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Postpartum health risks among women with hypertensive disorders of pregnancy, California 2008–2012

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Abstract

Objectives: The aim of this study was to understand the associations between hypertensive disorders of pregnancy (HDP) and postpartum complications throughout the newly defined 12-week postpartum transition.

Study design: We conducted a retrospective cohort study of the associations of HDP (any/subtype) with postpartum complications among 2.5 million California births, 2008–2012. We identified complications from discharge diagnoses from maternal hospital encounters (emergency department visits and readmissions) in the 12 weeks after giving birth. We compared rates of complications, overall and by diagnostic category, between groups defined by HDP. In survival analyses, we calculated the adjusted hazard ratios of postpartum complications associated with HDP. We adjusted for maternal age, race/ethnicity, prepregnancy obesity, chronic diabetes, gestational diabetes, insurance, delivery mode, gestational age and birth outcome (term and size).

Results: Among women with and without HDP, 12.8 and 7.7%, respectively, had a hospital encounter within 12 weeks of giving birth [adjusted hazard ratio 1.5, 95% confidence interval (95% CI): 1.5–1.5]. HDP was associated with increased risk across all major categories of complications: hypertension-related, adjusted hazard ratio 11.8 (95% CI: 11.2–12.3); childbirth-related, 1.4 (1.3–1.4); and other, 1.4 (1.4–1.4). Risk of any complication differed by hypertensive subtype: chronic hypertension with super-imposed preeclampsia, adjusted hazard ratio 1.8 (95% CI: 1.7–1.8); chronic hypertension, 1.6 (1.6–1.7); preeclampsia/eclampsia, 1.3 (1.3–1.4); and

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Conflicts of interest

The remaining authors report no conflict of interest.

gestational hypertension, 1.2 (1.2–1.3). Over a quarter (28.9%) of maternal hospital encounters occurred more than 6 weeks after giving birth; this did not differ substantially by HDP status.

Conclusion: Women with HDP are at an increased risk for virtually all postpartum complications, including those not related to hypertension, and may benefit from enhanced and comprehensive postpartum care.

Keywords

chronic hypertension; eclampsia; emergency care; gestational hypertension; healthcare use; hospital readmission; postpartum complications; preeclampsia; superimposed preeclampsia

INTRODUCTION

Approximately one in 10 births in the United States is complicated by hypertension [1]. Women with hypertensive disorders of pregnancy (HDP) face significant health risks after delivery. HDP is a leading cause of pregnancy-related mortality, with most HDP-attributed deaths occurring in the postpartum period [2]. HDP is also a risk factor for maternal cardiovascular disease such as immediate postpartum stroke [3,4] and chronic hypertension [5–7], as well as noncardiovascular outcomes such as mood disorders [8]. In addition, HDP is associated with higher rates of emergency department (ED) visits and hospital readmissions in the weeks to months after delivery, compared with normotensive pregnancies [1,9,10].

Postpartum care recommendations for women with HDP emphasize the importance of additional visits for blood pressure monitoring and management [6,11,12]. However, limited research specific to women with HDP exists to guide the content and timing of postpartum care for this population. For instance, it is unclear to what degree HDP is associated with noncardiovascular postpartum complications (e.g. infections), and when those complications occur. In addition, there are evidence gaps regarding the relationships of the HDP subtypes (gestational hypertension, preeclampsia-eclampsia, chronic hypertension and chronic hypertension with superimposed preeclampsia) with postpartum risks.

Study of postpartum complications is timely given the changing landscape of postpartum care. The redefinition of the postpartum period from 6 to 12 weeks [11,13] reflects the understanding that a large share of maternal morbidity and mortality occurs not weeks but months after delivery [2]. However, little is known about the type and timing of postpartum complications beyond the traditional 6-week postpartum period. Furthermore, studies vary in their definitions of postpartum complications and have often restricted their analyses to a subset of diagnoses [3,10,14–17]. A broader understanding of postpartum risk throughout the 12-week transition is needed to optimize the care of women after giving birth.

Our aim was to increase the understanding of postpartum risk, in terms of type and timing of complications, among women with HDP. We hypothesized that over the 12-week postpartum transition, risk of postpartum hospital encounters (ED visits and hospital readmissions) would be higher among women with versus without HDP and would vary by HDP subtype.

We also hypothesized that a sizeable share of 12-week postpartum complications would occur after the traditional six-week timepoint.

MATERIALS AND METHODS

Study population

We examined the associations of HDP and HDP clinical subtypes with postpartum complications within an historical cohort composed of all hospital births in the state of California from 2008–2012 [18]. We used data from California's Office of Statewide Health Planning and Development (OSHPD) database [19], which contains linked data from vital records (birth and foetal death certificates), hospital discharge and ED visits for mothers and their infants up to 279 days after delivery (as well as hospital discharge and ED data for women in the nine months before birth). The unit of analysis was a birth, and all of the maternal hospital encounters that followed it (up to 12 weeks after delivery) were included in the analysis. A woman with multiple births in the dataset was counted multiple times. Nonsingleton births counted as one record (i.e. the mother).

Exposure

We defined HDP as any evidence of hypertension from the birth record or patient discharge data from an antepartum hospital admission or the delivery hospitalization. We analysed women with HDP overall and by clinical subtype, as defined by the American College of Obstetricians and Gynecologists (ACOG) [12] and identified using International Classification of Disease, 9th Edition (ICD-9) codes, as in prior published studies [20–22]: gestational hypertension (ICD-9 code 642.3x); preeclampsia-eclampsia (642.4x, 642.5x, 642.6x); chronic hypertension (401.x-405.x, 642.0x, 642.1x, 642.2x); and chronic hypertension with superimposed preeclampsia (642.7x).

Outcomes

Our primary outcome of interest was any postpartum complication associated with a maternal hospital encounter (i.e. ED visit or hospital readmission) in the 12 weeks after giving birth.

First, we developed a two-tier classification system to help us understand the diagnoses associated with, and the underlying causes of, postpartum complications (Table 1). We compiled a list of severe or common postpartum diagnoses from prior publications [3,10,14,15,17] and clinical expertise. Next, on the basis of consensus among the physicians and epidemiologists on our team, we organized the diagnoses into mutually exclusive categories defined by a common organ system, pathophysiology or symptomatology ('condition-specific diagnostic categories'). Finally, we assigned each condition-specific category to an underlying cause ('major categories'). The major categories were in descending hierarchical order: hypertension-related, clinically related to the childbirth hospitalization and other (neither hypertension-nor childbirth-related). To provide information on the most common complications in the postpartum period, we analysed the most frequent condition-specific diagnostic categories (ten most common in addition to hypertensive disorders), along with our three major categories.

We identified postpartum complications from ICD-9 diagnosis and procedure codes (see Supplemental Digital Content Table 1, <http://links.lww.com/HJH/B507>); we lacked Current Procedural Terminology (CPT) codes for inpatient admissions. Up to 25 diagnoses or 21 procedures could be listed for a given ED visit or hospitalization in the OSHPD database, and we considered a condition to be present if it was listed in any of the available diagnosis fields. A single ED visit or readmission could count towards multiple diagnostic categories. A readmission was defined as any hospitalization occurring on or after the date of discharge from the childbirth hospitalization and within 12 weeks of delivery. We excluded hospitalizations that began within 1 day of discharge and included a record of hospital transfer, as these were likely to represent transfers for continued care after childbirth rather than independent episodes of care for postpartum complications.

Covariates

We identified covariates *a priori*, based on prior research and theoretical importance, as potential confounders of the relationship between HDP and postpartum complications. These included maternal age (<20, 20–24, 25–34, 35 years); race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Asian/Pacific Islander, other) [7]; prepregnancy obesity (nonobese, class I, class II, class III obesity or unknown); chronic diabetes; gestational diabetes; insurance type at childbirth (private, public, self-pay) [23]; prenatal care (based on timing of first visit and total number of visits; adequate plus, adequate, intermediate, inadequate) [24]; multifetal gestation; timing of delivery (early preterm, late preterm, term or postterm) and mode of delivery (vaginal versus caesarean) [25]; birth outcome [stillbirth, live birth either preterm (<37 weeks' gestation) or small for gestational age (SGA), and term non-SGA live birth]; neonatal ICU (NICU) admission; and length of stay after delivery (0–1, 2–3, 4–5, 6–7 and >7 days) [26].

Statistics

We compared demographic and pregnancy-related variables between groups defined by HDP status and subtype using the Chi-squared test. We also compared the prevalence of postpartum complications, overall and within each diagnostic category. In unadjusted analyses, we fit univariate Cox proportional hazard models to understand how HDP and its subtypes were associated with the timing of postpartum complications and first hospital encounters. When we adjusted for important potential confounders (i.e. maternal age category, race/ethnicity, prepregnancy obesity, chronic diabetes, gestational diabetes, insurance type, mode of delivery, gestational age at birth and birth outcome), the models produced adjusted hazard ratios estimating the independent effects of having HDP on postpartum complications. To assess postpartum healthcare use, we examined survival curves for postpartum hospital encounters, which illustrated the timing of first ED visit or hospital readmission by HDP status and subtype.

The analysis was conducted in Stata 15. A *P* value of 0.05 was considered significant. All 95% confidence intervals excluded 1.0 unless otherwise stated. This study was approved by the Institutional Review Board of Oregon Health & Science University (IRB# 00010620).

RESULTS

The overall analytical sample included 2 491 255 birth records (Table 2). The prevalence of HDP was 7.2%: 2.1% gestational hypertension, 3.0% preeclampsia-eclampsia, 1.3% chronic hypertension and 0.7% chronic hypertension with superimposed preeclampsia.

We found significant baseline differences by HDP status (Table 2). Women with HDP included a higher proportion of women aged at least 35 years (23.8%), of Black race (9.2%) and with chronic or gestational diabetes (17.9%) compared with women without HDP (17.7, 5.0 and 7.9%, respectively) ($P < 0.001$). Births to women with HDP were associated with multifetal gestation, 'adequate plus' prenatal care, caesarean delivery, preterm birth, NICU admission and hospital discharge 4 or more days after delivery.

Maternal characteristics also differed by HDP subtype. Women with chronic hypertension (with or without super-imposed preeclampsia) were more likely to be older or Black or diabetic, whereas women with gestational hypertension or preeclampsia-eclampsia were more likely to be younger or Hispanic or nondiabetic. More than half of births to women with chronic hypertension with superimposed preeclampsia were SGA or preterm (51.7%), compared with less than a quarter of births to women with chronic hypertension or gestational hypertension (22.5 and 22.7%, respectively) ($P < 0.001$). Chronic hypertension with superimposed preeclampsia was also associated with the highest rates of caesarean delivery and prolonged childbirth hospitalizations, among the HDP subtypes.

Eight percent of births resulted in at least one maternal hospital encounter within 12 weeks (12.8 and 7.7% among women with and without HDP, respectively), the majority of which were ED visits (89.1% overall; 85.3 and 89.6% among women with and without HDP, respectively) (Table 2).

Hospital encounters involving hypertensive complications occurred after 3.0% of births to women with HDP and were rare among women without HDP (0.2%, Table 3). Childbirth-related complications were nearly twice as common among women with versus without HDP (6.8 versus 4.0%, respectively), as were other complications (7.0 versus 3.8%, respectively). The leading categories of childbirth-related complications were urinary tract infection and uncontrolled pain, regardless of HDP status. (See Supplemental Digital Content Table 2, <http://links.lww.com/HJH/B507> for less common categories of complications.)

After adjusting for covariates, HDP was associated with increased hazards of postpartum hospital encounters involving complications in all three major categories: hypertensive, adjusted hazard ratio (aHR) 11.8; childbirth-related, aHR 1.4; and other, aHR 1.4. In condition-specific analyses, HDP was associated with increased hazards for nine of the ten most frequent types of complications, ranging from aHR 1.1 for gallbladder disease to aHR 1.8 for psychiatric disease.

There were significant differences in postpartum risk between the clinical subtypes of HDP (Table 4). Chronic hypertension with superimposed preeclampsia was associated with the greatest hazards of postpartum complications (aHR 1.8), followed closely by

chronic hypertension alone (aHR 1.6), compared to preeclampsia-eclampsia (aHR 1.3) and gestational hypertension (1.2). This rank-order of risk among the HDP subtypes persisted for all three major categories and nearly all condition-specific categories of postpartum complications. (See Supplemental Digital Content Tables 3 and 4, <http://links.lww.com/HJH/B507> for HDP subtype-specific results for less common categories of complications.)

In survival curves without adjustment, 23.4% of maternal hospital encounters occurred in the first week after delivery, 40.7% within two weeks after delivery and 28.9% between 6 and 12 weeks after delivery. This distribution did not vary substantially by HDP status or subtype (Figs. 1 and 2).

DISCUSSION

In this population-based study of 2.5 million births, women with HDP were at 50% increased risk of hospital encounters in the 12 weeks after delivery, compared with women with normotensive pregnancies, even after adjusting for maternal socioeconomic, pregnancy, delivery and birth characteristics. Among the clinical subtypes of HDP, chronic hypertension (with or without superimposed preeclampsia) was consistently associated with the greatest postpartum risks. In the entire sample, regardless of maternal HDP status, postpartum hospital encounters involved a wide range of diagnoses, about half of which were not childbirth-related and one-quarter of which occurred more than 6 weeks after delivery.

We focused on women with HDP, who are known to be at an increased risk of cardiovascular disease [4,5,7], hypertension-related severe maternal morbidity [16] and mood disorders [8] after delivery. In this study, HDP was associated with virtually all postpartum complications: the three major categories (hypertensive, childbirth-related and other) and most condition-specific diagnostic categories. These associations were not explained by confounders in our dataset; adjustment for a variety of factors only slightly attenuated the results. These findings expand our understanding of postpartum risk among women with HDP, who experience higher rates of both hypertensive and non-hypertensive complications when compared with women without HDP. We also show that risk varies by hypertensive subtype, highlighting that women with chronic hypertension are at greatest risk of postpartum complications and hospital encounters.

HDP is a leading cause of severe maternal morbidity and mortality in the United States. Current postpartum care recommendations for women with HDP centre on cardiovascular disease risk reduction [6,11,12]. Our findings suggest that HDP is an indicator of widely elevated postpartum risk. Women with HDP – in particular those with chronic hypertension – may benefit from close monitoring for a broader range of postpartum complications. A specialized postpartum clinic for women with preeclampsia has been shown to address early postpartum complications, raise awareness of postpartum risks and bridge women to primary care [27].

Our study also reveals opportunities to improve postpartum healthcare in the general population. Most postpartum hospital encounters in our study were ED visits (85–90%),

of which the vast majority (96%) resulted in a discharge to home. This suggested that many postpartum hospital encounters were for conditions amenable to outpatient care or prevention. Outpatient management, compared with ED visits, has the potential advantages of care team continuity and early risk detection. Unfortunately, postpartum women may delay outpatient care due to competing priorities and financial concerns, or prefer emergency care settings as a matter of convenience [28]. Multi-level approaches are needed to ensure that women can access outpatient postpartum care when they need it [13]; such approaches include patient counselling, postdischarge outreach, extended clinic hours and expanded insurance coverage after delivery [2]. Given the wide spectrum and time course of postpartum complications, there is also a need for nonobstetricians to collaborate in postpartum care [4,11,29]. Our findings support the need for timely outpatient postpartum care that is coordinated across disciplines and over time.

Further research among women with HDP is needed to identify additional risk factors for postpartum complications (e.g. blood pressure management and control); to understand which conditions are amenable to intervention; and to develop interventions (e.g. provider trainings, clinical protocols, checklists) that reduce postpartum morbidity and avoid hospital encounters through improved outpatient care.

Strengths of our study include our comprehensive evaluation of postpartum diagnoses for women with HDP, as most prior studies on this population have focused on a limited set of postpartum diagnoses (usually hypertension-related). In addition, we evaluate the specific risks associated with the distinct clinical subtypes of HDP. We also provide a much-needed overview of maternal complications and hospital encounters during the newly defined 12-week postpartum transition.

The limitations of our study warrant consideration. First, our sample was composed of births to women in California, which has the lowest state-level rates of postpartum readmission and maternal mortality in the United States (U.S.) [10,30]. Therefore, our findings may not be generalizable to the broader U.S. population. Second, our use of administrative data introduced several potential sources of measurement error. We were only able to assess outcomes based on inpatient and ED insurance claims; although a large proportion of serious morbidity was likely captured using this approach, some complications and healthcare use were missed (e.g. outpatient visits, hospital encounters in other states). We also did not censor cases with maternal mortality, given our limited ability to identify maternal deaths (i.e. only in hospital records), and because their low frequency relative to our population size ($n = 140$) had a negligible statistical impact on the regression results. Furthermore, we combined ED visits and hospital readmissions to present an overall picture of postpartum risk and healthcare use; this approach necessarily obscured some differences between ED visits and readmissions (e.g. distribution of diagnoses, severity of complications). In addition, because we relied on ICD-9 codes for outcome assessment, we underestimated procedural outcomes. We also lacked information on blood pressure management and control (e.g. antihypertensive prescriptions, blood pressure readings and other features to assess the severity of preeclampsia) and outpatient care, and therefore were unable to examine how these variables modify the relationship between HDP and postpartum outcomes [31]. We were also unable to account for some important potential

confounders (e.g. maternal smoking and substance use history), for which claims data have poor sensitivity [32,33]. Finally, we assessed outcomes up to 12 weeks after delivery, a critical milestone in the current postpartum care paradigm, although we recognized that definitions of the postpartum period vary, and that many maternal complications occurred more than 12 weeks after delivery.

In conclusion, this study reveals strong associations between HDP – especially chronic hypertension – and the full spectrum of postpartum complications, highlighting the broad impact of HDP on postpartum health and healthcare use. Over 40% of maternal deaths occur during the postpartum transition, of which 60% may be preventable [2]. Our results signal that comprehensive and coordinated postpartum care for women with HDP is a potential mechanism to reduce postpartum morbidity and mortality; it will be important to identify others, and how they interact with hypertensive disorders to cause postpartum complications.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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M.I.R. serves as a contraceptive trainer for Merck conducting FDA mandated trainings and served on an advisory board for Bayer. She is a postpartum contraceptive trainer for the American Congress of Obstetricians and Gynecologists.

Abbreviations:

ACOG	American College of Obstetricians and Gynecologists
aHR	adjusted hazard ratio
CI	confidence interval
ED	emergency department
HDP	hypertensive disorders of pregnancy
ICD-9	International Classification of Disease, 9th Edition
IQR	interquartile range
NICU	neonatal intensive care unit

OHSPD	Office of Statewide Health Planning and Development
SGA	small for gestational age
U.S.	United States

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FIGURE 1.

Time-to-first postpartum hospital encounter by hypertensive disorders of pregnancy status (unadjusted). (b) Zoomed in. Vertical lines denote common postpartum milestones: 1 week, 6 weeks and 12 weeks after delivery.

FIGURE 2.

Time-to-first postpartum hospital encounter by hypertensive disorders of pregnancy subtype (unadjusted). (b) Zoomed in. Vertical lines denote common postpartum milestones: 1 week, 6 weeks and 12 weeks after delivery.

TABLE 1.

Classification system for postpartum complications

Major diagnostic category	Condition-specific diagnostic category
Hypertension-related	<p>Hypertensive disorders, including uncontrolled blood pressure, eclampsia and hypertensive encephalopathy</p> <p>Acute cardiovascular disease, including heart failure, cardiomyopathy, myocardial infarction, ventricular fibrillation/flutter and cardiac arrest/cardiogenic shock</p> <p>Acute cerebrovascular disease, including stroke, intracranial haemorrhage and carotid/vertebral artery dissection</p> <p>Acute renal insufficiency or failure</p>
Other, clinically related to childbirth hospitalization	<p>Anaesthesia complications</p> <p>Bleeding risk/complications, including blood loss anaemia, haemorrhage, coagulation defects and/or retained products of conception</p> <p>Perineal complication (including vulvar, urethral, vaginal or cervical infection or inflammation) or surgical wound complication, infection, management (excluding uterine infection)</p> <p>Uterine infection, pelvic inflammatory disease, peritonitis</p> <p>Urinary tract infection, including pyelonephritis</p> <p>Other urinary dysfunction (including obstruction, retention, incontinence)</p> <p>Uncontrolled pain</p> <p>Constipation, haemorrhoids</p>
Other, not clinically related to childbirth hospitalization	<p>Venous thromboembolism (excluding stroke and myocardial infarction)</p> <p>Psychiatric disease, including substance abuse</p> <p>Poor glycaemic control/diabetic complications</p> <p>Breast infections/Lactation complications</p> <p>Gallbladder disease/pancreatitis</p> <p>Acute respiratory distress/failure</p> <p>Upper respiratory infection</p> <p>Cellulitis</p> <p>Appendicitis</p> <p>Bacteraemia/sepsis not otherwise specified</p> <p>Fever (unspecified)</p> <p>Malaise/Fatigue, Sleep disturbance</p> <p>Family planning/contraception</p> <p>Nonspecific postpartum diagnosis</p>

TABLE 2.

Pregnancy, delivery and postpartum characteristics of births to women with versus without hypertensive disorders of pregnancy, and by hypertensive subtype

Characteristic	HDP subtype ^b				
	Without HDP	With HDP ^a	Gestational hypertension	Preeclampsia-eclampsia	Chronic hypertension
<i>N</i> (% of total)	2 311 447 (92.8)	179 808 (7.2)	53 372 (2.1)	75 819 (3.0)	33 343 (1.3)
Age, years, median (IQR)	28 (23–33)	29 (24–34)	28 (23–33)	28 (22–33)	32 (27–36)
Age category, <i>n</i> (%)					
<20 years	197 462 (8.5)	16 227 (9.0)	5345 (10.9)	9537 (12.6)	752 (2.2)
20–24 years	490 746 (21.2)	34 449 (19.2)	11 507 (21.6)	17 157 (22.6)	3499 (10.5)
25–34 years	1 214 229 (52.5)	86 283 (48.0)	26 254 (49.2)	34 578 (45.6)	16 907 (50.6)
35 years	409 010 (17.7)	42 849 (23.8)	10 266 (19.2)	14 547 (19.2)	12 275 (36.7)
Race/ethnicity, <i>n</i> (%)					
Non-Hispanic white	588 194 (25.7)	46 711 (26.3)	15 826 (30.0)	17 877 (23.9)	9100 (27.6)
Non-Hispanic black	113 245 (5.0)	16 315 (9.2)	4007 (7.6)	5713 (7.6)	4312 (13.1)
Hispanic	1 241 301 (54.3)	91 855 (51.8)	26 296 (49.9)	42 720 (57.2)	14 629 (44.4)
Asian/Pacific Islander	291 707 (12.8)	17 432 (9.8)	5094 (9.7)	6603 (8.8)	3784 (11.5)
Other	50 456 (2.2)	5043 (2.8)	1495 (2.8)	1844 (2.5)	1134 (3.4)
Insurance type at childbirth, <i>n</i> (%)					
Private/mixed	1 111 532 (48.1)	88 054 (49)	25 901 (48.5)	39 600 (52.2)	17 974 (53.8)
Public	1 151 510 (49.8)	89 250 (49.6)	26 662 (50.0)	35 087 (46.3)	15,106 (45.2)
Self-pay	48 286 (2.1)	2499 (1.4)	807 (1.5)	1130 (1.5)	352 (1.1)
Prepregnancy BMI, kg/m ² , median (IQR)	24.4 (21.6–28.5)	27.6 (23.5–33.3)	27.3 (23.4–32.4)	26.5 (22.8–31.4)	30.7 (25.5–36.8)
Prepregnancy obesity, <i>n</i> (%)					
Nonobese (<30.0 kg/m ²)	1 729,947 (74.8)	102 104 (56.8)	32,045 (60.0)	47,950 (63.2)	14,575 (43.6)
Class I obesity 30.0–34.9 kg/m ²)	261 560 (11.3)	31 406 (17.5)	9263 (17.4)	11,887 (5.7)	6727 (20.1)
Class II obesity 35.0–39.9 kg/m ²)	102 310 (4.4)	17 821 (9.9)	4842 (9.1)	5835 (7.7)	4819 (14.4)
Class III obesity (≥ 40.0 kg/m ²)	55 454 (2.4)	14 760 (8.2)	3480 (6.5)	3994 (5.3)	4921 (14.7)
Missing BMI	162 176 (7.0)	175 893 (7.1)	3742 (7.0)	6153 (8.1)	2391 (7.2)
Chronic diabetes, <i>n</i> (%)	15 160 (0.7)	7480 (4.2)	866 (1.6)	2270 (3.0)	2708 (8.1)
Chronic hypertension with superimposed preeclampsia					17 184 (0.7)

Characteristic	HDP subtype ^b				
	Without HDP	With HDP ^a	Gestational hypertension	Preeclampsia-eclampsia	Chronic hypertension with superimposed preeclampsia
Gestational diabetes, <i>n</i> (%)	166 242 (7.2)	24 758 (13.8)	6199 (11.6)	8920 (11.8)	6360 (19.0)
Adequacy of prenatal care, <i>n</i> (%)					
Adequate Plus	693 052 (31.1)	82 921 (48.1)	21 301 (41.4)	35 285 (48.7)	16 142 (50.3)
Adequate	929 969 (41.7)	53 517 (31.1)	18 622 (36.2)	21 560 (29.8)	9925 (30.9)
Intermediate	37 881 (17.0)	19 055 (11.1)	6628 (12.9)	7930 (11.0)	3362 (10.5)
Inadequate	227 583 (10.2)	16 860 (9.8)	4912 (9.5)	7654 (10.6)	2668 (8.3)
Singleton or multiple gestation, <i>n</i> (%)					
Singleton	2 277 504 (98.5)	171 982 (95.6)	51 770 (97.0)	71 036 (93.7)	32 671 (97.7)
Multiple	33 943 (1.5)	7826 (4.4)	1602 (3.0)	4783 (6.3)	762 (2.3)
Timing of delivery, <i>n</i> (%)					
Early preterm (20 to <34 weeks)	5022 (0.2)	363 (0.2)	25 (0.1)	103 (0.1)	176 (0.5)
Late preterm (34 to <37 weeks)	154 807 (6.7)	41 007 (22.8)	5871 (11.0)	23 130 (30.5)	4626 (13.8)
Term (early to late) and postterm 2 (37–45 weeks)	151 618 (93.1)	138 438 (77.0)	47 476 (89.0)	52 586 (69.4)	28 631 (85.6)
Mode of delivery, <i>n</i> (%)					
Vaginal	1 575 607 (68.2)	88 796 (49.4)	30 847 (57.8)	35 187 (46.4)	16 679 (49.9)
Caesarean	735 827 (31.8)	91 011 (50.6)	22 525 (42.2)	40 632 (53.6)	16 754 (50.1)
Birth outcome, <i>n</i> (%)					
Term without SGA	1 969 014 (85.2)	118 062 (65.7)	41 122 (77.1)	43 196 (57.0)	25 598 (76.6)
Preterm or SGA	335 545 (14.5)	60 767 (33.8)	12 095 (22.7)	32 278 (42.6)	7,512 (22.5)
Stillborn	6888 (0.3)	979 (0.5)	155 (0.3)	345 (0.5)	323 (1)
NICU admission, <i>n</i> (%)	114 124 (4.9)	27 440 (15.3)	3992 (7.5)	14 978 (19.8)	3512 (10.5)
Length of childbirth hospitalization after delivery, <i>n</i> (%)					
0–1 days	365 571 (15.8)	7314 (4.1)	2967 (5.6)	1414 (1.9)	2598 (7.8)
2–3 days	1 633 696 (70.7)	100 076 (55.7)	34 588 (64.8)	36,612 (48.3)	21 929 (65.6)
4–5 days	281 334 (12.2)	53 851 (29.9)	13 573 (25.4)	27 122 (35.8)	7203 (21.5)
6–7 days	15 924 (0.7)	10 884 (6.1)	1569 (2.9)	6463 (8.5)	869 (2.6)
>7 days	14 922 (0.6)	7683 (4.3)	675 (1.3)	4208 (5.6)	834 (2.5)
At least one maternal hospital encounter in 12 weeks after delivery, <i>n</i> (%)					
Any	177 556 (7.7)	22 934 (12.8)	5772 (10.8)	9424 (12.4)	4799 (14.4)

Characteristic	HDP subtype ^b				Chronic hypertension with superimposed preeclampsia
	Without HDP	With HDP ^a	Gestational hypertension	Preeclampsia-eclampsia	
ED visit	159 056 (6.9)	19 575 (10.9)	4998 (9.4)	7925 (10.5)	2466 (14.4)
Hospital readmission	29 253 (1.3)	5244 (2.9)	1195 (2.2)		781 (4.5)

ED, emergency department; HDP, hypertensive disorders of pregnancy; IQR, interquartile range; NICU, neonatal ICU; SGA, small for gestational age.

^a All comparisons between groups without versus with HDP had $P < 0.001$.

^b All comparisons between HDP subtypes had family $P < 0.001$.

TABLE 3.

Prevalence and adjusted hazard ratios of postpartum hospital encounters by hypertensive disorders of pregnancy status

Postpartum complication	Prevalence of hospital encounters ^{a, n}		HDP-associated hazards, HR (95% CI)	
	Without HDP (N=2 311 447)	With HDP ^b (N=179 808)	Unadjusted	Adjusted ^c
Overall	177 556 (7.68)	22 934 (12.75)	1.72 (1.69–1.74)	1.38 (1.36–1.40)
Major diagnostic categories ^d				
Hypertension-related	3760 (0.15)	5300 (2.96)	18.46 (17.68–19.29)	11.76 (11.21–12.34)
Other, clinically related to childbirth hospitalization	91 721 (3.99)	12 274 (6.84)	1.69 (1.65–1.72)	1.38 (1.31–1.37)
Other, not clinically related to childbirth hospitalization	87 093 (3.76)	12 489 (6.97)	1.74 (1.70–1.78)	1.38 (1.35–1.41)
Condition-specific diagnostic categories ^e				
Urinary tract infection	27 870 (1.21)	3555 (1.98)	1.65 (1.59–1.71)	1.42 (1.37–1.48)
Nonspecific postpartum diagnosis	24 235 (1.05)	3789 (2.11)	2.02 (1.95–2.09)	1.56 (1.50–1.62)
Uncontrolled pain	24 649 (1.07)	2962 (1.65)	1.55 (1.49–1.61)	1.21 (1.16–1.26)
Gallbladder disease/Pancreatitis	15 739 (0.68)	1701 (0.95)	1.39 (1.32–1.46)	1.11 (1.05–1.17)
Bleeding risk/complications	12 890 (0.56)	2059 (1.15)	2.06 (1.97–2.16)	1.73 (1.64–1.81)
Perineal complication or surgical wound complication, infection, management	11 685 (0.51)	2077 (1.16)	2.29 (2.19–2.40)	1.29 (1.22–1.35)
Psychiatric disease	10 645 (0.46)	1969 (1.10)	2.39 (2.28–2.51)	1.75 (1.66–1.84)
Breast infections/Lactation complications	11 351 (0.49)	777 (0.43)	0.88 (0.82–0.95)	0.98 (0.91–1.06)
Cellulitis	7308 (0.32)	1126 (0.63)	1.98 (1.86, 2.11)	1.25 (1.17–1.34)
Fever (unspecified)	6760 (0.29)	724 (0.40)	1.38 (1.28–1.49)	1.29 (1.19–1.40)
Hypertensive disorders	2399 (0.10)	4546 (2.53)	24.65 (23.46–25.89)	15.58 (14.76–16.45)

CI, confidence interval; HDP, hypertensive disorders of pregnancy; HR, hazard ratio.

^aPrevalence defined as at least one maternal hospital encounter (with a qualifying diagnosis) in 12 weeks after delivery.^bAll comparisons between groups without versus with HDP had $P < 0.001$.^cAdjusted for maternal age category, race/ethnicity, insurance status, prepregnancy obesity, chronic diabetes, gestational diabetes, mode of delivery, gestational age category, and birth outcome [term not small for gestational age (SGA), versus preterm or SGA, versus stillborn].^dSee Table 1 for the condition-specific diagnostic categories included in each major category. The most common conditions in each major category were hypertensive disorders and acute cardiovascular disease (hypertension-related); urinary tract infection and uncontrolled pain (childbirth-related); and nonspecific postpartum diagnosis and gallbladder disease/pancreatitis (other).

^eTen most common condition-specific diagnostic categories, and hypertensive disorders. See Supplement 3, <http://links.lww.com/HJH/B507> for less common diagnoses.

TABLE 4.

Adjusted hazard ratios of postpartum hospital encounters by hypertensive disorders of pregnancy subtype

Postpartum complication	Adjusted ^d HR (95% CI)			
	Gestational hypertension (N=53 372)	Preeclampsia-eclampsia (N=75 819)	Chronic hypertension (N=33 343)	Chronic hypertension with superimposed preeclampsia (N=17 184)
Overall	1.22 (1.18–1.25)	1.33 (1.30–1.36)	1.61 (1.56–1.66)	1.75 (1.69–1.82)
Major diagnostic categories ^b				
Hypertension-related	6.75 (6.21–7.35)	8.45 (7.90–9.04)	19.47 (18.27–20.76)	25.10 (23.34–26.99)
Other, clinically related to childbirth hospitalization	1.20 (1.15–1.24)	1.29 (1.25–1.33)	1.52 (1.46–1.60)	1.66 (1.56–1.75)
Other, not clinically related to childbirth hospitalization	1.18 (1.13–1.23)	1.33 (1.28–1.37)	1.63 (1.56–1.71)	1.76 (1.67–1.87)
Condition-specific diagnostic categories ^c				
Urinary tract infection	1.20 (1.23–1.28)	1.39 (1.32–1.47)	1.62 (1.50–1.75)	1.99 (1.81–2.19)
Nonspecific postpartum diagnosis	1.33 (1.24–1.42)	1.56 (1.48–1.64)	1.67 (1.55–1.80)	2.03 (1.86–2.22)
Uncontrolled pain	1.09 (1.01–1.17)	1.07 (1.01–1.14)	1.67 (1.55–1.81)	1.43 (1.29–1.59)
Gallbladder disease/Pancreatitis	1.03 (0.94–1.13)	1.15 (1.07–1.24)	1.11 (0.98–1.25)	1.15 (0.98–1.34)
Bleeding risk/complications	1.50 (1.37–1.65)	1.84 (1.72–1.97)	1.64 (1.47–1.82)	2.10 (1.85–2.38)
Perineal complication or surgical wound complication, infection, management	1.23 (1.13–1.35)	1.18 (1.10–1.27)	1.44 (1.30–1.58)	1.57 (1.40–1.76)
Psychiatric disease	1.22 (1.10–1.36)	1.41 (1.30–1.53)	2.87 (2.63–3.13)	2.65 (2.37–2.97)
Breast infections/Lactation complications	1.00 (0.88–1.13)	0.98 (0.88–1.10)	0.92 (0.77–1.11)	1.03 (0.80–1.32)
Cellulitis	1.24 (1.10–1.40)	1.03 (0.93–1.14)	1.66 (1.47–1.87)	1.46 (1.24–1.71)
Fever (unspecified)	1.16 (1.01–1.34)	1.32 (1.18–1.48)	1.41 (1.18–1.68)	1.37 (1.08–1.75)
Hypertensive disorders	8.58 (7.83–9.41)	10.40 (9.64–11.22)	27.61 (25.77–29.59)	35.19 (32.54–38.04)

CI, confidence interval; HR, hazard ratio.

^a Compared to normotensive; adjusted for maternal age category, race/ethnicity, insurance status, prepregnancy obesity, chronic diabetes, gestational diabetes, mode of delivery, gestational age category and birth outcome.^b See Table 1 for the condition-specific diagnostic categories included in each major category.^c Ten most common condition-specific diagnostic categories, and hypertensive disorders. See Supplement 3, <http://links.lww.com/HJH/B507> for less common diagnoses.