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Characteristics and Regions of Hospital Locations and the Risk of Postpartum Hemorrhage.

Zahra Shahin

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CHARACTERISTICS AND REGIONS OF HOSPITAL LOCATIONS AND THE RISK OF POSTPARTUM HEMORRHAGE

by

ZAHRA SHAHIN

(Under the Direction of Gulzar H. Shah)

ABSTRACT

Background: Postpartum hemorrhage (PPH) is one of the contributing factors to maternal morbidity and mortality that in addition to maternal risk factors, may be related to other factors such as obstetric practice and clinical management of postpartum hemorrhage. Therefore, this study aimed to explore the association of postpartum hemorrhage with characteristics and regions of hospital locations across the United States, as the outcomes may create opportunities to improve policies and protocols regarding PPH management more effectively.

Method: A retrospective study was performed using the 2018 National Inpatient Sample (NIS) database. Low-risk delivery hospitalizations involving the third stage of labor with an index for PPH were selected. Postpartum hemorrhage is further categorized as third-stage hemorrhage, delayed and secondary PPH, other immediate PPH, and postpartum coagulation defects. Pearson chi-square tests and multivariable logistic regression models were performed to compare and examine the associations of the risk of PPH and PPH sub-categories with hospital characteristics and regions.

Results: Postpartum hemorrhage occurred in approximately 4% of the sample. Among postpartum cases, other immediate PPH was the most common (80%) cause of PPH cases. Results also revealed that hospitals in the West region had some of the strongest associations in an increased risk of PPH and third-stage hemorrhage, while hospitals owned by private investors had significant associations in decreased risk of all four PPH subcategories.

Conclusion: The
associations of the risk of PPH and some of the PPH subcategories were significantly varied across regions and hospital characteristics. Preliminary research is needed to determine whether these variations are due to obstetric practice and management or other factors to construct strategies and cost-effective intervention programs that can be tailored to patient characteristics, regions, and hospital types.

INDEX WORDS: Postpartum hemorrhage, Causes and management, Evaluation, Prevention, Treatment, Donabedian model of the quality of medical care
CHARACTERISTICS AND REGIONS OF HOSPITAL LOCATIONS AND THE RISK OF

POSTPARTUM HEMORRHAGE

by

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B.S., Isfahan University of Medical Science, Iran, 1999

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A Dissertation Submitted to the Graduate Faculty of Georgia Southern University in Partial Fulfillment of the Requirements for the Degree

DOCTOR OF PUBLIC HEALTH

JIANN PING HSU COLLEGE OF PUBLIC HEALTH
CHARACTERISTICS AND REGIONS OF HOSPITAL LOCATIONS AND THE RISK OF
POSTPARTUM HEMORRHAGE

by

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DEDICATION

This dissertation is dedicated to my dad, who was my inspiration to pursue my doctoral degree and always believed in my success in the educational arena. Although he was unable to see my graduation, his belief in me has made this journey possible.

To my mom, whose good examples taught me to work hard for the goals I aspire to achieve.

To my wonderful husband and daughter, completing this dissertation would not have been possible without your support and encouragement. I am really grateful to have you guys in my life.
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CHAPTER 1
INTRODUCTION

Statement of the Problem

Postpartum hemorrhage (PPH) is the most common complications of childbirth and one of the leading causes of maternal morbidity and mortality in the United States (Reale et al., 2020; Wormer et al., 2020). Postpartum hemorrhage occurs when blood loss exceeds 1000 ml regardless of the delivery route (Wormer et al., 2020). It occurs within the first 24 hours and up to 12 weeks after childbirth (Corvino et al., 2020). PPH prevalence increased from 2.9% in 2010 to 3.2% in 2017 (Reale et al., 2020).

PPH can occur in patients without risk factors for hemorrhage. However, certain conditions may increase the risk of PPH. These include multiple pregnancies, fibroids, preeclampsia, amnionitis, instrumental vaginal delivery, previous cesarean delivery (Corvino et al., 2020; Ford et al., 2015; Kramer et al., 2013; Leveno & Alexander, 2013), prolonged labor, obesity (Edhi et al., 2013 & Blomberg 2011), infection, and the use of forceps or vacuum-assisted delivery (Edhi et al., 2013); demographic factors such as an age of ≥35 years and ethnicity of African American (Bannerman et al., 2019), Asian, or Hispanic (Cabacungan et al., 2012; Harvey et al., 2017; Sebghati and Chandraharan, 2017).

Complications of PPH include anemia, fatigue, dilutional coagulopathy, orthostatic hypotension, myocardial ischemia, postpartum depression, postpartum pituitary necrosis (Sheehan syndrome), the need for blood transfusion, and death (Evensen, 2017). Sheehan syndrome, which occurs rarely, is characterized by lactation failure, amenorrhea, breast atrophy, loss of pubic and auxiliary hair, hypothyroidism, and adrenal cortical insufficiency (Collins & Crowe, 2013; Leveno & Alexander, 2013).
The causes of PPH are characterized by four “T’s,” including Tune (uterine atony), Tissue (retained tissue, invasive placenta), Trauma (genital tract laceration, uterine rupture, and uterine inversion), and Thrombin (coagulation abnormalities, disseminated intravascular coagulation) (Sebghati & Chandraharan, 2017). PPH is associated with hemodynamic instability symptoms and hypovolemic shock (Hawkins, 2020), and as the patient continues bleeding, it can lead to significant vasodilation and hypotension (Hawkins, 2020; Wormer et al., 2020). Severe hemorrhage can cause ischemic injury to the liver, heart, kidney, and brain, and increases the length of hospital stay (Marshall et al., 2017; Nyfløt et al., 2021). Increased length of hospital stay is also associated with an increased risk of other complications such as infection and venous thromboembolism, which can lead to increased maternal mortality rates (Marshall et al., 2017) as well as increased care costs (Law et al., 2015; Vesco et al., 2020).

Purpose of the Study

The purpose of this quantitative study was to explore the associations of the risk of postpartum hemorrhage with characteristics and regions of hospital locations in the United States based on 2018 data from the National Inpatient Sample (NIS). PPH is still one of the main causes of maternal morbidity and mortality in the United States through its direct impacts on the vital organs, and indirect consequences of related interventions such as blood transfusion that can lead to anaphylactic reactions and increased risk of infections. Careful assessment of various causes and risk factors of PPH is essential to reduce or even prevent further complications, avoid maternal morbidity and mortality, and better manage PPH. The impacts of PPH complications and the burden of those conditions on both individuals and healthcare systems demand more investigation on collected data, with specific attention to geographic regions and hospital characteristics to determine whether such factors contribute to clinical outcomes of maternal
delivery and PPH rates. To date, few studies have assessed the relationship of hospital characteristics and geographic region on obstetric practice and pregnancy outcomes, as most studies focused on the causes of PPH. Knowing about such factors and their impacts on determinants of PPH incidence may help policy- and decision-makers develop guidelines and protocols for more effective PPH management.

The study aims to answer the following research questions and test the associated hypotheses:

*Research Questions*

- Is there a relationship between hospital characteristics and the risk of PPH?
- Is there a relationship between the region of hospital location and the risk of PPH?

*Hypotheses*

H1A. Region of hospital location is significantly associated with the risk of overall postpartum hemorrhage when controlling for other risk factors.

H2A. The teaching/nonteaching status of the hospital is significantly associated with the risk of overall postpartum hemorrhage when controlling for other risk factors.

H3A. The rurality status of the hospital is significantly associated with the risk of overall postpartum hemorrhage when controlling for other risk factors.

H4A. The ownership status of the hospital is significantly associated with the risk of overall postpartum hemorrhage when controlling for other risk factors.

H5A. Region of hospital location is significantly associated with the risk of other immediate PPH when controlling for other risk factors.

H6A. The teaching/nonteaching status of the hospital is significantly associated with the risk of other immediate PPH when controlling for other risk factors.
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H20A. The ownership status of the hospital is significantly associated with the risk of postpartum coagulation defects when controlling for other risk factors.

The findings may help create better strategic plans for hospital management and patient safety policy, raise awareness of the importance of clinical diagnosis and early detection of PPH, promote effective communication and care coordination among the multidisciplinary team to reduce or even prevent PPH and related complications, improve maternal health outcomes, reduce the length of hospital stays, and reduce healthcare expenditures. This is the first study that examines the correlation between PPH rates with characteristics and the regions of hospital locations using HCUP data. A recent study that considered hospital characteristics by using NIS data focused on the relationships between hospital birth volume and maternal morbidity among low-risk pregnancies (Kozhimannil et al., 2016).

Significance of the Study

Reducing the incidence of postpartum hemorrhage (PPH) is one of the challenges of obstetric practice. Active management of the third stage of labor is critical in reducing PPH occurrence, but is influenced by many factors, including standard guidelines and protocols, quick service accessibility, availability of resources (equipment and staff), and quality of care services (Adane et al., 2019; Kacmar et al., 2014; Kozhimannil et al., 2016; Otolorin et al., 2015). It is noteworthy to point out that a study using national data found 45 percent of rural US counties lacked hospital obstetric services, and more than nine percent of rural counties confronted
hospital closures (Hung et al., 2018). Although researchers observed significant variations in the incidence of PPH by hospital types (Lu et al., 2005), hospital volume, teaching status, urban non-teaching, and rural setting (Snowden et al., 2015), the associations between PPH and characteristics and regions of hospital locations have never been carefully examined (Marshall, 2017).

Identifying the characteristics and regions of hospital locations with a higher rate of PPH may help predict and identify high-risk cases and prevent PPH complications during the third stage of labor and develop interventions to enhance effective communication and coordination of care services among medical team regarding childbirths to improve patient safety. Such a study facilitates further investigation regarding the implementation of PPH guidelines and protocols, availability of resources, coordination of a multi-professional team approach, and the assessment of training for healthcare providers about the importance of third-stage delivery management. Further, it provides the opportunity for policy- and decision-makers to improve the implementation of guidelines and protocols regarding maternal care. Such actions would reduce healthcare expenditures.

Delimitations

This is a retrospective cohort study that utilized the 2018 National Inpatient Sample (NIS) from Healthcare Cost and Utilization Project’s (HCUP) databases. The NIS database includes all patient discharges from community hospitals in the United States (although, since 2012, it has not included rehabilitation hospitals and long-term acute-care hospitals). The NIS data provides the opportunity to create national and regional estimates by analyzing weighted data to produce accurate and unbiased results (HCUP, 2017). The study population included a low-risk sample of women aged ≤19-54 in the third stage of labor, with an index for postpartum
hemorrhage (PPH), and excluded previous cesarean sections and cases with high-risk clinical conditions that are known to be associated with maternal hemorrhages such as antepartum hemorrhage, abruptio placentae, and placenta previa (Lu et al., 2005).

Definition of Terms

_Uterine atony_: Failure of uterus contraction following placental delivery.

_Retained tissue_: Small placental fragments or remaining pieces of the placenta that can cause late hemorrhage in the puerperium.

_Inversion of the uterus_: A complete or partial uterine inversion occurs after childbirth and when the umbilical cord is attached to a placenta implanted in the fundus, which is sometimes associated with immediate life-threatening hemorrhage. Often, the inverted uterus can be restored to its normal position; otherwise, laparotomy is imperative.

_Vaginal lacerations_: Vaginal lacerations are usually caused by injuries while using forceps or during vacuum operation but may occur with spontaneous delivery as well. Such tears may extend deep into the underlying tissues and cause significant bleeding. However, it is usually controlled with suturing.

_Cervical lacerations_: Cervical lacerations occur during delivery due to fetal delivery through the cervix during vaginal delivery. In heavy bleeding cases during and after the third stage of labor, a deep cervical laceration should be considered, especially when the uterus is fully contracted. A thorough examination and visual inspection of the cervix in addition to digital examination are required.

_Hematomas_: Hematomas is a solid swelling of blood collected outside the blood vessels, and may be caused by spontaneous or operative delivery and classified as vulvar, vulvovaginal,
paravaginal, or retroperitoneal. Sometimes hemorrhage is delayed, and pain is the first symptom noticed.

**Hypovolemia:** Hypovolemia refers to a condition of low extracellular fluid volume, and occurs due to hemorrhage, and that is “the common cause of acute renal tubular necrosis (ATN) and even acute respiratory distress syndrome (ARDS)” (Leveno & Alexander, 2013).

**Placenta Accrete:** The placenta accrete occurs when part of the placenta penetrates the uterine wall (the decidua but not myometrium), which can cause severe bleeding.

**Placenta Increta:** Placenta increta is a condition in which the placenta further penetrates the myometrium.

**Placenta Precreta:** The placenta percreta is a condition in which the placenta grows through the uterine wall and perforates the serosa and sometimes penetrates adjacent organs such as the bladder.

**Disseminated intravascular coagulation (DIC):** DIC is a pathological condition that disrupts the blood clotting process and leads to bleeding and multiple organ failure. DIC can develop after massive hemorrhage and thrombosis, which are life-threatening situations.

**Patient safety:** Preventing and eliminating medical errors in healthcare services.
CHAPTER 2
LITERATURE REVIEW

Postpartum hemorrhage (PPH) is an obstetric emergency that can be life-threatening if not properly managed (Sheikh et al., 2011). It usually occurs within the first 24 hours and up to 12 weeks after childbirth (Corvino et al., 2020). If hemorrhage occurs within 24 hours of delivery, it is considered primary PPH, and if bleeding occurs after 24 hours, that is considered secondary PPH (Edhi et al., 2013). Uterine atony is responsible for approximately 75% of PPH (Gill et al., 2020) and is the most common cause of primary PPH (Wormer et al., 2020; Edhi et al., 2013), while retained uterine products and cervical and vaginal tears are the most common causes of secondary postpartum hemorrhage (Edhi et al., 2013; Wormer et al., 2020). A retrospective study of the National Inpatient Sample (NIS) database from 2012 to 2013 showed that PPH occurred in 3% of deliveries, of which 76.6% were related to uterine atony and 23.4% were nonatonic. Researchers observed women with nonatonic PPH experienced the highest average length of hospital stay (3.67 days) compared to atonic PPH (2.98 days) and women without PPH (2.63 days) (Marshall et al., 2017).

Complete or partial placenta previa can increase the risk of placenta accreta, increta, and percreta. Placenta previa and accreta are serious conditions and can increase the risk of maternal morbidity and mortality (Peng, 2019), and often require a cesarean delivery. Early diagnosis is possible by performing ultrasound or having symptoms such as painless bleeding in the second or third trimester of pregnancy (Anderson & Sze, 2020).

Early detection of placenta previa in the first and second trimester of pregnancy is important for PPH management. MRI can be used for cases of posterior placenta previa or to assess potential invasion to the bladder (Anderson & Sze, 2020; Wormer et al., 2020). However,
it is an expensive procedure and has shown no superior diagnostic outcomes compared to ultrasonography. Usually, cesarean and hysterectomy are recommended if there is strong suspicion of the placenta accreta spectrum. Placenta previa also increases the risk of neonatal mortality and morbidity, such as preterm birth, lower birth weight, lower APGAR scores [Appearance, Pulse (heart rate), Grinace (reflexes), Activity (muscle tone), Respiration (breathing effort)], and respiratory distress syndrome (Anderson & Sze, 2020).

Risk Factors of PPH

Quantitative studies from the United States and other countries that used secondary data found various risk factors were associated with the PPH incidence rate. Blomberg (2011) used data of 1,114,071 women with singleton pregnancies in Sweden from January 1, 1997, through December 31, 2008. Obese women were compared with normal-weight women to assess the relationships between body mass index (BMI) and PPH incidence. Results showed that BMI over 40 increased the risk of atonic PPH (Blomberg, 2011).

Results of a prospective cohort study that used medical records from June 2013 to July 2016 to investigate the incidence and risk factors of PPH among 1,068 transvaginal deliveries of singleton pregnancies at a tertiary perinatal medical facility in Japan showed that weight gain >15 kg during pregnancy, fetal macrosomia (over 4000 g), severe vaginal or perineal lacerations, pregnancy-induced hypertension (PIH), use of assisted reproductive technology (ART), and maternal smoking habit were the risk factors of PPH. Researchers excluded cesarean delivery, stillbirth, and multiple pregnancies (Fukami et al., 2019).

Results of a study from medical records of 536 PPH cases in Turkey between December 2011 and November 2014 showed that risk factors such as body mass index, birth weight (≥4000g), maternal age, parity, previous cesarean delivery, polyhydramnios, multiple gestations,
elevated liver enzymes, hemolysis, severe preeclampsia, eclampsia, low platelets syndrome, chorioamnionitis, prolonged labor, oxytocin augmentation, episiotomy, emergency cesarean delivery, and general anesthesia were significantly associated with severe PPH (Ekin et al., 2015). A population-based, nested case-control study from six cluster-randomized controlled trials in 106 French maternity units between 2004 and 2006 also found that older age, labor induction, receiving more oxytocin during labor (total oxytocin dose more than 1.68 IU), use of instrumental delivery, episiotomy, perineal tear, and fetal macrosomia (birth weight > 4000g) were significantly associated with an increased risk of severe PPH in the case group. This study also found that epidural analgesia and prophylactic postpartum oxytocin administration significantly decreased the risk of severe PPH (Dionne et al., 2015).

Likewise, Kramer et al. (2013) used NIS data from 1999 to 2008 to examine risk factors for severe PPH found that changes in risk factors were associated with 5.6% of the increase in severe PPH. Researchers additionally observed that with a rise of severe PPH cases, from 1.9 in 1999 to 4.2 in 2008 per 1000 delivery, the rate of transfusion and hysterectomy also increased. This study identified cesarean delivery, instrumental vaginal delivery, maternal age of >35, multiple pregnancies, fibroids, preeclampsia, amnionitis, placenta previa or abruption, cervical laceration, and uterine rupture as risk factors of severe PPH with adjusted odds ratio (AOR) of 1.4, 1.5, 1.5; 2.8, 2.0, 3.1, 2.9, 7.0, 9.4, and 11.6, respectively. Researchers also found that risk factors such as fetal macrosomia, placenta previa or abruption, and cesarean delivery were significantly associated with atonic PPH, while placenta previa or abruption was significantly associated with severe nonatonic PPH. The odd ratios for atonic PPH with transfusion and hysterectomy were 1.8 (95% CI, 1.6–1.9); and 1.4 (95% CI, 1.03–1.8), respectively (Kramer et al., 2013).
Another case-control study examined the association of the induction method of labor and postpartum hemorrhage (PPH) of low-risk parturient women in 106 French maternity units between December 2004 and November 2006. Researchers identified 4,450 women with PPH. They classified subjects as 1,125 cases with severe PPH and 1,744 controls based on standard and non-standard induction. After adjustment for all potential confounders, results of the study evidenced that labor induction for low-risk women puts them at greater risk of PPH than spontaneous labor, and that was responsible for a 20% increased risk of severe PPH, regardless of the induction method used. The risk of severe PPH was significantly associated with the standard method, but no significant association was observed for non-standard induction. The induction method included oxytocin or prostaglandins (Khireddine et al., 2013). Driessen et al. (2011) used the same data and noticed that factors such as previous PPH, previous cesarean delivery, cervical ripening, prolonged labor, episiotomy, delay in initial care for PPH, and delivery in a public non-university hospital were associated with severe PPH (Driessen et al., 2011).

A study using the NIS 2001-2012 database showed that due to the occurrence of PPH, the rate of blood transfusions increased from 1.6 in 2001-2002 to 3.8 in 2011-2012 (p<0.001), and that was doubled for cesarean deliveries from 2.0 in 2001-2002 to 4.8 in 2011-2012; p<0.001). Researchers also found that uterine atony increased PPH cases by 14.1% among all cesarean deliveries during 2001-2002, but induction increased the rate of PPH cases in vaginal deliveries from 2011 through 2012. During the same period, however, PPH decreased by 18.3% in vaginal deliveries that were not induced (Ahmadzia et al., 2020).

Inconsistency was also observed among studies in the United States that assessed the associations between race and PPH incidence. Marshall et al. (2017) conducted a retrospective
study by using the NIS database during 2012 through 2013 to investigate the impact of postpartum hemorrhage on length of hospital stay and inpatient mortality and found that atonic PPH was more common in Hispanic women and nonatonic PPH was more common in White women. Researchers also observed multiparity, sociodemographic patient characteristics, and longer hospital stays (LOS) were associated with PPH (Marshall et al., 2017). Gyamfi-Bannerman et al. (2018) used NIS data from 2012-2014 to examine the associations between race and PPH, found that non-Hispanic Black women were at the highest risk for maternal morbidity with PPH compared to other races, and almost five times at higher risk for death. Non-Hispanic Black women had the highest risk for disseminated intravascular coagulation (8.4%) when compared to non-Hispanic White women, Hispanic, and Asian or Pacific Islander women (7.1%, 6.8%, and 6.8%, respectively, P < .01). They were also at higher risk for transfusion (19.4%) compared to Hispanic, Asian or Pacific Islander, and non-Hispanic White women (16.1%, 15.8%, and 13.9%, respectively, P < .01).

The results also showed more PPH cases (63.7%) in urban teaching hospitals. It should be pointed out that the rate of delivery for Asian and Hispanic women was higher in the West region (46.6% and 54.6%, respectively), while the rate for non-Hispanic Black and non-Hispanic White women, were higher in the south region (46.8% and 32.1% of deliveries, respectively) (Gyamfi-Bannerman et al., 2018).

A retrospective cohort study used data from the Centers for Disease Control and Prevention from 1979-2017 of all live births and maternal deaths within 42 days of a pregnancy that was caused by hemorrhage. The sample included 152,268,131 live births and 29,088 overall maternal deaths in the United States during the study period, of which 1,890 (6.5%) of maternal deaths were caused by hemorrhage. Results of the study showed that in 1999, the rate of
maternal death related to hemorrhage among non-Hispanic Black women was 4.58, which was four times higher compared to White women. The rate dropped slightly to 3.21 in 2017 when the rate for non-Hispanic White women was 1.11, and increased to 1.35 per 100,000 (Jenani et al., 2020).

Miller et al. (2017) also conducted a retrospective case-control study to examine the association between second-stage duration and PPH incidence after vaginal delivery. In this study of 159 cases and 318 controls, vaginal childbirths were performed by a labor nurse and obstetrician, and blood loss during and after each vaginal delivery was measured by the nurse. Results of the study showed that nulliparous women with a second stage duration of ≥3 hr had a higher risk of developing PPH when compared to those with a second stage duration of <2 hr or 2–2.9 hr (p=0.04). However, the second stage with a duration of ≥2 hr showed no significant differences in PPH incidence among multiparous women. Researchers also observed that among PPH cases, 4% received red blood cells, and 1% needed intensive care (Miller et al., 2017).

It is worth emphasizing that the risk of PPH increases with the third stage duration of 20 minutes, and the risk of severe PPH rises with the third stage duration of 23–25 minutes (Marshall et al., 2017; Dionne et al., 2015). Researchers noticed that every ten minutes of additional delay increased adjusted odd ratios of PPH risk by 1.11 (1.02–1.21) and 1.14 (1.03–1.27) for the risk of severe PPH (Dionne et al., 2015). Delayed diagnosis of severe hemorrhage, poor team communication, limited access to timely and quality care, delayed transfusion, and inadequate access to resources such as blood products are other contributing factors that can increase the risk of severe PPH (Hawkins, 2020; Kodan et al., 2020). The increased risk of severe PPH is worrying because it can increase the risk of blood transfusion, compromise women’s future fertility, and increase care costs (Driessen et al., 2011). A population-based
A cohort study found that prolonged labor, episiotomy, delayed initial care for PPH, specifically administered oxytocin more than 10-20 minutes after PPH diagnosis, and waiting more than 10 minutes to call for additional assistance (such as an obstetrician and an anesthesiologist) increased the risk of severe PPH (Driessen et al., 2011).

As pointed out earlier, PPH increases the length of hospital stays and results in increased health expenditures. The annual cost of increased length of hospital stay was estimated at approximately $106.7 million (Marshall et al., 2017). A study investigated the costs of care services for maternal complications during pregnancy and not solely for PPH complications. This study used the 2013 insurance claims data from the MarketScan® Commercial Claims and Encounters and the MarketScan® Medicaid database and selected 750 women with severe maternal morbidity (SMM) to estimate the cost of healthcare services. Costs were computed using the amounts paid by insurers, plus out-of-pocket and third-party payments. Results of the study showed that costs of care across maternal complications were higher than for normal delivery. The costs were counted for the prenatal care services, delivery hospitalization, and postpartum periods. Researchers found that the cost of the prenatal care, delivery, and postnatal care for women with SMM were $4504, $15,498, and $378, respectively, while such costs for women without SMM were $3235, $11,411, and $194, respectively. In addition, the average cost of care for women without and with SMM was estimated at $14,840 and $20,380, respectively (Vesco et al., 2020).

Management of Postpartum Hemorrhage Associated with PPH

Management of the third stage of labor can be done in two ways: expectant management and active management. Expectant management of the third stage of labor refers to waiting for spontaneous delivery of the placenta. Active management means the administration of uterotonic
drugs prior to placenta delivery and clamping and cutting the umbilical cord (Hale, 2019; Nothnagle & Taylor, 2003). However, because some risk factors of PPH cannot be anticipated as potential predictors of PPH, active management of the third stage of labor is recommended (Garba et al., 2019). Rapid assessment and identification of the cause of bleeding and the patient’s condition is crucial to take appropriate and timely measures to control bleeding and prevent further complications and adverse outcomes (Sebghati & Chandraharan, 2017; Wormer et al., 2020).

In conditions related to the third stage of labor, where postpartum hemorrhage can be predicted, evaluation and active management that includes a multidisciplinary team approach—including skilled birth attendants, laboratory and labor personnel, healthcare providers, and pharmacists—is essential to prevent adverse outcomes, and to reduce the administration of uterotonic drug therapy, maternal blood transfusions, and maternal blood loss (Anderson & Sze, 2020; Garba et al., 2019; Hale, 2019; Wormer et al., 2020). The presence of skilled birth attendants is significant in PPH management. One study found that adverse pregnancy outcomes were associated with the level of experience of healthcare providers. Researchers observed that minimum adverse maternal outcomes occurred when midwives led deliveries (Reif et al., 2017).

Evaluation of Postpartum Hemorrhage

Initial evaluations of PPH include detecting excessive bleeding and rapid assessment of the risk factors and patient’s status (Sebghati & Chandraharan, 2017; Wormer et al., 2020). Examining the entire genital tract for lacerations, uterine rupture, hematomas, or signs and symptoms of hemorrhage is vital to identify the possible cause of bleeding (Wormer et al., 2020). Bimanual pelvic exams, ultrasound, MRI, and laboratory tests are various approaches that can be used to detect the cause of hemorrhage and provide interventions such as administering
medications and blood products (Wormer et al., 2020). The patient should also be assessed for disseminated intravascular coagulation (DIC), and if suspected, appropriate medication should be administered (Collins ET AL., 2016; Wormer et al., 2020). Diagnosis and treatment of the cause of bleeding, fluid resuscitation for maintaining blood volume, and hemodynamic stability of the patient are important measures of PPH management (Sebghati & Chandraharan, 2017; Wormer et al., 2020). However, the administration of various uterotonic medications and methods to treat PPH depends on the conditions and cause of PPH. For instance, if Tissue (Retained placental fragments) is the cause of PPH, the uterus should be explored, and the fragment removed. Further information regarding the treatment of PPH was provided in Table 1 (Evensen et al., 2017; Leveno & Alexander, 2013).
### Table 1

*Evaluation of Postpartum Hemorrhage*

<table>
<thead>
<tr>
<th>Causes of PPH</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uterine atonyis</td>
<td>- Oxytocin 20U IN 1000mL of lactated Ringer,</td>
</tr>
<tr>
<td></td>
<td>- Methylergonvine 0.2,</td>
</tr>
<tr>
<td></td>
<td>- 15- methyl derivative of prostaglandin F$_{2a}$ (0.25mg) intramuscularly,</td>
</tr>
<tr>
<td></td>
<td>- Ligation if the internal iliac arteries</td>
</tr>
<tr>
<td>Retained placental fragments</td>
<td>- Uterus should be explored and the fragment removed</td>
</tr>
<tr>
<td>Placenta accrete, increta, precreta</td>
<td>- Immediate blood replacement therapy and prompt hysterectomy,</td>
</tr>
<tr>
<td></td>
<td>- Alternative measures: internal iliac artery ligation or angiographic embolization</td>
</tr>
<tr>
<td>Uterine inversion</td>
<td>- Reinverted by vaginal otherwise manipulation and laparotomy</td>
</tr>
<tr>
<td>Lacerations and hematomas</td>
<td>- Through examination and inspection, Extensive repair,</td>
</tr>
<tr>
<td></td>
<td>- Using gauze packs for vaginal laceration</td>
</tr>
<tr>
<td>Hematomas</td>
<td>- Prompt incision along with evacuation of blood and clots and ligation of bleeding points, and replacement of adequate blood replacement,</td>
</tr>
<tr>
<td></td>
<td>- Angiographic embolization</td>
</tr>
</tbody>
</table>


Other contributing factors that significantly impact the active and effective management of the third stage of labor include the availability of resources and access to quality emergency obstetric and delivery care. Among such factors, the role of hospital characteristics and region of hospital locations on the clinical outcomes and effective management of the third stage of labor cannot be ignored.
The following sections provide information regarding the role of characteristics and geographic regions of hospital locations on the third stage of labor and the rate of PPH.

Hospital Characteristics & Geographic Region

Since 2010, more than one hundred rural hospitals have been closed (O’Hanlon et al., 2019). National data from 2004 to 2014 showed that 45 percent of rural U.S. counties lacked hospital obstetric services, and nine percent of rural counties experienced hospital foreclosure (Hung et al., 2017). The loss of rural hospitals creates obstacles in receiving obstetric care services for women of reproductive age. Because of low birth volume, rural communities experience low-quality maternal health services as the result of workforce shortages and lack of financial resources, and these have affected maternal health outcomes (Hung et al., 2017).

One study used the 2011 Nationwide Inpatient Sample (NIS) from 607 hospitals to assess the relationship between hospital birth volume and multiple maternal morbidities (including postpartum hemorrhage (PPH), blood transfusion, and severe perineal laceration among low-risk pregnancies) in rural hospitals, urban non-teaching hospitals, and urban teaching hospitals. Researchers classified PPH for vaginal delivery and cesarean delivery, including transfusion of blood products, chorioamnionitis, endometritis, severe perineal lacerations (3rd and 4th degree) in spontaneous vaginal deliveries, and wound infection in cesarean deliveries. The adjusted odds of overall PPH (AOR=1.31) and PPH among vaginal deliveries (AOR=1.32), and the adjusted odds of blood transfusion (AOR=1.61) were higher for low-volume, rural hospitals than for urban teaching hospitals. Lower-volume hospitals had significantly lower odds of PPH when compared with high-volume hospitals. The odds of blood transfusion and severe perineal lacerations were higher in urban non-teaching and rural hospitals, and wound infection was higher in rural hospitals when compared to teaching hospitals (Kozhimannil et al., 2016).
A retrospective cohort study used California Patient Discharge Data from Vital Statistics in 2007–2008 to examine the impact of hospital obstetric volume on maternal outcomes. The sample populations were women without preexisting medical conditions who delivered full-term, normal-weight infants. Hospitals were categorized based on annual delivery volume into 50–1199, 1200–2399, 2400–3599, and 3600, or more deliveries per year. The results of the study discovered that in the lowest-volume rural hospitals, the odds of PPH (OR 3.06; 95% CI 1.51 – 6.23) were three times higher when compared to the highest-volume hospitals. Adjusted odds increased by two times (OR =1.95; 95% CI=1.00 – 3.81) for medium-volume rural hospitals when compared to the highest volume (Snowden et al., 2014). Another study also investigated the impacts of a busy day on maternal delivery outcomes. Yearly deliveries were categorized as < 1000, 1000–1999, 2000–2999, ≥ 3000, and correlated to the profile of university hospitals. Researchers observed that a busy day caused 28% and 25% more blood transfusions in hospitals with yearly delivery of 1000-1999 and the profile of university hospitals respectively, when 22% and 83% less blood transfusions were needed at university hospitals and hospitals with yearly delivery of 2000–2999 respectively (Vilkko et al., 2021).

Almost fifty percent of rural women live within a 30-minute drive to the nearest hospital, and some within 60 minutes or more to access prenatal care (Health Disparities, 2014). Evidence on using national data regarding the association between hospital geographic location and maternal outcomes are limited, and most studies assess the relationship between maternal outcomes and physician volume or birth volume (Kozhimannil et al., 2016). The present study found only one study from Canada that investigated the relationships of geographic accessibility and delivery volume on obstetric outcomes. The results of that study demonstrated that travel distance of more than 200-299 km increased the odds of adverse maternal delivery outcomes.
The outcomes improved when delivery volume exceeded 1000 deliveries per year but got worse when delivery/year exceeded >2500 (Bassler 2019).

Conceptual Framework

This study used the Donabedian model as a conceptual framework to guide the research method (Figure 1). This model helps in understanding which aspects of the program should be researched and scrutinized to explain the practical problems regarding effective and timely delivery of care services. It also shows the need to investigate scarcity in resources and their relations with delivering healthcare services in a broader context, and to develop policies to address those deficiencies and thereby improve the quality of care (Kitchel & Ball, 2014).
The Donabedian model focuses on assessing the quality of care and is established based on three interrelated concepts, including structure, process, and outcome, which influence each other.

Structure is defined as the physical and organizational aspects of care settings such as facilities, equipment, financial resources, and organization structure such as human resources, staff training program, methods of reimbursement, and peer review (Donabedian, 1988).

Process refers to a system where care activities occur and a setting in which care is provided and received. Process is focused on patient care and improving the care activities: the patient seeks care, and the practitioner makes diagnoses and provides treatment. According to the Donabedian conceptual framework, the technical and the interpersonal are two components of the practitioner’s performance. Technical performance is based on the knowledge, judgment, and
skills to perform proper care. The best practice is knowing what to do and when to do it to achieve the best results (Donabedian, 1988).

The second important element of the practitioner’s performance is to manage the interpersonal relationship, knowing how to communicate with patients and exchange information about the nature of the disease in order to make an accurate diagnosis. Also, learning how to manage the condition, which creates trust between patient and care provider and motivates the patient to participate in their care actively. Often, ineffective interpersonal communication creates obstacles in obtaining medical history information, potentially resulting in inadequate patient evaluation and delay or error in diagnosis. The model also emphasizes documentation of patient medical records as a way to assess and detect errors in diagnostic testing and clinical assessment, and to improve the quality of care (Donabedian, 1988).

The other component is patients’ access to quality care and whether they have greater or lesser access to care. The quality of care in a community is also influenced by many factors over which care providers have no control. Nonetheless, they need to be understood and considered. Therefore, in addition to practitioner performance, other factors such as resources, skilled personnel, and interpersonal process management should be considered when assessing the quality.

*Outcome* is the last category of the Donabedian conceptual framework. Outcome focuses on patient recovery, functional restoration, and survival. In the event of adverse or catastrophic outcomes, each case needs to be examined to identify deficiencies in the healthcare services (Donabedian, 1988).

Although the *process* category of the Donabedian model is focused mainly on the practitioner’s performance as a critical element of improving care quality, this category is
influenced directly by the structure category. In other words, the three categories of the Donabedian model are interrelated, and each category directly influences the next category. If deficiencies exist in any of the categories, they will affect the quality of care. Thus, identifying deficiencies in the healthcare system that impact patient health outcomes in order to correct them requires the assessment and monitoring of each of the three categories of the framework (Donabedian, 1988). That said, the Donabedian model focuses more on assessing the quality of care rather than on its continuous improvement, and each concept can be used independently for assessment since there is no explicit description of the relationship between each category (Haj et al., 2013).

The flexibility of the Donabedian Conceptual framework allows it to be used in various types of research, especially health-care quality research (Haj et al., 2013; McDonald et al., 2007). For instance, Binder et al. (2021) used the Donabedian model as a framework for guiding the design of a method for COVID-19 response at a hospital in Suburban Westchester County, New York. The framework helped researchers formulate the initial response to COVID-19 emergency care and enabled them to modify the structure and process categories to maintain high-quality clinical outcomes while ensuring the safety of the Emergency Department staff. McDonald et al. (2007) used the Donabedian model to design a theoretical framework to predict or explain mechanisms of care coordination controlled by factors in the health care system and their relationship to patient health outcomes and care costs. Haj et al. (2013) also applied such a model to create a theory-driven program to offer interprofessional education (IPE) in the School of Health Sciences to improve the quality of patient care services.
CHAPTER 3

METHODOLOGY

Study Design

This study employs a population-based retrospective cohort design. It uses a large database to perform a quantitative analysis exploring the associations between a hospital’s characteristics (regional location, ownership, teaching status) and the risk of postpartum hemorrhage, in order to answer the research questions. The population-based retrospective cohort study is a type of observational study design that allows researchers to measure and compare the outcomes and exposure in the study population at the same time and investigate the relationship between the variables to estimate the prevalence of a disease in a certain subset of the population (Setia, 2016).

Data Source

The source of the data used is the 2018 National Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project (HCUP). The NIS is the largest publicly available all-payer inpatient-care database in the United States and consists of data for more than seven million hospital stays from U.S. community hospitals each year. The NIS was redesigned in 2012 to improve the national estimate and renamed from “Nationwide Inpatient Sample” to “National Inpatient Sample.”

The NIS is a hospital inpatient-stays database derived from hospitals’ billing data gathered by statewide data organizations across the United States and includes clinical and resource-use information from discharge abstracts. It encompasses data for all hospital stays regardless of the payer (Barrett & Hensche, 2020). Discharges in the NIS sample are obtained from the State Inpatient Database (SID) and classified based on five hospital characteristics such
as census division, location, teaching status, control, and bed size (HCUP, 2018). The large sample size enables researchers to analyze specific populations and develop national and regional estimates (HCUP, 2018). Researchers and policymakers use the NIS data to estimate costs, use, accessibility, quality, and outcomes of the healthcare services (HCUP, 2012).

The NIS provides an annual national sample of hospital discharge records that can be used to examine the relationships among hospital outcomes, discharge characteristics, and hospital characteristics at the national, regional, and census division levels. For states participating in the HCUP Central Distributor, each state’s Inpatient Database provides an annual census of hospital discharge data for that state (HCUP, 2012).

The NIS uses the ICD-10-CM/PCS coding system to report a full calendar year of data with diagnosis and procedure codes. Beginning of the 2016 data year, the NIS coding schema changed from the ICD-9-CM diagnosis codes to ICD-10-CM/PCS coding. In the last quarter of 2015, data elements acquired from AHRQ software tools were not available for ICD-10-CM / PCS or method codes on the NIS, except for the Clinical Classifications Software Refined (CCSR) for ICD-10-CM diagnoses, and that is available from the beginning of 2018 data year (HCUP, 2018).

Study Population

The NIS data was used to select all women aged ≤19-54 in the third stage of labor with an index for postpartum hemorrhage (PPH) from January 1, 2018, to December 30, 2018.
Measures/Variables

To identify inpatient childbirth and delivery hospitalizations involving PPH, this study used the International Classification of Diseases, Tenth Revision (ICD-10) from the American Academy of Professional Coders (AAPC) medical coding. Codes O72, O720, O721, O722, O723, were identified for PPH and PPH subcategories. Other codes that were selected for further analysis include O0993, O432, O43213, O43223, O43233, O468X3, O458X3, O4693, O61, O610, O611, O618, O619, O63, O630, O63, O70, O702, O703, O71, O710 O719, O8611, O8612, O8619, Z3800, and Z3801 (Marshall et al., 2017; Lu et al., 2005; & ICD 10-AAPC). The unit of analysis was the inpatient discharge. Regarding the ICD-10-CM/PCS diagnosis and procedure codes, this study used I10_DX1- I10_DX40 and I10_PR1-10_PR25 to identify the coding scheme for postpartum hemorrhage and other variables in the HCUP databases (HCUP NIS, 2018).

Dependent Variables

The main dependent variables of interest for this study and their corresponding ICD-10 codes are the following

PPH (ICD-10 O72),
- third-stage hemorrhage (ICD-10 O720),
- other immediate PPH (ICD-10 O721),
- delayed and secondary PPH (ICD-10 O722), and
- postpartum coagulation defects (ICD-10 O723),

All of these are dichotomous variables.

“Third-stage hemorrhage” (ICD-10 O720) is classified as retained, trapped, or adherent placenta. “Other immediate PPH” (ICD-10 O622) is defined as uterine atony with hemorrhage.
“Delayed secondary PPH” (ICD-10 O432) is classified as hemorrhage associated with retained portions of placenta or membranes after the first 24 hours following delivery of placenta, retained products of conception NOS, and following delivery. “Postpartum coagulation defects” (ICD-10 O723) were defined as postpartum afibrinogenemia and postpartum fibrinolysis (ICD10-AAPC; ICD-10-CM, 2018).

Independent Variables

Independent variables include hospital characteristics and regions of hospital locations. “Hospital characteristics” included location, ownership, teaching status, and bed size. Regions included Northeast, Midwest, South, and West.

Location. HCUP data categorized hospital location/teaching status and coded as (1) rural, (2) urban nonteaching, and (3) urban teaching. Rural hospitals provide fewer services and are smaller than urban hospitals. “Rural” and “urban” locations are defined using the Core Based Statistical Areas (CBSAs) designated by the U.S. Office of Management and Budget (OMB). The OMB designates three types of areas:

- Metropolitan: agglomerations of one or more counties (or county equivalents) containing at least one urbanized area of at least 50,000 people;
- Micropolitan: agglomerations of one or more counties (or county equivalents) containing at least one urban cluster of at least 10,000 but fewer than 50,000 residents; and
- Counties outside Metropolitan or Micropolitan areas (i.e., rural) (U.S. Census Bureau, 2019).

Hospitals within a Metropolitan CBSA division fall into the urban category, while all others were categorized as rural.
Teaching Status includes teaching and non-teaching. A teaching hospital must meet one of three criteria: Residency training approval by the Accreditation Council for Graduate Medical Education (ACGME); membership in the Council of Teaching Hospitals (COTH), and a ratio of full-time equivalent interns and residents to beds of 25 or higher (HCUP, 2018).

Regarding Ownership, the HCUP data element for hospital ownership was coded as (1) government, non-federal (“public”); (2) private, not-for-profit (“voluntary”); and (3) private, investor-owned (“proprietary”). Hospitals have various responses to government regulations and policies based on their type of ownership.

The variable bed size was coded as (1) small, (2) medium, and (3) large, depending on the number of hospital beds specific to the location, region, and teaching status of the hospital.

The variable region had the following categories (1) Northeast, (2) Midwest, (3) South, and (4) West (HCUP, 2018).

Control Variables

Control variables include maternal age, race/ethnicity, failed induction of labor, prolonged labor, perineal laceration during delivery, puerperal infections, other obstetric trauma, and perineal laceration during delivery.

HCUP calculates the age from the patient’s date of birth (DOB) and the admission data. If the age cannot be calculated, or if the birth date is missing or invalid, then the age is set to the supplied age. If the age cannot be calculated and the age supplied is missing, then age is missing (HCUP, 2018).

Maternal age was categorized as ≤19, 20-34, and 35-54 years of age. Maternal race and ethnicity are defined based on HCUP coding. The race and ethnicity in HCUP dataset are combined into a single data element (HCUP, 2018). In HCUP dataset race variables was coded
as (1) White, (2) Black, (3) Hispanic, (4) Asian/Pacific Islander, (5) Native American, and (6) Other (HCUP, 2018).

The variable Failed Induction of Labor was coded as O61, and included the following:

- failed medical induction of labor (ICD-10 O610);
- failed instrumental induction of labor (ICD-10 O611);
- other failed induction of labor (ICD-10 O618); and
- failed induction of labor, unspecified (ICD-10 O619).

This study selected variables O610 and O611 for failed induction of labor.

The Prolonged Labor variable was coded as O63, and included

- prolonged first stage (of labor) (ICD-10 O630);
- prolonged second stage (of labor) (ICD-10 O631);
- delayed delivery of second twin, triplet, etc. (ICD-10 O632);
- long labor (ICD-10 O639); and
- unspecified (ICD10-AAPC; ICD-10-CM, 2018).

This study selected variables O630 and O631 for the calculation of prolonged labor.

The variable Perineal Laceration During Delivery was coded as O70, and included

- third degree perineal laceration during delivery (ICD-10 O702);
- fourth degree perineal laceration during delivery (ICD-10 O703);
- anal sphincter tear complication delivery (ICD-10 O704); and
- perineal laceration during delivery unspecified (ICD-10 O705).

The Other Obstetric Ttrauma variable was coded as O71, and included

- rupture of uterus before onset of labor, third semester (ICD-10 O7103);
- rupture of uterus during labor (ICD-10 O711);
• obstetric laceration of cervix (ICD-10 O713);
• obstetric high vaginal laceration alone (ICD-10 O714);
• other obstetric injury to pelvic organs (ICD-10 O715);
• obstetric damage to pelvic joints and ligaments (ICD-10 O716);
• obstetric hematoma of pelvic (ICD-10 O717);
• other specified obstetric trauma (ICD-10 O718); and
• obstetric trauma unspecified (ICD-10 O719) (ICD10-AAPC; ICD-10-CM, 2018).

Puerperal Infections variable was coded as O86 and ICD-10 and included
• cervicitis following delivery (ICD-10 O8611);
• endometritis following delivery (ICD-10 O8612);
• vaginitis following delivery (ICD-10 O8613); and
• other infection of genital tract following delivery (ICD-10 O8619).

The variable Single Liveborn Infant in Hospital was coded as ICD-10 Z370, and included
• single liveborn infant, delivered vaginally (ICD-10 Z3800); and
• single liveborn infant, delivered by cesarean (ICD-10 Z3801).

ICD-10 codes for Exclusion variables include
• placenta accreta, third trimester (ICD-10 O43213);
• placenta increta, third trimester (ICD-10 O43223);
• placenta percreta, third trimester (ICD-10 O43233);
• other antepartum hemorrhage, third trimester (ICD-10 O468X3);
• other premature separation of placenta, third trimester (ICD-10 O458X3); and
• antepartum hemorrhage, unspecified, third trimester (ICD-10 O4693).

ICD-10 codes for Supervision of High Risk Pregnancy, unspecified, third trimester was O0993.
Statistical Analysis

STATA software version 16.1 was used to manage and analyze the data. The analysis was restricted to a low-risk sample since variations in PPH rates were more related to differences in obstetrical practice than to patient risk status. Therefore, cases with previous c-sections, high-risk cases in obstetrics, and women with intrapartum hemorrhage, abruption placenta, and placenta previa were excluded due to their high-risk clinical conditions associated with maternal hemorrhage. This is consistent with the previous study (Lu et al., 2005).

Analysis was conducted in several stages. First, the associations of PPH and PPH subcategories (third-stage hemorrhage, other immediate PPH, delayed and secondary PPH, and postpartum coagulation defects) were compared with hospital characteristics, including ownership, teaching status, urban-rural location, bed size, and region for the selected sample. This study analyzed separately the associations between PPH and PPH subcategories with hospital characteristics and the four regions.

Second, the association of process variables—including failed induction of labor, other obstetric trauma, perineal lacerations (3rd and 4th degree), and puerperal infection—were compared with each type of hospital characteristic, including ownership, bed size, teaching status, urban-rural location, and region separately. In addition, five multivariable logistic regression models were performed as model one to estimate the adjusted odds ratio and 95% confidence intervals (CI) of process variables for further analysis with hospital characteristics and region while controlling for age and race/ethnicity (Marshall et al., 2017; Lu et al., 2005).

For model two, five multivariable logistic regression models were performed to estimate the adjusted odds ratio and 95% confidence intervals (CI) of PPH and PPH subcategories—including third-stage hemorrhage, other immediate PPH, delayed and secondary PPH, and
postpartum coagulation defects for each type of hospital characteristic and regions—while controlling for age, race/ethnicity, failed induction of labor, other obstetric trauma, perineal lacerations (3rd and 4th degree), and puerperal infections (Kozhimannil et al., 2016; Lu et al., 2005). Statistical weights were computed and used in the study analyses to produce the population estimates (HCUP, 2017).

Ethical Considerations

This study was exempted from institutional review board approval since it is using secondary data and that given the large size of the database, the subjects cannot be identified at any time.

Chapter Summary

This chapter explained the study design, data source, study population, measures and variables, and analytical methods used.
CHAPTER 4
RESULTS
This chapter presents information about the findings of all statistical analyses and hypothesis testing. The following sections provided a narrative summary of findings regarding sociodemographic characteristics and results of Pearson’s chi-square tests and 10 multiple logistic regression models for PPH, PPH subcategories, and other risk factors with characteristics and regions of hospital locations.

Descriptive Statistics

Sociodemographic Characteristics
In 2018, there were 3,517,119 single live-birth hospitalizations and that included 2,389,394 vaginal deliveries and 1,099,470 cesarean sections. The study sample included a total of 2,978,244 with low-risk pregnancy and ages ≤19-54 from the 3,517,119 single live-birth hospitalizations. In the sample population, women’s races included White 53.23%, Black 14.27%, Hispanic 20.73%, Asian/Pacific Islander 6.31%, Native-American 0.72%, and other 4.74%. Approximately 4% (3.93) of the sample was identified as having had postpartum hemorrhage (PPH). Other immediate PPH was the most common cause of PPH cases (80%), followed by delayed and secondary PPH (10%), third stage hemorrhage (9%), and postpartum coagulation defects (1%). Age group ≤19 accounted for approximately 7% of all PPH cases, 6% of delayed and secondary PPH, 5% of third stage hemorrhage, 7% of other immediate PPH, and 7% of postpartum coagulation defects. Age group 20-34 accounted for almost 93% of all PPH cases, 94% of delayed and secondary PPH, 94% of third stage hemorrhage, 92% of other immediate PPH, and 93% of postpartum coagulation defects. Age group 35-54 accounted for only 0.33% of all PPH cases, 0.13% of delayed and secondary PPH, 0.51% of third stage hemorrhage.
hemorrhage, 0.33% of other immediate PPH, and 0.33% of postpartum coagulation defects (Table 2).

Bivariate Analysis

Comparison of PPH and PPH Subcategories with Sociodemographic characteristics

Pearson’s chi-square test results for PPH and PPH subcategories regarding race showed significant associations for PPH and other immediate PPH with most races (p<0.0001) except for Black and Other. There were significant associations between being Native American and PPH subcategories except for postpartum coagulation defects. The category of postpartum coagulation defects was significantly associated with being White and Asian/Pacific Islander, and less significant with being Other race. The category of third-stage hemorrhage was significantly associated with being Black and Native American. Pearson’s chi-square tests regarding age showed significant associations for all age groups with the risk of PPH and other immediate PPH (p<0.0001), and also significant association between age 35-54 and third-stage hemorrhage (p<0.0001) (Table 2).

Comparison of PPH and PPH Subcategories with Hospital Characteristics and Regions

Pearson’s chi-square tests for overall PPH and PPH subcategories with regions revealed that except Northeast, all other regions were significantly associated with the risk of overall PPH, delayed and secondary PPH, other immediate PPH, and third stage hemorrhage (p<0.0001). There were less significant association for Northeast region with third-stage hemorrhage (p=0.0195) and post coagulation defect (p=0.02), but no association was observed between other regions and postpartum coagulation defects (Table 3).
### Table 2

Comparison of PPH and PPH Subcategories with Race, and Age by Using Pearson Chi-Square Tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall Postpartum Hemorrhage</th>
<th>Delayed and Secondary PPH</th>
<th>Third-stage Hemorrhage</th>
<th>Other Immediate PPH</th>
<th>Postpartum Coagulation Defects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>P-value</td>
<td>Percent</td>
<td>P-value</td>
<td>Percent</td>
</tr>
<tr>
<td>RACE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>46.09</td>
<td>&lt;0.0001</td>
<td>50.67</td>
<td>0.5048</td>
<td>51.91</td>
</tr>
<tr>
<td>Black</td>
<td>13.27</td>
<td>0.4627</td>
<td>12.05</td>
<td>0.0247</td>
<td>11.41</td>
</tr>
<tr>
<td>Hispanic</td>
<td>19.13</td>
<td>&lt;0.0001</td>
<td>21.45</td>
<td>0.162</td>
<td>19.56</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>7.85</td>
<td>&lt;0.0001</td>
<td>6.21</td>
<td>0.8368</td>
<td>6.32</td>
</tr>
<tr>
<td>Native American</td>
<td>1.15</td>
<td>&lt;0.0001</td>
<td>1.84</td>
<td>&lt;0.0001</td>
<td>1.58</td>
</tr>
<tr>
<td>Other</td>
<td>4.57</td>
<td>0.9645</td>
<td>4.03</td>
<td>0.2124</td>
<td>4.44</td>
</tr>
<tr>
<td>AGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤19</td>
<td>6.58</td>
<td>&lt;0.0001</td>
<td>5.71</td>
<td>0.9216</td>
<td>4.69</td>
</tr>
<tr>
<td>20-34</td>
<td>93.08</td>
<td>&lt;0.0001</td>
<td>94.15</td>
<td>0.9848</td>
<td>94.8</td>
</tr>
<tr>
<td>35-54</td>
<td>0.33</td>
<td>&lt;0.0001</td>
<td>0.13</td>
<td>0.5692</td>
<td>0.51</td>
</tr>
</tbody>
</table>

*Note.* P value set at $p < 0.01$ statistically significant and $p < 0.0001$ statistically highly significant. Variables such as race, age, hospital characteristics, and regions have multiple levels; therefore, a dummy variable was created separately for each level, and Pearson Chi-square was computed to get a $p$-value for each level separately.
Table 3

Comparison of PPH and PPH Subcategories with the U.S. Hospital Characteristics, and Region by Using Pearson Chi-Square Tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall Postpartum Hemorrhage</th>
<th>Delayed and Secondary PPH</th>
<th>Third-stage Hemorrhage</th>
<th>Other Immediate PPH</th>
<th>Postpartum Coagulation Defects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>$P$ -value</td>
<td>Percent</td>
<td>$P$ -value</td>
<td>Percent</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>4.06</td>
<td>0.4198</td>
<td>0.38</td>
<td>0.6828</td>
<td>0.28</td>
</tr>
<tr>
<td>Midwest</td>
<td>4.35</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.43</td>
<td><strong>0.0023</strong></td>
<td>0.42</td>
</tr>
<tr>
<td>South</td>
<td>3.04</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.28</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.22</td>
</tr>
<tr>
<td>West</td>
<td>4.89</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.46</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.49</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>3.57</td>
<td><strong>0.0042</strong></td>
<td>0.51</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.33</td>
</tr>
<tr>
<td>Urban non-teaching</td>
<td>3.15</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.33</td>
<td><strong>0.0256</strong></td>
<td>0.28</td>
</tr>
<tr>
<td>Urban teaching</td>
<td>4.18</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.37</td>
<td>0.3785</td>
<td>0.34</td>
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<tr>
<td>Ownership</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government, non-federal</td>
<td>4.67</td>
<td><strong>0.0042</strong></td>
<td>0.43</td>
<td>0.0873</td>
<td>0.34</td>
</tr>
<tr>
<td>Private, not-for-profit</td>
<td>4.16</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.38</td>
<td>0.3074</td>
<td>0.36</td>
</tr>
<tr>
<td>Private, investor owned</td>
<td>2.46</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.29</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.16</td>
</tr>
<tr>
<td>Bed Size</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>3.78</td>
<td>0.0679</td>
<td>0.37</td>
<td>0.9516</td>
<td>0.35</td>
</tr>
<tr>
<td>Medium</td>
<td>3.57</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.3</td>
<td>0.0256</td>
<td>0.28</td>
</tr>
<tr>
<td>Large</td>
<td>4.35</td>
<td><strong>&lt;0.0001</strong></td>
<td>0.4</td>
<td>0.0216</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Note. $P$ value set at $p < .01$ statistically significant and $p < .0001$ highly statistically significant. Variable’s hospital characteristics and regions have multiple levels; therefore, variables such as race, age, hospital characteristics, and regions have multiple levels; therefore, a dummy variable was created separately for each level, and Pearson Chi-square was computed to get a $p$-value for each level separately.
As shown in Table 3, regarding hospital characteristics, Pearson’s chi-square tests showed significant associations between hospitals located in rural, urban non-teaching, and urban teaching with the risk of overall PPH and other immediate PPH (p<0.0001). The risk of association for overall PPH was more significant in urban non-teaching and urban teaching (p<0.0001) than rural hospitals (p<0.0042). Also, significant associations were observed between delay and secondary PPH and hospitals located in rural areas (p<0.0001), but less significant associations were observed for urban non-teaching hospitals (p=0.0256). Results also illustrated significant associations for the risk of overall PPH in hospitals in the ownership categories government non-federal, private not-for-profit, and private investors. The associations were more significant for the hospitals owned by the private not-for-profit and private investor-owned (p<0.0001) than for government, non-federal (p<0.0042). In addition, the category hospital-owned by private-investor showed significant associations with the risk of all PPH subcategories including the risk of delayed and secondary PPH, other immediate PPH, third-stage hemorrhage, and postpartum coagulation defects (p<0.0001). Significant associations were also observed for the risk of overall PPH and other immediate PPH with rural, medium, and large bed size hospitals, but the risk of associations was more significant in urban non-teaching and urban teaching hospitals (p<0.0001). The risk of third-stage hemorrhage was also significant for medium bed size hospitals (p<0.0026), but more significant for private not not-for-profit (p<0.0001).

Comparison of Process Variables with Regions and Hospital characteristics

As presented in Table 4, the Pearson’s chi-square tests showed significant associations for the risk of failed induction of labor with hospitals located in Northeast, South, and West
Table 4

Comparison of Process Variables across the U.S. Regions and Hospital Characteristics Using Pearson Chi-Square Tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>Failed induction of labor</th>
<th>Other obstetric trauma</th>
<th>Perineal laceration during delivery</th>
<th>Puerperal infections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>P-value</td>
<td>Percent</td>
<td>P-value</td>
</tr>
<tr>
<td><strong>Region</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>1.28</td>
<td>0.0023</td>
<td>2.08</td>
<td>0.0171</td>
</tr>
<tr>
<td>Midwest</td>
<td>1.02</td>
<td>0.7989</td>
<td>2.52</td>
<td>0.0066</td>
</tr>
<tr>
<td>South</td>
<td>0.62</td>
<td>&lt;0.0001</td>
<td>2.16</td>
<td>0.0057</td>
</tr>
<tr>
<td>West</td>
<td>1.45</td>
<td>&lt;0.0001</td>
<td>2.51</td>
<td>0.0159</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>1.18</td>
<td>0.0187</td>
<td>2.3</td>
<td>0.9513</td>
</tr>
<tr>
<td>Urban non-teaching</td>
<td>1.01</td>
<td>0.9976</td>
<td>2.03</td>
<td>0.0002</td>
</tr>
<tr>
<td>Urban teaching</td>
<td>0.99</td>
<td>0.358</td>
<td>2.38</td>
<td>0.0012</td>
</tr>
<tr>
<td><strong>Ownership</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government, non-federal</td>
<td>0.86</td>
<td>0.0213</td>
<td>2.48</td>
<td>0.1309</td>
</tr>
<tr>
<td>Private, not-for-profit</td>
<td>1.11</td>
<td>&lt;0.0001</td>
<td>2.41</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Private, investor owned</td>
<td>0.6</td>
<td>&lt;0.0001</td>
<td>1.65</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Bed Size</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>1.12</td>
<td>0.0537</td>
<td>3.01</td>
<td>0.0144</td>
</tr>
<tr>
<td>Medium</td>
<td>0.89</td>
<td>0.0126</td>
<td>2.23</td>
<td>0.2231</td>
</tr>
<tr>
<td>Large</td>
<td>1.03</td>
<td>0.4736</td>
<td>2.36</td>
<td>0.2308</td>
</tr>
</tbody>
</table>

Note. P value set at p < .01 statistically significant and p < .0001 highly statistically significant. Variable’s hospital characteristics and regions have multiple levels; therefore, a dummy variable was created separately for each level, and Pearson Chi-square was computed to get a p-value for each level separately.
regions (p<0.0001). Regarding hospital characteristics, the analysis found significant associations for failed induction of labor with the private, not-for-profit, and private investor owned hospitals (p<0.0001), and less significant associations with government non-federal hospitals (p=0.0213), rural hospitals (p=0.0187), and medium bed size hospitals (p=0.0126).

The Pearson’s chi-square tests for regions and other obstetric trauma showed significant associations in the Midwest and South regions (p<0.0001), and less significant associations with Northeast (p=0.0171) and West region hospitals (p=0.0159). Results for other obstetric trauma and hospital characteristics also showed substantial associations with other obstetric trauma and urban nonteaching, urban teaching, private not-for-profit, and private investor-owned hospitals (p<0.0001), but there were less significant associations with small bed size hospitals (p=0.0144).

The Pearson’s chi-square tests for regions with perineal laceration during delivery displayed significant associations for the South region (p<0.0001), and less significant associations for Midwest (p=0.0388) and West region hospitals (p=0.0402). Results for the hospital characteristic and perineal laceration during delivery showed significant associations with rural, urban nonteaching (P= 0.0025), urban teaching, the private, not-for-profit, and private, investor-owned (p=0.0001), and less significant associations with medium bed size hospitals (p=0.0304).

Results for the risk of puerperal infections and regions also showed significant associations for the Northeast and South regions and less significant associations with Midwest region (p=0.0259). Significant associations with puerperal infections were also observed for rural, urban non-teaching, urban teaching hospitals, government non-federal, private, investor-owned, and large bed size hospitals (P <0.0001) and small (P =0.0047) (Table 4).
Multivariate Analysis

*Multivariable Logistic Regression Models for Process Variables*

In model one, five multivariable logistic regressions were performed separately for overall PPH and each process variable—risk of failed in induction of labor, other obstetric trauma, prenatal laceration, and puerperal infections—in the low-risk sample population with characteristics and regions of hospital locations to estimate adjusted odds ratios while holding the race and age constant (see Table 5).

Results illustrated that compared to small bed size hospitals, women who delivered in large bed size hospitals had a higher adjusted odds of puerperal infections (AOR=1.44; CI=1.13-1.81), and overall PPH (AOR=1.11; CI=1.02-1.21), and women who delivered in medium bed size hospitals had a lower adjusted odds of failed induction labor (AOR=0.81; CI=0.70-0.94). Delivery in urban teaching hospitals increased the risk of postpartum hemorrhage (AOR=1.15; CI=1.06-1.25), puerperal infection (AOR=1.6; CI=1.19-1.98), perineal laceration (AOR=1.19; CI=1.09-1.30) and decreased adjusted odds of failed induction of labor (AOR=0.76; CI=0.65-0.89) compared to delivery in rural hospitals.

Women who delivered at hospitals in the Midwest region had lower adjusted odds of puerperal infection (AOR=0.65; CI=0.52-0.81) and failed induction of labor (AOR=0.78; CI=0.63-0.96), but higher adjusted odds of other obstetric trauma (AOR=1.23; CI=1.09-1.39), overall PPH (AOR=1.14; CI=1.01-1.28), and perineal laceration (AOR=1.1; CI=1.08-1.21) compared to Northeast hospitals. Women who delivered at hospitals located in the South region had lower adjusted odds of postpartum hemorrhage (AOR=0.80; CI=0.71-.89), failed induction of labor (AOR=0.55; CI=0.45-0.67), and puerperal infections (AOR=0.54 CI=0.44-0.66) compared to those women who delivered at Northeast hospitals. Women who delivered at
hospitals located in the West region had higher adjusted odds of postpartum hemorrhage (AOR=1.21; CI=1.07-1.37) and other obstetric trauma (AOR=1.26; CI= 1.11-1.44), but lower adjusted odds of puerperal infections (AOR=0.69; CI= 0.55-0.86) compared to delivery at Northeast hospitals.
<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall Postpartum Hemorrhage</th>
<th>Failed induction of labor</th>
<th>Puerperal infections</th>
<th>Perineal laceration</th>
<th>Other obstetric trauma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AOR &amp; CI P-value</td>
<td>AOR &amp; CI P-value</td>
<td>AOR &amp; CI P-value</td>
<td>AOR &amp; CI P-value</td>
<td>AOR &amp; CI P-value</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference (Northeast)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>1.14(1.01-1.28) <strong>0.025</strong></td>
<td>0.78(0.63-0.96) <strong>0.019</strong></td>
<td>0.65(0.52-0.81) &lt;0.001</td>
<td>1.1(1.08-1.21) <strong>0.032</strong></td>
<td>1.23(1.09-1.39) <strong>0.001</strong></td>
</tr>
<tr>
<td>South</td>
<td>0.80(0.71-0.89) &lt;0.001</td>
<td>0.55(0.45-0.67) &lt;0.001</td>
<td>0.54(0.44-0.66) &lt;0.001</td>
<td>1.07(0.98-1.17) 1.05</td>
<td>1.09(0.98-1.23) 0.104</td>
</tr>
<tr>
<td>West</td>
<td>1.21(1.07-1.37) <strong>0.002</strong></td>
<td>1.20(0.96-1.15) 0.101</td>
<td>0.69(0.55-0.86) <strong>0.001</strong></td>
<td>1.07(0.97-1.19) 0.137</td>
<td>1.26(1.11-1.44) &lt;0.001</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference (Rural)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Urban non-teaching</td>
<td>0.93(0.83-1.001) 0.054</td>
<td>0.83(0.66-0.1.04) 0.114</td>
<td>1.02(0.76-1.37) 0.955</td>
<td>1.05(0.95-1.16) 0.335</td>
<td>0.93(0.83-1.05) 0.285</td>
</tr>
<tr>
<td>Urban teaching</td>
<td>1.15(1.06-1.25) <strong>0.001</strong></td>
<td>0.76(0.65-0.89) &lt;0.001</td>
<td>1.6(1.19-1.98) &lt;0.001</td>
<td>1.19(1.09-1.30) &lt;0.001</td>
<td>1.07(0.96-1.2) 0.167</td>
</tr>
<tr>
<td>Ownership</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Reference (Government)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private, not-for-profit</td>
<td>0.85(0.74-0.98) <strong>0.025</strong></td>
<td>1.16(0.99-0.36) <strong>0.051</strong></td>
<td>0.68(0.55-0.83) &lt;0.001</td>
<td>0.99(0.90-1.09) 0.895</td>
<td>0.99(0.88-1.11) 0.953</td>
</tr>
<tr>
<td>Private, investor owned</td>
<td>0.56(0.48-0.65) &lt;0.001</td>
<td>0.71(0.58-0.87) <strong>0.001</strong></td>
<td>0.50(0.38-0.65) &lt;0.001</td>
<td>0.85(0.76-0.96) <strong>0.008</strong></td>
<td>0.67(0.57-0.80) &lt;0.001</td>
</tr>
<tr>
<td>Bed Size</td>
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</tr>
<tr>
<td>Reference (Small)</td>
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<td></td>
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<td></td>
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<tr>
<td>Medium</td>
<td>0.97 (0.89-1.06) 0.596</td>
<td>0.81(0.70-0.94) <strong>0.007</strong></td>
<td>1.12(0.87-1.43) 0.374</td>
<td>0.98(0.90-1.05) 0.612</td>
<td>0.98(0.89-1.08) 0.776</td>
</tr>
<tr>
<td>Large</td>
<td>1.11 (1.02-1.21) <strong>0.011</strong></td>
<td>0.88(0.76-1.02) 0.114</td>
<td>1.44(1.13-1.81) <strong>0.002</strong></td>
<td>1.01(0.93-1.08) 0.772</td>
<td>1.01(0.91-1.10) 0.905</td>
</tr>
<tr>
<td>Variables</td>
<td>Overall Postpartum Hemorrhage</td>
<td>Failed induction of labor</td>
<td>Puerperal infections</td>
<td>Perineal laceration</td>
<td>Other obstetric trauma</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------</td>
<td>---------------------------</td>
<td>----------------------</td>
<td>--------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td></td>
<td>AOR &amp; CI</td>
<td>P -value</td>
<td>AOR &amp; CI</td>
<td>P -value</td>
<td>AOR &amp; CI</td>
</tr>
<tr>
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<td></td>
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<tr>
<td>Reference (White)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>1.14(1.08-1.21)</td>
<td>&lt;0.001</td>
<td>0.63(0.56-0.71)</td>
<td>&lt;0.001</td>
<td>2.29(1.98-2.66)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.26(1.18-1.35)</td>
<td>&lt;0.001</td>
<td>0.76(0.68-0.85)</td>
<td>&lt;0.001</td>
<td>1.96(1.69-2.39)</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>1.34(1.24-1.45)</td>
<td>&lt;0.001</td>
<td>1.26(1.09-1.46)</td>
<td><strong>0.002</strong></td>
<td>2.05(1.60-2.64)</td>
</tr>
<tr>
<td>Native American</td>
<td>1.74(1.51-2.01)</td>
<td>&lt;0.001</td>
<td>0.80(0.71-1.21)</td>
<td>0.292</td>
<td>2.51(1.56-4.04)</td>
</tr>
<tr>
<td>Other</td>
<td>1.19(1.10-1.30)</td>
<td>&lt;0.001</td>
<td>0.84(0.71-1.003)</td>
<td>0.055</td>
<td>2.26(1.82-2.79)</td>
</tr>
<tr>
<td><strong>AGE</strong></td>
<td>0.85(0.80-0.90)</td>
<td>&lt;0.001</td>
<td>1.03(0.90-1.16)</td>
<td>0.642</td>
<td>0.45(0.39-0.53)</td>
</tr>
</tbody>
</table>

*Note.* P value set at $p < .01$ statistically significant and $p < .001$ highly statistically significant.
Compared to women who delivered at government non-federal hospitals, women who delivered at hospitals in the category private not-for-profit had lower adjusted odds of puerperal infections (AOR=0.68; 0.55-0.83) and overall PPH (AOR=0.025; CI= 0.74-0.98). Also, women who delivered at hospitals owned by private investors had lower odds of postpartum hemorrhage (AOR=0.56; CI=0.48-0.65), failed induction of labor (AOR=0.71; CI=0.58-0.87), puerperal infections (AOR=0.50; CI=0.38-0.65), perineal laceration (AOR=0.85; CI=0.76-0.96) and other obstetric trauma (AOR= 0.67; CI=0.57-0.80).

Results for race and age as control variables found that all races compared to White had significantly higher adjusted odds of overall PPH, and odds were the highest for Native Americans (AOR=1.74; CI=1.51-2.01). Results also showed each one-year increase in age decreased adjusted odds of overall PPH risk by 15% (AOR=0.85; CI=0.80-0.90).

Regarding failed induction of labor, results showed that being Black and Hispanic decreased adjusted odds of overall PPH risk (AOR=0.63; CI=0.56-0.71 and AOR=0.76; CI=0.68-0.85 respectively); however, being Asian/Pacific Islander increased adjusted odds of failed induction of labor risk (AOR=1.26; CI=1.09-1.46). There was no association between age and the risk of failed induction of labor.

Regarding puerperal infections, results showed all races compared to White had higher adjusted odds of puerperal infections. The odds were the highest for Native Americans compared to other races (AOR=2.51; CI= 1.56-4.04). The result for age showed each one-year increase in age decreased adjusted odds of puerperal infections by 55% (AOR=0.45; CI= 0.39-0.53).

Regarding perineal laceration, results showed being Black and Hispanic decreased adjusted odds of perineal laceration [(AOR=0.52; CI=0.48-0.56) and (AOR=0.66; CI=0.62-0.71 respectively] and being Asian/Pacific Islander increased odds of perineal lacerations by 2.22
(CI= 2.05-2.41) and Other by 17% (AOR=1.17; CI=1.07-1.29). Each one-year increase in age had a 14% decrease in adjusted odds of perineal laceration (AOR=0.86; CI=0.79-0.93).

Regarding other obstetric trauma, results for race showed being Asian/Pacific Islander decreased adjusted odds of obstetric trauma (AOR=0.88; CI=0.81-0.96), and each one-year increase in age decreased in adjusted odds of other obstetric trauma by 49% (AOR=0.51; CI=0.48-0.55) (see Table 5).

**Multivariable Logistic Regressions for PPH and PPH Subcategories**

In model two, five multiple logistic regression were performed to examine the study hypotheses and to estimate adjusted odds ratios for the risk of PPH and PPH subcategories with hospital characteristics and regions across the United States, while holding race, age, failed induction of labor, other obstetric trauma, perineal laceration during delivery, and puerperal infection constant (Table 6).

**Region and Hospital Characteristics Associated with the Risk of the Overall Postpartum Hemorrhage While Adjusting for Age, Race, Failed Induction of Labor, Other Obstetric Trauma, Perineal Laceration during Delivery, and Puerperal Infections**

Results for regions showed that compared to Northeast hospitals, women who delivered at the South region hospitals had a lower odd of overall postpartum hemorrhage (AOR=0.80; CI=0.71-.89) while women who delivered in the West and Midwest regions’ hospitals had a higher odd of PPH [(AOR=1.20; CI=1.06-1.35) and (AOR=1.13; CI=1.01-1.28) respectively], and those differences for West region hospitals were statistically significant. Women who delivered at hospitals owned by private investors and at private not-for-profit hospitals had lower odds of PPH [(AOR=0.56; CI=0.49-0.67) and (AOR=0.85; CI=0.74-0.98) respectively]
Table 6
Logistic Regression Model 2 of Postpartum Hemorrhage, and PPH Subcategories with Hospital Characteristics and Regions

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall Postpartum Hemorrhage</th>
<th>Third-stage Hemorrhage</th>
<th>Postpartum Coagulation Defects</th>
<th>Other Immediate PPH</th>
<th>Delayed and Secondary PPH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AOR &amp; CI</td>
<td>P-value</td>
<td>AOR &amp; CI</td>
<td>P-value</td>
<td>AOR &amp; CI</td>
</tr>
<tr>
<td>Region Reference (Northeast)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midwest</td>
<td>1.13(1.01-1.28)</td>
<td><strong>0.025</strong></td>
<td>1.52(1.26-1.83)</td>
<td><strong>&lt;0.001</strong></td>
<td>0.75(0.53-1.06)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.11(0.98-1.26)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.07(0.90-1.27)</td>
</tr>
<tr>
<td>South</td>
<td>0.80(0.71-0.89)</td>
<td><strong>&lt;0.001</strong></td>
<td>0.91(0.75-1.82)</td>
<td>0.353</td>
<td>0.73(0.52-1.02)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.80(0.71-0.90)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.74(0.61-0.89)</td>
</tr>
<tr>
<td>West</td>
<td>1.20(1.06-1.35)</td>
<td><strong>0.003</strong></td>
<td>1.71(1.42-2.07)</td>
<td><strong>&lt;0.001</strong></td>
<td>0.81(0.59-1.30)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.16(1.02-1.33)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1.15(0.96-1.38)</td>
</tr>
<tr>
<td>Location Reference (Rural)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban nonteaching</td>
<td>0.93(0.83-1.001)</td>
<td>0.054</td>
<td>0.94(0.74-1.18)</td>
<td>0.61</td>
<td>1.04(0.67-1.61)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.95(0.85-1.05)</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>0.67(0.56-0.81)</td>
</tr>
<tr>
<td>Urban teaching</td>
<td>1.14(1.05-1.24)</td>
<td><strong>0.001</strong></td>
<td>1.06(0.85-1.32)</td>
<td>0.567</td>
<td>1.08(0.73-1.60)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1.22(1.12-1.33)</td>
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<td></td>
<td>0.72(0.61-0.85)</td>
</tr>
<tr>
<td>Ownership Reference (Government)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Private, not-for-profit</td>
<td>0.85(0.74-0.98)</td>
<td><strong>0.023</strong></td>
<td>0.99(0.75-1.32)</td>
<td>0.988</td>
<td>0.78(0.54-1.13)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.85(0.74-0.96)</td>
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<td></td>
<td></td>
<td>0.85(0.69-1.04)</td>
</tr>
<tr>
<td>Private, investor owned</td>
<td>0.57(0.49-0.67)</td>
<td><strong>&lt;0.001</strong></td>
<td>0.48(0.33-0.68)</td>
<td><strong>0.001</strong></td>
<td>0.40(0.25-0.62)</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>0.57(0.49-0.67)</td>
</tr>
<tr>
<td>Bed size Reference (Small)</td>
<td></td>
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</tr>
<tr>
<td>Medium</td>
<td>0.97 (0.89-1.06)</td>
<td>0.596</td>
<td>0.85(0.72-0.99)</td>
<td><strong>0.044</strong></td>
<td>0.87(0.627-1.21)</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>1.004(0.91-1.06)</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>0.93(0.791.08)</td>
</tr>
<tr>
<td>Large</td>
<td>1.11 (1.02-1.21)</td>
<td>0.011</td>
<td>0.94(0.81-1.08)</td>
<td>0.414</td>
<td>0.78(0.58-1.05)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1.14(1.04-1.25)</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td>1.01(0.88-1.16)</td>
</tr>
<tr>
<td>Variables</td>
<td>Overall Postpartum Hemorrhage</td>
<td>Third-stage Hemorrhage</td>
<td>Postpartum Coagulation Defects</td>
<td>Other Immediate PPH</td>
<td>Delayed and Secondary PPH</td>
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<tr>
<td>-----------------------------------------------</td>
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</tr>
<tr>
<td></td>
<td>AOR &amp; CI</td>
<td>P-value</td>
<td>AOR &amp; CI</td>
<td>P-value</td>
<td>AOR &amp; CI</td>
</tr>
<tr>
<td><strong>RACE</strong></td>
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<tr>
<td>Reference (White)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Black</td>
<td>1.15 (1.09-1.22)</td>
<td>&lt;0.001</td>
<td>0.92 (0.79-1.08)</td>
<td>0.352</td>
<td>1.13 (0.83-1.53)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.26 (1.18-1.35)</td>
<td>&lt;0.001</td>
<td>0.96 (0.81-1.13)</td>
<td>0.664</td>
<td>1.23 (0.98-1.55)</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>1.30 (1.20-1.41)</td>
<td>&lt;0.001</td>
<td>0.89 (0.73-1.08)</td>
<td>0.257</td>
<td>1.75 (1.29-2.37)</td>
</tr>
<tr>
<td>Native American</td>
<td>1.73 (1.50-1.9)</td>
<td>&lt;0.001</td>
<td>1.9 (1.32-2.82)</td>
<td>0.001</td>
<td>2.68 (0.81-8.86)</td>
</tr>
<tr>
<td>Other</td>
<td>1.18 (1.08-1.28)</td>
<td>&lt;0.001</td>
<td>1.12 (0.88-1.43)</td>
<td>0.319</td>
<td>1.6 (1.17-2.44)</td>
</tr>
<tr>
<td><strong>AGE</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Perineal laceration</td>
<td>2.04 (1.88-2.22)</td>
<td>&lt;0.001</td>
<td>1.8 (1.39-2.32)</td>
<td>&lt;0.001</td>
<td>1.64 (1.04-2.59)</td>
</tr>
<tr>
<td>Other obstetric trauma</td>
<td>2.63 (2.46-2.81)</td>
<td>&lt;0.001</td>
<td>1.84 (1.46-2.31)</td>
<td>&lt;0.001</td>
<td>2.21 (1.51-3.24)</td>
</tr>
<tr>
<td>Puerperal infections</td>
<td>5.01 (4.41-5.68)</td>
<td>&lt;0.001</td>
<td>4.38 (1.46-2.70)</td>
<td>&lt;0.001</td>
<td>4.50 (2.30-8.83)</td>
</tr>
<tr>
<td>Failed induction of labor</td>
<td>1.97 (1.77-2.19)</td>
<td>&lt;0.001</td>
<td>1.99 (1.46-2.7)</td>
<td>&lt;0.001</td>
<td>1.65 (0.90-3.00)</td>
</tr>
</tbody>
</table>

Note. P value set at p < .01 statistically significant and p < .001 highly statistically significant.
compared to those who delivered in government-owned hospitals. Women who delivered at urban teaching hospitals had a higher odd of PPH (AOR=1.14; CI=1.05-1.24) compared to those who delivered at rural hospitals. Women who delivered at large bed size hospitals had higher odds of PPH (AOR=1.11; CI= 1.02-1.21) compared to those who delivered at small bed size hospitals.

Results displayed significant associations for the race, age, and other control variables with the overall PPH (p<0.001). Compared to White women, all other race groups had increased adjusted odds of overall PPH, but the adjusted odds were the highest for the Native American race compared to other races (AOR= 1.73; CI=1.50-1.9). However, age decreased the adjusted odds of the overall PPH (AOR=0.88; CI= 0.83-0.93).

Other control variables include failed induction of labor, other obstetric trauma, perineal laceration during delivery, and puerperal infections increased adjusted odds of the overall PPH by 1.97(CI= 1.77-2.19), 2.63 (CI= 2.46-2.81), 2.04, (CI= 1.88-2.22), 5.01 (CI= 4.41-5.68) respectively. The odds were the highest for puerperal infections (AOR=5.01).

*Region and Hospital Characteristics Associated with the Risk of Other Immediate PPH While Adjusting for Age, Race, Failed Induction of Labor, Other Obstetric Trauma, Perineal Laceration during Delivery, and Puerperal Infections*

Results showed that women who delivered at large bed size hospitals had a higher odd of other immediate PPH (AOR=1.14; CI=1.04-1.25) compared to those who delivered at small bed size hospitals, and women who delivered at urban teaching hospitals had a higher odd of other immediate PPH (AOR=1.22; CI=1.12-1.33) compared to those who delivered at rural hospitals. However, women who delivered at the South region hospitals had a lower odd of other immediate PPH (AOR=0.80; CI=0.71-0.90) compared to Northeast hospitals, and women who
delivered at hospitals owned by private investors and private, not-for-profit had lower adjusted odds of other immediate PPH [(AOR=0.57; CI=0.49-0.67) and (AOR=0.85; CI=0.74-0.96) respectively] compared to those who delivered at hospitals owned by the government.

Results revealed significant associations for the race, age, and other control variables with other immediate PPH (p<0.001). Except for age, which decreased adjusted odds of other immediate PPH (AOR=0.85; CI=0.80-0.90), race and other control variables increased adjusted odds of other immediate PPH. Compared to White women, all other race groups had higher adjusted odds of other immediate PPH, but the adjusted odds were the highest for the Native American race compared to other races (AOR=1.62; CI= 4.41-5.80).

Other control variables—including failed induction of labor, other obstetric trauma, perineal laceration during delivery, and puerperal infections—increased adjusted odds of other immediate PPH by 2.01(CI=1.79-2.23), 2.68 (CI=1.98-2.36), 2.16, (CI=1.98-2.36) 5.06 (CI=4.41-5.80) respectively. The odds were the highest for puerperal infections (AOR=5.06).

Region and Hospital Characteristics Associated with the Risk of the Third-Stage Hemorrhage While Adjusting for Age, Race, Failed Induction of Labor, Other Obstetric Trauma, Perineal Laceration during Delivery, and Puerperal Infections

Results showed that women who delivered at hospitals located in the Midwest and West regions had higher adjusted odds of third-stage hemorrhage (AOR=1.52%; CI=1.26-1.83 and AOR=1.71%; CI=1.42-2.07 respectively) compared to those who delivered at the Northeast region hospitals. However, women who delivered at medium bed size hospitals compared to small bed size hospitals and hospitals owned by private investors compared to those who delivered at hospitals owned by the government had lower adjusted odds of third-stage hemorrhage [(AOR=0.85; CI=0.72-0.99) and (AOR=0.48; CI=0.33-0.68) respectively].
Again, results for race showed Native American had higher adjusted odds of third-stage hemorrhage (AOR=1.9; CI=1.32-2.82). Other control variables—including failed induction of labor, other obstetric trauma, perineal laceration during delivery, and puerperal infections—increased adjusted odds of third-stage hemorrhage by 1.99 (CI=1.46-2.7), 1.84 (CI=1.46-2.31), 1.80 (CI=1.39-2.32), 4.38(CI=1.46-2.70) respectively, and odds were the highest for puerperal infections (AOR=4.38).

Region and Hospital Characteristics Associated with the Risk of Delayed and Secondary PPH While Adjusting for Age, Race, Failed Induction of Labor, Other Obstetric Trauma, Perineal Laceration during Delivery, and Puerperal Infections

Women who delivered at urban nonteaching and urban teaching hospitals had lower adjusted odds of delayed and secondary PPH (AOR=0.67; CI=0.56-0.81 and AOR=0.72; CI=0.61-0.85 respectively) compared to those who delivered at rural hospitals. Also, women who delivered at the South region hospitals had a lower adjusted odds of delayed and secondary PPH (AOR=0.74; CI=0.61-0.89) compared to those who delivered at the Northeast region hospitals.

Results regarding race showed that Native Americans had higher adjusted odds of delayed and secondary PPH by 2.31 (CI=0.81-1.19). Other obstetric trauma and puerperal infections increased adjusted odds of delayed and secondary PPH by 2.47 (CI=2.05-2.99) and 3.63 (CI=2.43-5.41) times, respectively.
Region and Hospital Characteristics Associated with the Risk of Postpartum Coagulation Defects While Adjusting for Age, Race, Failed Induction of Labor, Other Obstetric Trauma, Perineal Laceration during Delivery, and Puerperal Infections

Women who delivered at hospitals owned by private investors had lower adjusted odds of postpartum coagulation defects (AOR=0.40; CI=0.25-0.62) compared to those who delivered at hospitals owned by the government.

Results for race showed Asian/Pacific Islander, and Other Race had higher adjusted odds of postpartum coagulation defects (AOR=1.75; CI=1.29-2.37 and AOR=1.6; CI=1.17-2.44 respectively). Other obstetric trauma and puerperal infections increased adjusted odds of postpartum coagulation defects by 2.21 (CI=1.51-3.24) and 4.50 (CI=2.30-8.83) times, respectively.

This study found no associations for the risk of overall PPH and PPH subcategories with prolonged labor.

Postpartum Hemorrhage before and after Adjusting for Process Variables

After comparing the overall PPH before and after adjusting for process variables, this project observed in model 2, the adjusted odds of overall PPH for Midwest region hospitals changed from 1.14 (1.01-1.28) to 1.13 (1.01-1.28); the change for West region hospitals was from 1.21 (1.07-1.37) to 1.20 (1.06-1.3), from 1.15 (1.06-1.25) to 1.14 (1.05-1.24) for urban teaching hospitals; and from 0.56 (0.48-0.65) to 0.57 (0.49-0.67) for hospitals owned by private investors(Table7).
Table 7
Comparing Postpartum Hemorrhage before and after Adjusting for Process Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall Postpartum Hemorrhage Before Adjusting for Process Variables</th>
<th>Overall Postpartum Hemorrhage After Adjusting for Process Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Region Reference (Northeast)</strong></td>
<td>AOR &amp; CI</td>
<td>P-value</td>
</tr>
<tr>
<td>Midwest</td>
<td>1.14(1.01-1.28)</td>
<td><strong>0.025</strong></td>
</tr>
<tr>
<td>South</td>
<td>0.80(0.71-.89)</td>
<td>&lt;<strong>0.001</strong></td>
</tr>
<tr>
<td>West</td>
<td>1.21(1.07-1.37)</td>
<td><strong>0.002</strong></td>
</tr>
<tr>
<td><strong>Location Reference (Rural)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban nonteaching</td>
<td>0.93(0.83-1.001)</td>
<td>0.054</td>
</tr>
<tr>
<td>Urban teaching</td>
<td>1.15(1.06-1.25)</td>
<td><strong>0.001</strong></td>
</tr>
<tr>
<td><strong>Ownership Reference (Government)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private, not-for-profit</td>
<td>0.85(0.74-0.98)</td>
<td><strong>0.025</strong></td>
</tr>
<tr>
<td>Private, investor owned</td>
<td>0.56(0.48-0.65)</td>
<td>&lt;<strong>0.001</strong></td>
</tr>
<tr>
<td><strong>Bed Size Reference (Small)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>0.97(0.89-1.06)</td>
<td>0.596</td>
</tr>
<tr>
<td>Large</td>
<td>1.11(1.02-1.21)</td>
<td><strong>0.011</strong></td>
</tr>
</tbody>
</table>

*Note.* Process Variables included failed induction of labor, other obstetric trauma, perineal laceration during delivery, and puerperal infections.
CHAPTER 5

DISCUSSION

This study investigated the association of postpartum hemorrhage with hospital characteristics and the regions of hospital locations across the United States, using the 2018 National Inpatient Sample (NIS) from the HCUP database. Pearson chi-square tests and multivariable logistic regressions were performed to compare and examine the associations of the risk of PPH and PPH sub-categories with characteristics and regions of hospital locations (Tables 2-6). Significant associations for the risk of PPH and PPH subcategories and related risk factors were observed across the regions and hospital types. Of the findings observed by this study, some were supported by previous studies, and some contrasted with findings from previous studies. The following sections provide a summary of the main findings.

Overview of chapter and Summary of Findings

This project had three main objectives. The first objective was to compare the associations of overall PPH and PPH subcategories with hospital characteristics and regions of hospital locations. The structure of the Donabedian model was used to design and assess the associations of hospital characteristics and the regions of hospital locations as independent variables with the risk of overall PPH and PPH subcategories.

The second objective of the study was to compare the associations of process variables with the characteristics and regions of hospital locations across the U.S. and further perform risk adjustment (Model 1). The process category of the Donabedian model was used to identify variables that may be related to the management of delivery care services during the third stage of labor that led to overall PPH and PPH subcategories. Therefore, process variables included failed induction of labor, other obstetric trauma, perineal lacerations (3rd and 4th degree), and
puerperal infection. Pearson chi-square tests and multivariable logistic regressions were performed to assess process variables for further risk adjustment, and to reduce potential bias.

The third objective was to estimate the adjusted odds ratio and 95% confidence intervals (CI) of overall PPH and PPH subcategories across the U.S. hospital characteristics and regions while controlling for process variables by performing multivariable logistic regressions (Model 2). The outcome category of the Donabedian model was used to identify variations in care outcomes related to overall PPH and PPH subcategories in the third stage of labor across the U.S. hospital characteristics and regions of hospital locations.

It should be noted that after adjusting for process variables in model 2, the adjusted odds of overall PPH remained largely consistent, and process variables did not cause many changes in the overall PPH results.

Reflection on Each Research Question and Main Findings

This study investigated whether there were relationships between the risk of overall PPH and PPH subcategories with hospital characteristics and regions of hospital locations. Twenty hypotheses were proposed based on study research questions. The first four hypotheses were that the risk of overall PPH was significantly associated with hospital characteristics and regions of hospital locations across the United States. Pearson chi-square tests supported the hypotheses and revealed significant associations for hospital locations, ownership, and medium and large bed size hospitals, and also for all regions except Northeast. Although Pearson chi-square tests supported the hypotheses for both characteristics and regions of hospital locations, further analysis was performed using multivariable logistic regressions to adjust for process variables. Results supported the hypotheses for urban teaching hospitals and hospitals located in the West and South regions and hospitals owned by private investors. Significant associations were
observed for the increased risk of overall PPH with urban teaching hospitals and hospitals located in the West region. In contrast, significant associations were observed between decreased risk of overall PPH, and hospitals located in the South region, and hospitals owned by private investors.

The second four hypotheses were that the risk of other immediate PPH was significantly associated with hospital characteristics and regions of hospital locations across the United States. Pearson chi-square tests supported hypotheses for all regions, hospital locations, ownership, and medium and large bed size hospitals. However, the multivariable logistic-regression results supported hypotheses for hospitals located in the South region, urban teaching hospitals, and hospitals owned by private investors. Results of multiple logistic regressions showed significant associations for the increased risk of other immediate PPH with urban teaching hospitals and large bed size hospitals. Still, significant associations of decreased risk of other immediate PPH were observed for hospitals located in the South region and hospitals owned by private investors.

The third four hypotheses were that the risk of third-stage hemorrhage was significantly associated with hospital characteristics and regions of hospital locations across the United States. Pearson chi-square tests supported hypotheses for all regions except Northeast hospitals, private not-for-profit hospitals, hospitals owned by private investors, and medium bed size hospitals. Results of multivariable logistic regressions supported the associations for hospitals located in the Midwest and West regions and hospitals owned by private hospitals. Results illustrated significant associations between the increased risks of third-stage hemorrhage with hospitals located in the Midwest and West, and decreased risk of third-stage hemorrhage with hospitals owned by private investors.
The fourth four hypotheses were that the risk of delayed and secondary PPH was significantly associated with hospital characteristics and regions of hospital locations across the United States. Pearson chi-square tests supported the associations between the risk of delayed and secondary PPH with all region hospitals except Northeast, and hospitals owned by private investors. However, the result of multivariable logistic regressions was supportive for hospitals located in urban nonteaching, urban teaching, and hospitals located in the South region. Results showed significant associations between decreased risk of delayed and secondary PPH with hospitals located in urban nonteaching and urban teaching and hospitals located in the South region.

The last four hypotheses were that the risk of postpartum coagulation defects was significantly associated with hospital characteristics and regions of hospital locations across the United States. Pearson chi-square tests supported the associations between the risk of postpartum coagulation defects and hospitals owned by private investors. The result of logistic regression also supported the association between the decreased risks of postpartum coagulation defects with hospitals owned by private investors.

In general, significant variations were observed in the sample, specifically regarding the proportion of associated rate of overall PPH risk with hospital characteristics and regions, ranging from 2.46 for hospitals owned by private investors to 4.89 for hospitals located in the West region. As Table 3 shows, the proportion of associated rate of overall PPH was more than two times higher for hospitals owned by the government than for hospitals owned by private investors. These findings were consistent with the prior study by Lu et al. (2005). The present study also noticed that hospital types with the highest associations of overall PPH risk tend to have the highest associations of failed induction of labor, other obstetric trauma, perineal
laceration during delivery, and puerperal infections. Lu et al. (2005) also found higher rates of chorioamnionitis and protracted labor for hospitals with high incidence of postpartum hemorrhage.

Increased risk of postpartum hemorrhage was observed in urban teaching hospitals when compared to rural hospitals, which is consistent with the previous study by Gyamfi-Bannerman et al. (2018), but contrasts with studies conducted by Snowden et al. (2015) and Kozhimannil et al. (2016), in which researchers found higher odds of overall PPH in rural low-volume hospitals compared to low-volume urban teaching hospitals. Further, results showed that hospitals located in the West region had the highest associations with increased odds of overall postpartum hemorrhage and third stage hemorrhage, while hospitals owned by private investors had the highest associations with decreased odds of overall PPH and all four process variables. This study also found a higher risk of delayed and secondary PPH in rural hospitals when compared with urban teaching and urban nonteaching hospitals, and that may be related to lack of resources such as scarcity in delivering obstetric care services or shortage of obstetricians (Salman et al., 2020) or due to other circumstances including low birth volume and lack of financial resources (Hung et al., 2017). That, however, requires further investigation.

It should be noted that Hispanics, Asians and Pacific Islanders, and Native Americans had the highest delivery rates in hospitals located in the West region compared to other regions, which again was consistent with findings from previous research conducted by Gyamfi-Bannerman et al. (2018). This study also found the increased risk of overall PPH, other immediate PPH, and puerperal infections for all races, but the risk was particularly higher for Native Americans and Asian/Pacific Islanders. These findings were consistent with previous studies conducted by Harvey et al. (2017) and Kozhimannil et al. (2016) and in contrast with
findings by Gyamfi-Bannerman et al. (2018) and Cabacungan et al. (2012). Gyamfi-Bannerman et al. (2018) found an increased risk of PPH for African Americans, and Cabacungan et al. (2012) found an increased risk of PPH for African Americans and Native Americans, compared to White women.

Although this study found significant associations for the risk of overall PPH and PPH subcategories across hospital characteristics and regions, the exact reasons for such associations need more investigation, specifically for those hospitals with highest and lowest adjusted odds of associations. For instance, it was interesting to note that South region hospitals, compared to other regional hospitals, had the lowest adjusted odds of overall PPH, immediate PPH, and delayed and secondary PPH. Such variations might be explained by the sample selections, and to some extent, might reflect differences in the quality of obstetric practice and management. Also, this study found that delivery in urban teaching hospitals increased adjusted odds of overall PPH, some of PPH subcategories, and process variables compared to other types of hospital characteristics, and that might be influenced by adverse effects of cohort turnover, in which experienced employees depart. When experienced employees depart, the arrival of new workers can cause disruption in team function and quality of care delivery. In the case of teaching hospitals, it can be explained that the departure of experienced residents and fellows, and the arrival of new residents who are not productive at the beginning of their tenure, may impact their productivity and functions regarding the quality-of-care services and patient health outcomes (Huckman and Barro, 2005).

Further, the reason for significant associations in decreased adjusted odds of risk of overall PPH and PPH subcategories in hospitals owned by private investors might be explained by the availability of resources or the number of care providers in such hospitals, which may be
higher than hospitals owned by the government and private not-for-profit hospitals (Cram et al., 2010). In addition, government and not-for-profit hospitals rely on government allocations and funding and may sometimes encounter financial constraints, especially when tax revenues decline or other competing interests demand public support. Such constraints create barriers to improving the provision of human and financial resources (Thomas et al., 2000).

Finally, this study observed race as a significant factor in increasing the risk of overall PPH and some of the PPH subcategories. Researchers suggested that genetic entities may play a role as potential independent risk factors for PPH (Harvey et al., 2017).

Public Health Practice Implications and Recommendations

Despite medical advances, PPH remains one of the challenges of obstetric care services. Therefore, management of PPH regarding patient safety needs to be carried out throughout the pregnancy and third stage of labor. Risk factors of PPH should be assessed during prenatal care, and the high-risk case process. Mothers need to be educated regarding signs and symptoms of PPH and should be advised to give birth in a hospital and under the supervision of a skilled birth attendant (Garba et al., 2019). A multidisciplinary team must be vigilant in the event of PPH occurrence. All the initial assessment and patient resuscitation needs to be done within the first 15 minutes of PPH occurrence (Anderson & Etches, 2007).

Essential components of management of the third stage of labor include the availability of required medications, blood productions, and standard protocols and instructions in delivery units regarding hemorrhage (Kacmar et al., 2014). Protocols and guidelines should provide the knowledge and tools necessary for the obstetric team for early detection and rapid evaluation of PPH. However, successful implementation of protocols and guidelines requires active management, multidisciplinary team cooperation, available resources, constant surveillance, and
staff training programs regarding protocol performance (Kacmar et al., 2014). A multidisciplinary-team approach including skilled birth attendants, laboratory and labor personnel, healthcare providers, and pharmacists is essential to managing blood loss and the administration of uterotonic drug therapy and maternal blood transfusions (Hale 2019), in order to prevent adverse outcomes related to the third stage of labor (Anderson and Sze, 2020; Garba et al., 2019; Wormer et al., 2020).

In addition, the dissemination of information and communication among providers regarding patient medical history should be improved to enable them to make accurate diagnoses and provide treatment options in the events of severe hemorrhage (Reiling et al., 2008). Documentation of every stage of PPH management is also critical for comparing with protocols and guidelines, preventing future mistakes, and identifying areas for improvement, policy development, and decision making (Sheikh et al., 2011).

Postpartum cases should be examined to identify causes and medical errors regarding PPH. Further, reviewing each case of PPH helps identify and address challenges of improving the quality of services and implementation of a standard protocol. It also helps identify areas for improvement to develop strategies and future policies that effectively reduce risk factors associated with increasing PPH, deficiencies in PPH management, and challenges in active participation in a multidisciplinary approach. The obstetric team should periodically be evaluated via surveys, need assessment, and interviews or focus groups to identify their training needs and they should be informed about the causes of PPH and medical errors after examining each PPH case (Huwe 2020).

Overall, the root causes of the PPH conditions should be investigated to identify whether they are related to maternal risk factors or to PPH management, by considering the availability of
skilled birth attendants, multi-professional team collaboration, and medical services such as blood products and medications. Such an examination would determine deficiencies in the system and how they can be improved (Hale 2019). California Maternal Quality Care Collaborative or the Council on Patient Safety in Women’s Health Care has created evidence-based, quality-improvement toolkits to investigate the leading causes of preventable death and complications, including PPH and thromboembolism, for mothers and infants. These toolkits provide prevention resources that can be used by hospitals to better manage the third stage of labor (Huwe 2020). Finally, women need to be involved in their care and should be educated regarding their situation and the warning signs and symptoms of hemorrhage and should be empowered to be responsive to their health needs and to participate in treatment decision-making (Reiling et al., 2008).

Strengths and Limitations

An important strength of this study is the use of the NIS database, which provides a large sample size with results that can be generalized to the U.S. population. The other strength of this study is the analysis of weighted data, which produces accurate and unbiased results. Further, this is the first study that compares overall PPH and PPH subcategories across U.S. hospital characteristics and regions of hospital locations. Thus, it provides new information that can be used to develop policies to improve variations in obstetric care and reduce maternal morbidity and mortality as well as healthcare costs.

This study has also several limitations. First, only the NIS 2018 database was analyzed; therefore, caution should be considered in generalizing the study results. Second, the sample included low-risk delivery cases and deliveries performed in the hospitals because the study focus was on obstetric practice and management across the U.S. hospitals. Other potential
limitations of the study regarding NIS data include differences in diagnosis, and coding, missing, and mismatched data, which lead to error and the misclassification of information. Further, lack of access to information such as human resources, medical-team performance, PPH management after placenta delivery, medical equipment, and technology availability are other limitations of this study.

Conclusion

Though early studies evidenced significant regional variations in healthcare delivery and utilization, there is limited evidence on whether maternity outcomes are impacted by the geographic region of hospital locations or hospital characteristics where delivery takes place (Chassin et al., 1986; Leap et al., 1990; Quin et al., 2011). However, it should be emphasized that regional and hospital characteristics differences could be influenced partly by variations in resources, obstetric practices, and the processes of operative-care management, as well as factors that may not be identified by the current database. Or they may be a result of regional variations in data collections and reporting, geographic differences, and patient characteristics. Therefore, to improve future management and evaluation of operative processes regarding PPH, additional revision on data collection and the addition of variables related to care management and obstetric protocols are suggested to elucidate such discrepancies in variations of regional and hospital characteristics.

To conclude, the highest and lowest risks of overall PPH and PPH subcategories with hospitals located in the West and South regions, teaching hospitals, and hospitals owned by private investors, or a higher risk of delayed and secondary PPH in rural hospitals needs further investigation regarding resources, obstetric practice, hospital management, and population or socio-demographic characteristics. It is essential to identify race as a potential risk factor for the
increased risk of PPH. Although this study found significant associations for the risk of overall PPH and PPH subcategories with hospital characteristics and regions, other risk factors—mainly genetic predispositions such as coagulation factors or tissue elasticity (Bryant et al. 2012)—should be considered when making decisions and developing policies to improve the quality-of-care performance at the hospital-level factors. Therefore, to develop better policies and decision making, further research is needed to provide evidence regarding associations between such factors and increased risk of PPH, and whether they are influenced by population or socio-demographic characteristics or related to variations in obstetric practice and management of regional and hospital types.
REFERENCES


https://doi.org/10.1016/j.anclin.2020.08.010


https://doi.org/10.1213/ANE.0000000000000399


https://doi.org/10.1371/journal.pone.0244087


Pregnancy, childbirth and the puerperium ICD-10-CM code range O00-O9A.

https://www.aapc.com › Resources › Hot Topics. https://www.aapc.com/codes/icd-10-codes-range/O00-O9A


**APPENDIX A**

**RESEARCH QUESTIONS AND RESEARCH HYPOTHESES**

<table>
<thead>
<tr>
<th>1. Is there a relationship between hospital characteristics and the risk of PPH?</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Is there a relationship between the region of hospital location and the risk of PPH?</td>
</tr>
</tbody>
</table>

**1st four Hypotheses**

<table>
<thead>
<tr>
<th>H0: After controlling for other variables in the model, there is not association with the risk of the overall postpartum hemorrhage with hospital characteristics and the region of hospital location.</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: Region of hospital location is significantly associated with the risk of the overall postpartum hemorrhage when controlling for other risk factors.</td>
</tr>
<tr>
<td>H2: Teaching/nonteaching status of Hospital characteristic is significantly associated with the overall postpartum hemorrhage when controlling for other risk factors.</td>
</tr>
<tr>
<td>H3: The rurality status of hospital characteristics is significantly associated with the risk of overall postpartum hemorrhage when controlling for other risk factors.</td>
</tr>
<tr>
<td>H4: The ownership status of the hospital is significantly associated with the risk the overall postpartum hemorrhage when controlling for other risk factors.</td>
</tr>
</tbody>
</table>

**2nd four Hypotheses**

<table>
<thead>
<tr>
<th>H0: After controlling for other variables in the model, there is not association with the risk of other immediate PPH with hospital characteristics and the region of hospital location.</th>
</tr>
</thead>
<tbody>
<tr>
<td>H5: Region of hospital location is significantly associated with the risk of other immediate PPH when controlling for other risk factors.</td>
</tr>
<tr>
<td>H6: Teaching/nonteaching status of Hospital characteristic is significantly associated with other immediate PPH when controlling for other risk factors.</td>
</tr>
<tr>
<td>H7: The rurality status of hospital characteristics is significantly associated with the risk of other immediate PPH when controlling for other risk factors.</td>
</tr>
<tr>
<td>H8: The ownership status of the hospital is significantly associated with the risk of other immediate PPH when controlling for other risk factors.</td>
</tr>
</tbody>
</table>

**3rd four Hypotheses**

<table>
<thead>
<tr>
<th>H0: After controlling for other variables in the model, there is not association with the risk of other immediate PPH with hospital characteristics and the region of hospital location.</th>
</tr>
</thead>
<tbody>
<tr>
<td>H9: Region of hospital location is significantly associated with the risk of the third-stage hemorrhage when controlling for other risk factors.</td>
</tr>
<tr>
<td>H10: Teaching/nonteaching status of Hospital characteristic is significantly associated with the third-stage hemorrhage when controlling for other risk factors.</td>
</tr>
<tr>
<td>H11: The rurality status of hospital characteristics is significantly associated with the risk of the third-stage hemorrhage when controlling for other risk factors.</td>
</tr>
<tr>
<td>H12: The ownership status of the hospital is significantly associated with the risk the third-stage hemorrhage when controlling for other risk factors.</td>
</tr>
</tbody>
</table>
### APPENDIX A, CONTINUED

#### RESEARCH QUESTIONS AND RESEARCH HYPOTHESES

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Hypotheses</th>
</tr>
</thead>
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<tr>
<td>1. Is there a relationship between hospital characteristics and the risk of PPH?</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; four Hypotheses</td>
</tr>
<tr>
<td>2. Is there a relationship between the region of hospital location and the risk of PPH?</td>
<td>5&lt;sup&gt;th&lt;/sup&gt; four Hypotheses</td>
</tr>
</tbody>
</table>

**4<sup>th</sup> four Hypotheses**

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>H0</td>
<td>After controlling for other variables in the model, there is not association with the risk of delayed and secondary PPH with hospital characteristics and the region of hospital location.</td>
</tr>
<tr>
<td>H13</td>
<td>Region of hospital location is significantly associated with the risk of delayed and secondary PPH when controlling for other risk factors.</td>
</tr>
<tr>
<td>H14</td>
<td>Teaching/nonteaching status of Hospital characteristic is significantly associated with the risk of delayed and secondary PPH when controlling for other risk factors.</td>
</tr>
<tr>
<td>H15</td>
<td>The rurality status of hospital characteristics is significantly associated with the risk of delayed and secondary PPH when controlling for other risk factors.</td>
</tr>
<tr>
<td>H16</td>
<td>The ownership status of the hospital is significantly associated with the risk of delayed and secondary PPH when controlling for other risk factors.</td>
</tr>
</tbody>
</table>

**5<sup>th</sup> four Hypotheses**

<table>
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<tr>
<th>Hypothesis</th>
<th>Details</th>
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<tbody>
<tr>
<td>H0</td>
<td>After controlling for other variables in the model, there is not association with the risk of postpartum coagulation defects with hospital characteristics and the region of hospital location.</td>
</tr>
<tr>
<td>H17</td>
<td>Region of hospital location is significantly associated with the risk of postpartum coagulation defects when controlling for other risk factors.</td>
</tr>
<tr>
<td>H18</td>
<td>Teaching/nonteaching status of Hospital characteristic is significantly associated with the risk of postpartum coagulation defects when controlling for other risk factors.</td>
</tr>
<tr>
<td>H19</td>
<td>The rurality status of hospital characteristics is significantly associated with the risk of postpartum coagulation defects when controlling for other risk factors.</td>
</tr>
<tr>
<td>H20</td>
<td>The ownership status of the hospital is significantly associated with postpartum coagulation defects when controlling for other risk factors.</td>
</tr>
</tbody>
</table>
## APPENDIX B

### CODING METHODS BASED ON RESEARCH QUESTIONS

#### Dependent Variables

<table>
<thead>
<tr>
<th>Code Type</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICD-10-CM</td>
<td>O72</td>
<td>Postpartum Hemorrhage</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O720</td>
<td>Third- stage hemorrhage</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O721</td>
<td>Other immediate PPH</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O722</td>
<td>Delayed and secondary PPH</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O723</td>
<td>Postpartum coagulation defects</td>
</tr>
</tbody>
</table>

#### Independent Variables

<table>
<thead>
<tr>
<th>Code Type</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOSP _ LOCTEACH</td>
<td>Location/Teaching Status</td>
<td>(1) Rural, (2) Urban nonteaching, (3) Urban teaching</td>
</tr>
<tr>
<td>H_CONTRL</td>
<td>Ownership</td>
<td>(1) Government, non-federal (public), (2) Private, not-for-profit (voluntary), and (3) private, investor-owned</td>
</tr>
<tr>
<td>HOSP_BEDSIZE</td>
<td>Bed Size</td>
<td>(1) Small, (2) Medium, and (3) Large</td>
</tr>
<tr>
<td>HOSP_REGION</td>
<td>Region</td>
<td>(1) Northeast, (2) Midwest, (3) South, and (4) West</td>
</tr>
</tbody>
</table>

#### Control Variables

<table>
<thead>
<tr>
<th>Code Type</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age</td>
<td>AGE</td>
<td>Age ≤19, 20-34, and 35-54</td>
</tr>
<tr>
<td>Maternal race and ethnicity</td>
<td>RACE</td>
<td>(1) White, (2) Black, (3) Hispanic, (4) Asian/Pacific Islander, (5) Native American, and (6) Other</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O61</td>
<td>Failed induction of labor</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O610</td>
<td>Failed medical induction of labor</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O611</td>
<td>Failed instrumental induction of labor</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O618</td>
<td>Other failed induction of labor</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O619</td>
<td>Failed induction of labor, unspecified</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O622</td>
<td>Atony of uterus without hemorrhage</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O63</td>
<td>Prolonged labor</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O630</td>
<td>Prolonged first stage (of labor)</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O631</td>
<td>Prolonged second stage (of labor)</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O632</td>
<td>Delayed delivery of second twin, triplet; etc</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O639</td>
<td>Long labor, unspecified</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O70</td>
<td>Perineal laceration during delivery</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O702</td>
<td>Third degree perineal laceration during delivery</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O703</td>
<td>Fourth degree perineal laceration during delivery</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O704</td>
<td>Anal sphincter tear complication delivery</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O705</td>
<td>Perineal laceration during delivery unspecified</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O71</td>
<td>Other obstetric trauma</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O7103</td>
<td>Rapture of uterus before onset of labor, third semester</td>
</tr>
</tbody>
</table>
### ICD-10-CM

<table>
<thead>
<tr>
<th>Code Type</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICD-10-CM</td>
<td>O711</td>
<td>Rupture of uterus during labor</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O712</td>
<td>Postpartum inversion of uterus</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O713</td>
<td>Obstetric laceration of cervix</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O714</td>
<td>Obstetric high vaginal laceration alone</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O715</td>
<td>Other obstetric injury to pelvic organs</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O716</td>
<td>Obstetric damage to pelvic joints and ligaments</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O717</td>
<td>Obstetric hematoma of pelvic</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O718</td>
<td>Other specified obstetric trauma</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O719</td>
<td>Obstetric trauma unspecified</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O86</td>
<td>Puerperal infections</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O8611</td>
<td>Following delivery</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O8612</td>
<td>Endometritis following delivery</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O8613</td>
<td>Vaginitis following delivery</td>
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</table>

#### Excluded Variables

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<tr>
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<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>ICD-10-CM</td>
<td>O432</td>
<td>Hemorrhage associated with retained portions of placenta</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O43213</td>
<td>Placenta accreta, third trimester</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O43223</td>
<td>Placenta increta, third trimester</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O43233</td>
<td>Placenta percreta, third trimester</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O458X3</td>
<td>Other premature separation of placenta</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O4693</td>
<td>Antepartum hemorrhage, unspecified, third trimester.</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O0993</td>
<td>Supervision of high-risk pregnancy, unspecified, third trimester.</td>
</tr>
</tbody>
</table>

#### Single liveborn Deliveries Variables

<table>
<thead>
<tr>
<th>Code Type</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICD-10-CM</td>
<td>Z370</td>
<td>Single liveborn infant in hospital</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>Z3800</td>
<td>Single liveborn infant, delivered vaginally</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>Z3801</td>
<td>Single liveborn infant, delivered by cesarean</td>
</tr>
<tr>
<td>ICD-10-CM</td>
<td>O34211</td>
<td>Previous C-section</td>
</tr>
</tbody>
</table>