospitalization factors associated with early and later readmission were preterm birth <34 weeks’ gestation, cesarean delivery, postpartum hemorrhage, and prolonged birth hospitalization (Table 3). There were more stillbirths among patients with early (0.8%) and later (0.7%) readmission than among patients with no postpartum readmission (0.3%). However, the group sizes were too small to calculate point estimates for the associations. We found no significant association between perineal trauma and early or later readmission (Table 3).

### Conditions before birth hospitalization

After adjustments, preeclampsia had the strongest association with early readmission among the conditions present before birth hospitalization (adjusted odds ratio [aOR], 3.67; 95% CI, 3.54−3.81) (Table 2). The association between preeclampsia and later readmission was less strong (aOR, 1.65; 95% CI, 1.57−1.73). Other prebirth hospitalization factors associated with early readmission were a major mental health condition (aOR, 2.01; 95% CI, 1.91−2.12), bleeding disorder (aOR, 1.59; 95% CI, 1.46−1.74), preexisting diabetes mellitus (aOR, 1.73; 95% CI, 1.60−1.88), and thyroid disorder (aOR, 1.40; 95% CI, 1.32−1.48). These associations were similar for later readmission (Table 2).

### Comment

**Principal findings**

We found a more than 4-fold higher risk for early postpartum readmission (within 6 days of discharge) among patients who had sepsis during birth hospitalization and a >3-fold higher risk for early postpartum readmission among patients who had severe maternal morbidity or preeclampsia. In addition, there was a 2-fold higher risk for early readmission among patients with preterm birth <34 weeks’ gestation or a major mental health condition. Associations between conditions...
and later readmissions (7–29 days after discharge) were overall less pronounced with the main difference being for preeclampsia, which had a much stronger association with early readmissions than with later readmission. The large majority (88%) of readmissions during the first week were because of perinatal, circulatory, and infectious conditions. The causes for later readmission were more dispersed overall with perinatal, infectious, and digestive causes covering more than half (69%) of the later readmissions.

**Results in the context of what is known**

Maternal care during the immediate postpartum period has received significant attention. Based on the United States vital statistics records from 2011 to 2015, 18.6% of pregnancy-related mortalities occurred within 1 to 6 days postpartum and 21.4% occurred within 7 to 42 days postpartum. Furthermore, we have shown previously that approximately 12% of severe maternal morbidity cases occurred after delivery hospitalization discharge. Despite a median time from discharge to readmission of 7 days, previous studies have mainly investigated readmissions within 30 or 60 days of discharge after delivery hospitalization with only a few examining readmissions within the first 7 days. We selected postpartum readmission within the first 6 days as our primary outcome as a vehicle to examine the care needed during the immediate postpartum period. Although postpartum readmission as a quality metric of obstetrical care is a controversial topic (Combs AC 2022), unarguably, return to the hospital within days after discharge is an untoward outcome with potential negative impact on the wellbeing of the mother and the infant. We found that the strongest predictors of early readmission were sepsis, severe maternal morbidity, and preeclampsia.

### Conditions at birth hospitalization associated with early readmission (0–6 days after discharge) and later readmission (7–29 days after discharge) compared with no readmission within 30 days of discharge from birth hospitalization in California from 2007 to 2018

| Conditions or events during birth hospitalization<sup>a</sup> | Early readmission 0–6 d after discharge from birth hospitalization n=23,636 | Later Readmission 7–29 d after discharge from birth hospitalization n=24,712 | No readmission within 30 d of discharge from birth hospitalization n=5,200,398 | aOR (95% CI) for early readmission within 0–6 d | aOR (95% CI) for later readmission within 7–29 d |
|---|---|---|---|---|---|
| Severe maternal morbidity | 1614 (6.8) | 1296 (5.2) | 75,017 (1.4) | 3.46 (3.28–3.65) | 3.27 (3.09–3.46) |
| Severe maternal morbidity excluding transfusion-only cases | 816 (3.5) | 620 (2.5) | 31,508 (0.6) | 3.71 (3.45–3.98) | 3.51 (3.24–3.81) |
| Postpartum hemorrhage | 1593 (6.7) | 1456 (5.9) | 160,895 (3.1) | 1.69 (1.60–1.78) | 1.80 (1.71–1.90) |
| Sepsis | 131 (0.6) | 116 (0.5) | 4086 (0.1) | 4.63 (3.87–5.53) | 4.92 (4.08–5.93) |
| Perineal trauma | 974 (4.1) | 991 (4.0) | 212,459 (4.1) | 0.96 (0.90–1.02) | 0.98 (0.92–1.05) |
| Cesarean delivery | 12,416 (52.5) | 11,020 (44.6) | 1,677,636 (32.3) | 1.97 (1.92–2.02) | 1.55 (1.51–1.59) |
| Prolonged birth hospital length of stay<sup>c</sup> | 8508 (36.0) | 7240 (29.3) | 1,094,070 (21.0) | 1.56 (1.52–1.61) | 1.34 (1.30–1.38) |
| Stillbirth at ≥20 wk gestation | 184 (0.8) | 163 (0.7) | 17,815 (0.3) | ---<sup>c</sup> | ---<sup>c</sup> |

#### Preterm birth:

| Preterm birth: | Early readmission 0–6 d after discharge from birth hospitalization n=5,200,398 | Later Readmission 7–29 d after discharge from birth hospitalization n=5,200,398 | No readmission within 30 d of discharge from birth hospitalization n=5,200,398 | aOR (95% CI) for early readmission within 0–6 d | aOR (95% CI) for later readmission within 7–29 d |
|---|---|---|---|---|---|
| <34 wk | 1542 (6.5) | 1181 (4.8) | 109,132 (2.1) | 2.12 (2.00–2.23) | 1.94 (1.83–2.07) |
| 34–36 wk | 2531 (10.7) | 2177 (8.8) | 298,724 (5.7) | 1.52 (1.45–1.58) | 1.45 (1.38–1.51) |
| ≥37 wk | 19,563 (82.8) | 21,354 (86.4) | 4,792,542 (92.2) | Ref | Ref |

The data are displayed for 5,248,746 pregnancies.

- **aOR** adjusted odds ratio; **BMI** body mass index; **CI** confidence interval.
- **a** Models adjusted for maternal age, parity, prepregnancy BMI, education, race/ethnicity, and expected payment method for delivery, diabetes mellitus, chronic hypertension, and preeclampsia before birth hospitalization.
- **b** Defined as ≥3 days for vaginal deliveries and ≥5 days for cesarean deliveries.
- **c** Sample size too small for point estimate calculation.

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readmission, although these studies did not focus on early readmissions\textsuperscript{10,23}. Our ability to differentiate the risk factors for early and later readmission revealed how the effect of sepsis and severe maternal morbidity on readmission may persist past the early postpartum period, whereas preeclampsia seems to be much more of a risk factor in the early postpartum period; preeclampsia increased the odds of early readmission by almost 4-fold, whereas the odds of later readmission were increased only about 1.5-fold.

In this study, the most common diagnosis for readmission within 0 to 6 days was perinatal conditions (complications of pregnancy, childbirth), followed by circulatory systems conditions (including hypertensive disorder) and infectious conditions. Our findings are in line with previous literature demonstrating that infection,\textsuperscript{7,24,25} hypertensive disorders,\textsuperscript{7,26,27} and psychiatric illness\textsuperscript{7} are most common indicators for postpartum readmission. Interestingly, the primary diagnoses for readmission between 7 to 29 days after discharge were slightly different from those in the first week with perinatal, infectious, and digestive conditions accounting for 69% of the diagnoses and circulatory causes being less frequently diagnosed than during the early readmission. This is aligned with previous literature showing that a high percentage of postpartum readmissions within the first 6 weeks of delivery are for pneumonia (infectious), appendicitis, and cholecystitis (digestive causes).\textsuperscript{25} Furthermore, our results support the previous findings that hypertensive readmissions are more likely to occur within the first few days\textsuperscript{28} and that proactive monitoring and treatment of these patients before discharge are warranted.

**Clinical implications**

Because so many of the maternal morbidity and mortality cases are tied to the postpartum period, understanding postpartum inpatient and outpatient care utilization is important in improving maternal outcomes. Our results suggest that pregnant patients requiring readmission in the immediate postpartum period have similar risk factors. The strongest risk factors for readmission within 6 days of discharge in our study were sepsis, severe maternal morbidity, and preeclampsia. Not surprisingly, these are all aligned with the leading causes of pregnancy-related mortality in California, which are cardiovascular disease, sepsis or infection, hemorrhage, and hypertensive disorders.\textsuperscript{25} Patients with early readmission had the highest frequency of prolonged birth hospital length of stay, thus suggesting that their conditions were also the most severe. It is unclear whether incorporation of immediate postpartum check-ins or treat-and-discharge visits in an outpatient setting would be beneficial or more appropriate for some of the postpartum patients. Preeclampsia was specifically associated with early readmission as opposed to later readmission, which may be improved by better planning in terms of antihypertensive medications or care team follow-up right after the hospital discharge as suggested by others.\textsuperscript{28} Similar to hypertensive disorders, there might be opportunities to improve discharge readiness of patients with sepsis during birth hospitalization, for example, by proactive treatment with antibiotics and close postpartum follow-up. Furthermore, major mental health conditions before birth hospitalization contributed about a 2-fold increase in the odds of both early and later postpartum readmission, thus emphasizing the role of mental health conditions on the overall maternal health during the immediate postpartum period.

**Research implications**

The results of this study highlight that postpartum patients with sepsis, severe maternal morbidity, or preeclampsia are at highest risk for immediate return to

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**FIGURE 2**

Primary diagnosis for readmission

Primary diagnosis for readmission within 0−6 days (blue) and 7−29 days (red) after discharge from birth hospitalization.

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the hospital. It is unclear how much the recent national guidelines on postpartum care\(^6\) have improved readmission outcomes and if postpartum readmission is surrogate for severe maternal morbidity or if it actually improves outcomes. Furthermore, more research on the effects of birth hospital discharge planning would be needed. The nonobstetrical literature has shown that discharge education (giving instructions, assessing patient understanding, reinforcement, and reassessing patient understanding) has a potential to decrease readmission rates after heart failure.\(^30\) In addition, hospital discharge quality (defined as patient experience of having adequate information and resources at the time of discharge) has been associated with lower readmission rates among a nonobstetrical population.\(^31\) A recent study on hypertensive postpartum readmissions suggests that proactive treatment of postpartum hypertension before discharge could significantly reduce readmissions and improve outcomes.\(^28\) Finally, an evaluation of the systems of care associated with early readmissions would be a key addition to this study.

**Strengths and limitations**

Among our study’s limitations, we acknowledge that the data were derived from linked patient discharge records and birth certificate data and are hence subject to miscoding and underreported information.\(^32\) In addition, some patient comorbidities may not have been accounted for in our data on delivery hospitalizations.\(^33\) Our data set did not include information on the parameters of clinical management including medications, vital signs, laboratory values, or the severity of conditions, all of which could have impacted the risk for postpartum readmission. Although the California population is diverse and large (accounting for 1 in 8 births in the United States), we acknowledge that examining data from just 1 state might affect the generalizability of our results.

The strengths of our study include a large and diverse population-based cohort that was used for the analysis. The hospitalizations in our data set were linked across pregnancy and the postpartum period and linked to both live birth and fetal death certificates. As such, our data set is a highly unusual source of data to investigate these important but rare events. The size of our data set allowed us to examine rare risk factors like sepsis or stillbirth. Furthermore, we were able to examine primary diagnoses and account for patient characteristics in the analysis.

**Conclusion**

Our study found that pregnant patients with sepsis and severe maternal morbidity had the highest risk for readmission either within 0 to 6 days (early) or 7 to 29 days (later) after discharge from birth hospitalization. Preeclampsia was a major risk factor for early but not for later readmission. The vast majority of early readmissions were owing to perinatal, circulatory, and infectious causes, whereas causes for later readmissions were more dispersed and associated with infectious and digestive conditions to a greater extent. Future studies should investigate the impact of proactive management and short-term postpartum follow-up of pregnant patients with these conditions.

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**REFERENCES**

1. Callaghan WM, Creanga AA, Kuklina EV. Severe maternal morbidity among delivery and postpartum hospitalizations in the United States. Obstet Gynecol 2012;120:1029–36.
2. Creanga AA, Berg CJ, Syverson C, Seed K, Bruce FC, Callaghan WM. Pregnancy-related mortality in the United States, 2006-2010. Obstet Gynecol 2015;125:5–12.
3. MacDorman MF, Declercq E, Cabral H, Morton C. Recent increases in the U.S. Maternal mortality rate: disentangling trends from measurement issues. Obstet Gynecol 2016;128: 447–55.
4. Tikkanen R, Gunja MZ, FitzGerald M, Zephyrin L. Maternal mortality and maternity care in 10 other developed countries. 2020. Available at: https://www.commonwealthfund.org/publications/issue-briefs/2020/nov/maternal-mortality-maternity-care-us-compared-10-countries. Accessed August 10, 2022.
5. Petersen EE, Davis NL, Goodman D, et al. Vital Signs: pregnancy-related deaths, United States, 2011–2015, and strategies for prevention, 13 states, 2013-2017. MMWR Mortal Wkly Rep 2019;68:423–9.
6. ACOG Committee Opinion No. 736: optimizing postpartum care. Obstet Gynecol 2016;131:e140–50.
7. Olapp MA, Little SE, Zheng J, Robinson JN. A multi-state analysis of postpartum readmissions in the United States. Am J Obstet Gynecol 2018;219:113–e1–10.
8. Zuckerman RB, Sheingold SH, Orav EJ, Ruhter J, Epstein AM. Readmissions, observation, and the hospital readmissions reduction program. N Engl J Med 2016;374:1543–51.
9. Fein A, Wen T, Wright JD, et al. Postpartum hemorrhage and risk for postpartum readmission. J Matern Fetal Neonatal Med 2021;34:187–94.
10. Nam JY, Park EC. The relationship between severe maternal morbidity and a risk of postpartum readmission among Korean women: a nationwide population-based cohort study. BMC Pregnancy Childbirth 2020;20: 148.
11. Batra P, Fridman M, Lang M, Gregory KD. Emergency department care in the postpartum period: California births, 2009-2011. Obstet Gynecol 2017;130:1073–81.
12. Miller EC, Wen T, Elkind MSV, Friedman AM, Boehme AK. Infection During delivery hospitalization and risk of readmission for postpartum stroke. Stroke 2019;50:2685–91.
13. Matas JL, Mitchell LE, Sharma SV, Louis JM, Salemi JL. Severe maternal morbidity at delivery and postpartum readmission in the United States. Paediatr Perinat Epidemiol 2021;35:627–34.
14. The California Department of Health care access and information (HCAI). Research data request information. 2021. Available at: https://hcai.ca.gov/data-and-reports/research-data-request-information/. Accessed February 27, 2022.
15. Leonard SA, Kennedy CJ, Carmichael SL, Lyell DJ, Main EK. An expanded obstetric comorbidity scoring system for predicting severe maternal morbidity. Obstet Gynecol 2020;136:440–9.
16. Centers for Disease Control and Prevention. Severe maternal morbidity in the United States. 2021. Available at: https://www.cdc.gov/reproductivehealth/maternalinfanthealth/severerematernaltobidity.html#anchor_References. Accessed February 27, 2022.
17. Hebert PR, Reed G, Entman SS, Mitchel EF, Berg C, Griffin MR. Serious maternal morbidity after childbirth: prolonged hospital stays and readmissions. Obstet Gynecol 1999;94: 942–7.
18. Agency for Healthcare Research and Quality. Healthcare Cost and Utilization Project (HCUP). 2020. Available at: www.hcup-us.ahrq.gov/faststats/national/inpatientcommon-diagnoses.jsp. Accessed February 27, 2022.

19. Society for Maternal-Fetal Medicine (SMFM) Quality and Safety and Health Policy Committees. Bailit JL, Gregory KD. Society for Maternal-Fetal Medicine (SMFM) Special Report: current approaches to measuring quality of care in obstetrics. Am J Obstet Gynecol 2016;215:B8–16.

20. Girsen AI, Sié L, Carmichael SL, et al. Rate and causes of severe maternal morbidity at readmission: California births in 2008-2012. J Perinatol 2020;40:25–9.

21. Wen T, Yu VX, Wright JD, et al. Postpartum length of stay and risk for readmission among women with preeclampsia. J Matern Fetal Neonatal Med 2020;33:1086–94.

22. Declercq ER, Cabral HJ, Cui X, et al. Using longitudinally linked data to measure severe maternal morbidity. Obstet Gynecol 2022;139:165–71.

23. Black CM, Vesco KK, Mehta V, Ohman-Strickland P, Demissie K, Schneider D. Hospital readmission following delivery with and without severe maternal morbidity. J Womens Health (Larchmt) 2021;30:1736–43.

24. Clapp MA, Robinson JN, Little SE. The relationship between the rising cesarean delivery and postpartum readmission rates. J Perinatol 2017;37:355–9.

25. Belfort MA, Clark SL, Saade GR, et al. Hospital readmission after delivery: evidence for an increased incidence of nonurogenital infection in the immediate postpartum period. Am J Obstet Gynecol 2010;202:35.e1–7.

26. Mogos MF, Salemi JL, Spooner KK, McFarlin BL, Salihu HH. Hypertensive disorders of pregnancy and postpartum readmission in the United States: national surveillance of the revolving door. J Hypertens 2018;36:608–18.

27. Chornock R, Iqbal SN, Kawakita T. Racial disparity in postpartum readmission due to hypertension among women with pregnancy-associated hypertension. Am J Perinatol 2021;38:1297–302.

28. Lovgren T, Connealy B, Yao R, Dahlke JD. Postpartum management of hypertension and effect on readmission rates. Am J Obstet Gynecol MFM 2022;4:100517.

29. California Pregnancy Mortality Surveillance System. California pregnancy-related deaths, 2008–2016. 2021. Available at: https://www.cdph.ca.gov/Programs/CFH/DMCAH/surveillance/CDPH%20Document%20Library/CA-PMSS/CA-PMSS-Surveillance-Report-2008-2016.pdf. Accessed June 6, 2022.

30. Oh EG, Lee HJ, Yang YL, Kim YM. Effectiveness of discharge education With the teach-back method on 30-day readmission: a systematic review. J Patient Saf 2021;17:305–10.

31. Henke RM, Karaca Z, Jackson P, Marder WD, Wong HS. Discharge planning and hospital readmissions. Med Care Res Rev 2017;74:345–68.

32. Lydon-Rochelle MT, Holt VL, Nelson JC, et al. Accuracy of reporting maternal in-hospital diagnoses and intrapartum procedures in Washington State linked birth records. Paediatr Perinat Epidemiol 2005;19:460–71.

33. Salemi JL, Hansen MA, Modak S, et al. Estimating the obstetric co-morbidity burden using administrative data: the impact of the pregnancy-related assessment window. Paediatr Perinat Epidemiol 2020;34:440–51.