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Hypertension in Pregnancy: Current Challenges and Future Opportunities for Surveillance and Research

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Abstract

Hypertension in pregnancy (HP) includes eclampsia/preeclampsia, chronic hypertension, superimposed preeclampsia, and gestational hypertension. In the United States, HP prevalence doubled over the last three decades, based on birth certificate data. In 2019, the estimated percent of births with a history of HP varied from 10.1% to 15.9% for birth certificate data and hospital discharge records, respectively. The use of electronic medical records may result in identifying an additional third to half of undiagnosed cases of HP. Individuals with gestational hypertension or preeclampsia are at 3.5 times higher risk of progressing to chronic hypertension and from 1.7 to 2.8 times higher risk of developing cardiovascular disease (CVD) after childbirth compared with individuals without these conditions. Interventions to identify and address CVD risk factors among individuals with HP are most effective if started during the first 6 weeks postpartum and implemented during the first year after childbirth. Providing access to affordable health care during the first 12 months after delivery may ensure healthy longevity for individuals with HP. Average attendance rates for postpartum visits in the United States are 72.1%, but the rates vary significantly (from 24.9% to 96.5%). Moreover, even among individuals with CVD risk factors who attend postpartum visits, approximately 40% do not receive counseling on a healthy lifestyle. In the United States, as of the end of September 2023, 38 states and the District of Columbia have extended Medicaid coverage eligibility, eight states plan to implement it, and two states proposed a limited coverage extension from 2 to 12 months after childbirth. Currently, data gaps exist in national health surveillance and health systems to identify and monitor HP. Using multiple data sources, incorporating electronic medical record data algorithms, and standardizing data

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Authors' Contributions

E.V.K.: conceptualization; writing—original draft preparation. R.K.M.: supervision; writing—reviewing and editing. J.S.W.: writing—reviewing and editing. A.S.V.: writing—reviewing and editing. F.C.: conceptualization; supervision; writing—reviewing and editing.

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definitions can improve surveillance, provide opportunities to better track progress, and may help in developing targeted policy recommendations.

Keywords

hypertension; pregnancy; surveillance; long-term outcomes

Introduction

Hypertension in pregnancy (HP) is among the leading causes of maternal and fetal/infant morbidity and mortality in the United States.[1–5] It is also a risk factor for cardiovascular disease (CVD).[6] Racial and ethnic minority women experience higher rates of preeclampsia[7,8] and complications compared with White women.[9,10]

Improving maternal health is a priority for the U.S. Department of Health and Human Services. In the Blueprint for Addressing the Maternal Health Crisis, released by the White House in June 2022, one of the five goals focuses on data capacity, including data collection, standardization, transparency, research, and analysis.[11] In the United States, studies identifying HP rely on surveys based on maternal recall, birth certificate data, or discharge data. The estimated percent of births with a history of HP in 2019 varied from 10.1%12 to 15.9%3 for birth certificate data and hospital discharge records, respectively. A study based on birth certificate data also found that HP prevalence doubled over the last three decades in the United States.12 Differences in HP ascertainment methods can explain the variability in prevalence estimates. The usage of electronic medical records (EMRs) suggests that an additional third to half of previously undiagnosed cases of HP can be identified through clinical data.[13,14]

This report presents an overview of the negative consequences of HP, with a particular focus on long-term outcomes and an emphasis on the racial and ethnic inequalities in HP occurrence and outcomes. We also suggest strategies to enhance HP surveillance and improve long-term CVD outcomes of HP in the United States.

Definition of Hypertension in Pregnancy

In the United States, the Task Force on Hypertension in Pregnancy classifies HP into four categories: eclampsia/preeclampsia, chronic hypertension, chronic hypertension with preeclampsia (superimposed preeclampsia), and gestational hypertension.[15]

Elevated blood pressure (systolic blood pressure [SBP] ≥140 mm Hg or diastolic blood pressure [DBP] ≥90 mm Hg) is a distinctive feature of any HP.[15] Chronic hypertension is diagnosed before pregnancy or before 20 weeks, and gestational hypertension is diagnosed at or after 20 weeks.[15] Severe hypertension is SBP ≥160 mm Hg or DBP ≥110 mm Hg on two measurements at 15–20 minutes apart.[15]

The Task Force further separates eclampsia/preeclampsia into eclampsia and preeclampsia.[15] Preeclampsia is new-onset hypertension with proteinuria or at least one other target organ

manifestation, including central nervous, cardiorespiratory, hematologic, renal, or hepatic system. Preeclampsia with severe features is the presence of severe hypertension or significant end-organ dysfunction.[15] Eclampsia is gestational hypertension or preeclampsia with new-onset tonic–clonic, focal, or multifocal seizures without other causative conditions.[15] Clinical transition from chronic hypertension or gestational hypertension to preeclampsia, or preeclampsia to eclampsia, may occur unpredictably, rapidly, and without specific warning signs.[15]

The literature describes postpartum hypertension or postpartum preeclampsia as new-onset conditions within 6 weeks after delivery using the same diagnostic criteria for these conditions as during pregnancy.[16] The diagnosis of postpartum hypertension within clinical practice, along with its identification for surveillance and research purposes, poses a challenge. Postpartum hypertension needs to be differentiated from persistent preeclampsia or gestational hypertension, undiagnosed primary or secondary chronic hypertension during pregnancy or delivery, or transient hypertension due to volume overload, pain, or medications.[17] Another classification of preeclampsia accepted by clinicians and researchers is preeclampsia by the timing of onset: early (before 34 weeks of gestation) and late (34 or more weeks of gestation). Late onset is further classified into preterm (34–36 weeks of gestation) and term preeclampsia (37 or more weeks of gestation).[18]

Adverse Outcomes of HP

Women who experience gestational hypertension or preeclampsia are at a significantly elevated risk of developing chronic hypertension after childbirth, 3.5 times higher than those unaffected by these conditions.[6] The researchers drew this conclusion from a meta-analysis of 59 independent studies, including approximately 6 million individuals.[6] The risk for developing chronic hypertension after gestational hypertension and preeclampsia compared with normotensive pregnancies is highest among women with body mass index ≥35 kg/m^2,[19] non-Hispanic Black women,[19] women with early onset of preeclampsia,[6,20] and women with preeclampsia with severe features.[6] Risk factors for persistent hypertension at 3 months postpartum in women with preeclampsia include older age, higher BP, and larger medication doses before delivery.[21] The risk of chronic hypertension development is highest during the first 6 months[22] after delivery and remains high during the first 5 years after gestational hypertension or preeclampsia diagnosis.[6]

Women with a history of HP also have an increased risk of developing CVD later in life, including coronary artery disease, congestive heart failure, and stroke, and an increased risk of CVD-associated death.[23] The relative risk for developing these conditions ranges from 1.7 for coronary artery heart disease to 2.8 for heart failure, according to the results of a 2020 systematic review and meta-analysis including >13 million women.[23] The increased risk for all incident CVD is greater at ≤10 years compared with at >10 years after hypertensive disorders in pregnancy (HDP).[23] Women with preeclampsia had a higher risk than women with gestational hypertension, and women with chronic hypertension complicated by preeclampsia had a higher CVD risk compared with women with preeclampsia without chronic hypertension.[23] Two recent systematic reviews and meta-analyses confirmed the strength of these associations.[6,24] The risk of developing major

cardiovascular and cerebrovascular events is almost 6 times higher among women with early-onset preeclampsia than those with previous late-onset preeclampsia.[20] Evidence is accumulating about the association of HP with mental well-being and various chronic conditions, including diabetes,[25] chronic kidney disease,[26] neovascular age-related macular degeneration,[27] dementia,[28] depression, anxiety, and post-traumatic stress disorder.[29]

Adverse effects of HDP on the fetal cardiovascular system and brain development are likely to persist across the life span.[30,31] Several studies have demonstrated that children born from mothers with preeclampsia had an increased risk of being overweight or obese or having chronic hypertension and systemic vascular dysfunction,[32] which, in turn, may result in early-onset CVD.[33] There is increasing evidence that gestational hypertension is associated with chronic hypertension in offspring.[34]

Disparities in the Prevalence and Adverse Outcomes of HP

In the United States, racial and ethnic minority women typically experience a higher burden of HP and associated complications than non-Hispanic White women. Hispanic women exhibit a lower prevalence of HP but a higher prevalence of preeclampsia.[8] Among Hispanic/Latina and non-Hispanic Asian subgroups, Puerto Rican and Filipina individuals exhibit the highest prevalence of gestational hypertension or preeclampsia, respectively.[35] African American (AA) women demonstrate double the prevalence rates of preeclampsia compared with White women.[7] American Indians or Alaska Natives (AI/AN) exhibit the highest preeclampsia rates among all racial and ethnic groups.[8] Gestational hypertension or preeclampsia significantly contributes to maternal mortality among racial and ethnic minority groups, accounting for 8.2% of all maternal deaths in AA, 9.7% in Hispanic women, and 12.8% in AI/AN women.[10] Foreign-born individuals, including refugees from racial and ethnic groups, tend to display a lower incidence of preeclampsia when compared with their U.S.-born counterparts.[36] However, preeclampsia may be underdiagnosed among this group because of language barriers;[36] their risk of HDP increases with a longer duration of U.S. residency.[37]

Few studies are available on the relationship between HP and CVD outcomes among different racial and ethnic groups despite the high occurrence of HP in these groups.[38] Available research on women belonging to racial and ethnic groups other than White and AA is limited for comparison. AA women experience a slower decline in BP and have more persistent hypertension for up to 6 weeks after delivery compared with White women.[39] In addition, AA women have a higher prevalence of postpartum preeclampsia, which has been linked to increased BP at ≥12 weeks postpartum and a greater risk for progression to chronic hypertension.[40] AA women progress faster from mild chronic hypertension during pregnancy to severe chronic hypertension within 5–7 years after pregnancy.[41] Compared with White women without any HP, AA women with eclampsia, preeclampsia, and gestational hypertension and with eclampsia, preeclampsia, gestational hypertension, and chronic hypertension are 8.5 and 11.3 times more likely to develop heart failure within 5 years of pregnancy, respectively.[42] In contrast, the magnitude of these associations is smaller in White women with HP compared with White women without any HP: 4.1 times

for eclampsia, preeclampsia, and gestational hypertension and 4.1 times for eclampsia, preeclampsia, gestational hypertension, and chronic hypertension.[42]

Racial and ethnic minorities often encounter economic instability, including substandard education, limited employment opportunities, increased food and housing insecurity, crime and violence, and a lack of social support, resulting in chronic psychosocial stress,[43] a well-established risk factor for high BP.[44] The daily influence of systematic and structural racism may result in the lack of resources for promoting and maintaining a healthy lifestyle and limited access to health care, resulting in a higher incidence of chronic conditions associated with HP and adverse pregnancy outcomes.[43] Within the U.S. health care system, individual-level racial bias also can play a significant role in creating disparities in HP care.[43] Thus, structural, systematic, and individual racism may contribute to differences in the timeliness, utilization, and quality of prenatal care and postpartum care.[43]

Public health efforts can reduce these disparities through strategies to mitigate racism across all levels including improvements in data capture and use, health system and community-based interventions coupled with policy solutions encompassing quality improvement initiatives, and telehealth.[45,46] In a large retrospective cohort study of >1,500 patients, the implementation of telemedicine eliminated the difference in postpartum visit attendance by race.[47] In addition, a study demonstrated that universal health care access in the military may mitigate racial disparities in the relative risk for significant maternal morbidity such as preeclampsia.[48]

Ascertainment of HP from Available Data Sources

Classifications of HP in the U.S. birth certificate records,[49] International Classification of Diseases Clinical Modification (ICD-10-CM), Official Guidelines for Coding and Reporting,[50] clinical guidelines,[15] and algorithms to identify HP in EMRs[13,14] vary in terms and numbers of HP subtypes. These classifications may not adequately capture the nuanced severity of HP or do not encompass postpartum hypertension and early, late, preterm, and term preeclampsia. To facilitate the comparison of HP prevalence and enhance comprehension of the limitations associated with these classifications, we have constructed Table 1.

Birth certificate data are frequently used to estimate the prevalence of HP and its subtypes, including new-onset HP: gestational preeclampsia or preeclampsia.[10,52,53] Ascertainment through birth certificate data relies on the compilation of information from various sources by trained birth attendants. The quality of these data varies widely by hospital location (state, city, urban, or rural).[54–56] A review of hospital medical records confirmed 94% of gestational preeclampsia or preeclampsia cases identified in birth certificate data from New York City.[57,58] However, about 23% of the recorded gestational preeclampsia or preeclampsia in the medical charts was missing from birth certificates. In addition, estimates of HP obtained from birth certificates are about 30% lower than those from hospital discharge data based on the ICD-9 or ICD-10 codes.[3,12] Underreporting is more likely to happen among women with an increased risk of developing HP or having adverse outcomes

from HP, including AA and Hispanic women, women with lower educational attainment, or women with public insurance.[57,58]

Ascertainment through hospital discharge data involves the usage of diagnosis codes from the ICD-10-CM that are documented for insurance claim reimbursement.[50] Studies indicate that ascertaining overall HP instead of subtypes using ICD-CM codes provides more accurate estimates.[59] In a hospital-level study, the specificity of ICD-10 codes was high for all HP (>80%), but the sensitivity for preeclampsia with and without severe features was moderate and low, respectively (58.3% and 3.2%).[60] A recent systematic review examined case-finding definitions for HP in administrative databases.[61] Specificity was high in 60% of studies, with the highest sensitivity observed for any HP (91%, range: 15–97%), but sensitivity varied widely from 3% to 100% among studies.[61] Thus, although ICD-10-CM codes can identify preeclampsia with high specificity, the moderate and low sensitivity may underestimate the disease burden. Finally, reporting quality was poor, unclear, or a high risk of reporting bias in all studies.[61] Researchers have called for validation studies that overcome the limitations of the previous studies.[61]

Difficulties exist in identifying chronic conditions and treatments, including HP, using vital records and hospital data. Approximately, 2% of cases report hypertension during delivery hospitalization, whereas studies based on National Health and Nutrition Examination Survey (NHANES) data indicate that 9.7% of women of reproductive age have been diagnosed with hypertension.[3,62] This discrepancy can be partially explained by the fact that some women with chronic hypertension may have difficulties or contraindications getting pregnant. Challenges also include a lack of standardized terminology for chronic hypertension (e.g., prepregnancy, pregestational, and preexisting) in these data sources and possible misclassification or underestimation.[15,49,50] Different thresholds to define hypertension among pregnant and nonpregnant women are additional contributors.[15,63] Finally, the medical coders should apply ICD-10-CM codes for chronic hypertension only if this condition interferes with the clinical management of the patient during the hospitalization.[50] For chronic hypertension, one example would be a pharmacy order for antihypertensive medication. The benefits of antihypertensive treatment for mild to moderate hypertension during pregnancy were unclear until recently.[64] A recent meta-analysis supported mild and moderate hypertension treatment with no adverse effects on the mother and the fetus.[64] Presently, it is unknown how many women with prepregnancy mild or moderate elevated BP stop taking medication during pregnancy, resulting in a possible underestimation of chronic hypertension prevalence and a possible overestimation of gestational hypertension (due to undiagnosed chronic hypertension) based on hospital discharge data.[65]

Successful implementation of evidence-based measures to address HP is only possible with systems that collect high-quality clinical data. EMRs offer novel prospects to determine HP through clinical data.[51] For instance, an algorithm combining BP measurements and medication fills with ICD-10 diagnosis codes identified 28% more HP than using diagnosis codes only.[13] In another study, estimates of HP incidence increased by 50% after implementing an algorithm that included health care utilization, such as office visits, hospitalizations, emergency room visits, chart abstraction using the full EMR text, and natural language processing.[14] Furthermore, based on the results of the one study, EMR

algorithms have substantially higher sensitivity in identifying gestational hypertension (83.8% vs. 8.1%) and preeclampsia (71.4% vs. 7.5%) compared with ICD-10-CM codes.[66] Thus, using algorithms within EMRs opens new opportunities to examine undercoded and underdiagnosed HP and underreported social determinants of health, given that their assessment is becoming a more common clinical practice.[67] Medical records are the gold standard for validating ICD-10 codes and HP identification algorithms. Nonetheless, medical records also may have limitations; approximately one-third of medical records with preeclampsia lacked crucial BP monitoring or laboratory data, as discovered in a recent validation study.[68]

Jurisdiction surveys, such as the Pregnancy Risk Assessment Monitoring System (PRAMS), and research studies often use maternal recall of HP, with data quality differing by study design, population, and method of pregnancy assessment.[69,70] Studies indicate that the length of recall periods, ranging from 2 days to 30 years, did not affect recall quality.[71] Recall reliability for early-onset preeclampsia is high, even 5–10 years after pregnancy, whereas recall reliability for late-onset preeclampsia and gestational hypertension is low.[72] In general, maternal recall of HP performs well in excluding cases without HP (specificity) but only moderately in correctly identifying cases with HP.[71]

Ascertainment of Chronic Hypertension Before and After Pregnancy

NHANES data permit the calculation of chronic hypertension prevalence in nonpregnant women based on self-reporting, medication use, or BP measurements on physical examination.[73] In NHANES, mean SBP and DBP are calculated from one visit.[73] NHANES estimates may differ from EMR estimates since the average of two or more BP readings from separate visits is needed for the clinical diagnosis.[63] A study using NHANES data found that 10.6% of women aged 20–50 years reported having hypertension, whereas 9.7% had undiagnosed hypertension (SBP ≥130 mm Hg and DBP ≥80 mm Hg). Overall, the prevalence of chronic hypertension was 20.3%.[62] Among women with self-reported hypertension, 87.2% who had controlled hypertension reported use of antihypertensive medication.[62] About 40% used medications not recommended in pregnancy (e.g., angiotensin-converting enzyme inhibitors and angiotensin II receptor blockers), and only about 3% used first-line antihypertensive medications for pregnancy (labetalol, nifedipine, or methyldopa).[62] Another study using NHANES data indicated that about 7% of women with self-reported hypertension used estrogen-containing contraceptives,[74] which are not recommended based on criteria outlined in the 2016 U.S. Medical Eligibility Criteria for Contraceptive Use.[75]

Jurisdiction-specific (e.g., PRAMS) and national surveys, including the Behavioral Risk Factor Surveillance System and the National Health Interview Survey, rely on self-reporting of diagnosed hypertension to identify nonpregnant individuals with diagnosed hypertension.[69] Social desirability, recall period, sampling approach, or selective recall can lead to self-reporting bias in these surveys.[76] People who are overweight or obese, young people (45 years and younger), and those who have an annual health care visit are more likely to overreport hypertension than those with a normal weight, older than 45 years, or lack an annual health care visit.[77]

It is imperative to identify cases of chronic hypertension accurately in EMR data for surveillance and clinical research purposes. Nevertheless, about 30% of hypertension cases determined by BP measurements in EMR lacked the appropriate diagnostic ICD-10-CM code.[78,79] Thus, the development of standardized operational definitions and phenotypes of hypertension using a combination of ICD-10-CM codes, BP measurements, antihypertensive medications, and other relevant data elements has been proposed.[13,80,81] Integrating ambulatory and home BP monitoring, increasingly used in hypertension diagnosis and management, into the EMR may help to enhance ascertainment.[63] Clinical notes from EMR may be used to improve the accuracy of identifying hypertension.[81] However, despite the process automation, challenges exist in extracting information from free text, often requiring phenotype algorithms developed using machine learning.[81] Finally, in June 2023, the Office of the National Coordinator for Health Information Technology ruled that the average self-measured BP should be included in all certified EMRs.[82] When implemented, this measure will facilitate the tracking and monitoring of self-measured BP data in EMR and provide another data point for the accurate detection of HP within this key source of data.

Implications

The effects of HP, as they are understood today, extend beyond pregnancy and postpartum maternal and infant morbidity and mortality. Focusing on preventing HP and its consequences through a life course approach may be important to improve the health of women and their families.[52] The estimates of overall HP prevalence are currently available at the national level from the hospital discharge data since the introduction of ICD-10 codes in 2015.[3] However, additional validation studies of ICD-10-CM codes for HP subtypes (gestational hypertension, preeclampsia, and eclampsia) and in hospitals with various characteristics (geographical locations, health care systems, and populations) are not yet available. The ascertainment of HP improves substantially with the linkage of two or more data sources (e.g., birth certificates and hospital discharge records) and by using the broad category of HP without dividing it into subcategories.[59] Although more than 20 states have demonstrated the capacity to link hospital discharge and birth certificate data for maternal and child health research, technical assistance and interagency collaboration could overcome barriers and ensure the expansion of this approach across a larger number of states.[83]

Progress in reducing HP prevalence and its adverse outcomes can only be achieved by accurately identifying HP, as well as chronic hypertension outside of pregnancy. Currently, administrative data sources are limited in identifying cases of HP during pregnancy and postpartum because of the potential for underestimation, lack of clinical details, and limited ability to track HP longitudinally. In addition, there is presently a data gap in national health surveillance systems and other health datasets on the social vulnerability of communities, detailed race-ethnicity data, racial bias, and the quality of clinical care at the individual patient level.[84] This information may be needed to better understand health disparities and promote health equity.[84] EMRs offer novel prospects to determine HP through clinical data. Nevertheless, the current BP electronic clinical quality measure (CMS165v10) excludes pregnant people, challenging surveillance of HP.[85] Furthermore, EMRs have not been effective in accurately documenting a patient's pregnancy status owing to the lack of

standardized “pregnancy episode” data elements incorporated into EMRs.[86] Thus, when a patient is currently pregnant, additional data fields should be collected including date of pregnancy status, estimated pregnancy start and delivery date, gestational age, and other data elements.[86]

The risk of chronic hypertension after gestational hypertension and preeclampsia is highest in the first 6 months after pregnancy.[6] Thus, evidence supports the importance of timely diagnosis of these conditions and postpartum care for healthy longevity for women.[6] Interventions to identify and address CVD risks among women with gestational hypertension and preeclampsia are most effective if started during the first 6 weeks and implemented during the first year after delivery.[87–89] In addition, women with chronic hypertension also should receive optimal BP management during this time. Average attendance rates for postpartum visits in the United States are 72.1%, but the rates vary significantly, ranging from 24.9% to 96.5%.[90] Among contributing factors to this wide fluctuation are the demographics of the study groups, the interpretation of what qualifies as a postpartum visit, and the methods used to collect data (medical charts, self-reported survey data, claim-based information, etc.).[90] Unfortunately, even among women with two or more CVD risk factors and attendance to postpartum visits, approximately 40.2% do not receive counseling on healthy diet, physical activity, and postpartum weight management.[91] Another example of intervention could be ensuring the timely follow-up for these women with their health care providers for ongoing coordination of care after postpartum visit.[92] The lack of postpartum care combined with a lack of preventive visits during the first year after delivery may contribute to maternal mortality associated with chronic hypertension[2] and decreasing trends in controlled hypertension among women.[93] In the United States, Medicaid covered 41.0% of births in 2021,[94] and as of September 28, 2023, 38 states and the District of Columbia have extended eligibility coverage from 2 months to 12 months after delivery, 8 states plan to implement it, and 2 states proposed a limited coverage extension for Medicaid.[95] This opportunity to provide access to affordable health care during the first 12 months after giving birth may improve preventive care access.

In conclusion, multiple data-related barriers exist in monitoring the prevalence of HP and chronic hypertension among women in the United States. The use of various data sources, incorporating EMR data algorithms, and standardized data definitions can improve surveillance, provide opportunities to better track progress, ensure comparability of results, and may help in developing targeted policy recommendations.

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Table 1.

Classification of Hypertension in Pregnancy Used in the United States

Clinical classification by Task Force on Hypertension in Pregnancy, 2013[15]	ICD-10-CM Official Guidelines for Coding and Reporting, 2023[51]	U.S. birth certificate, 2003[50]	Electronic medical records (examples)
Chronic hypertension repeating blood pressure (≥140 or ≥90 mm hg for SBP and DBP, respectively, and occurred during office two visits) before pregnancy or before 20 weeks of pregnancy	O10 Preexisting hypertension complicating pregnancy, childbirth, and the puerperium	Prepregnancy hypertension	**1** More than or equal to two high BPs (≥140/90 mm Hg) within 30 days from the start of pregnancy through 35 weeks 6 days (high BP):[13] or **2** An antihypertensive medication fills in the 120 days before pregnancy and a hypertension diagnosis from 1 year before pregnancy through 20 weeks' gestation (chronic hypertension treatment):[13] or **3** A high BP from the start of pregnancy through 35 weeks 6 days with one hypertension diagnosis, and one prescription fill within 7 days during pregnancy (rapid treatment)[13]
Chronic hypertension with preeclampsia	O11 Preexisting hypertension with preeclampsia	N/A	ICD-9/10 codes or algorithm-specific
N/A	O12 Gestational (pregnancy-induced) edema and proteinuria without hypertension	N/A	N/A
Gestational hypertension (severe and nonsevere) repeating BP (≥140 or ≥90 mm hg for SBP and DBP, respectively, and occurred at least twice) at least 4 hours apart after 20 weeks of pregnancy in patients with previously normal BP	O13 Gestational hypertension (pregnancy-induced): without significant proteinuria	Gestational hypertension: pregnancy-induced hypertension	ICD-9/10 codes or algorithm-specific
Preeclampsia without severe features repeating BP (≥140 or ≥90 mm hg for SBP and DBP, respectively, occurred at least twice) at least 4 hours apart after 20 weeks of pregnancy in patients with previously normal BP, and proteinuria is defined as 300 mg of protein in 24 hours (gold standard) or a urine protein/creatinine ratio of 0.3 (or this amount extrapolated from a timed collection), or dipstick reading of 2+ (used only if other quantitative methods are not available)	O140 Preeclampsia, mild to moderate	Gestational hypertension: preeclampsia	ICD-9/10 codes or algorithm-specific
1 Preeclampsia with severe features Any of the following symptoms: **2** Systolic BP ≥160, or diastolic BP ≥110 mm Hg, or both **3** Creatinine >1.1 mg/dL **4** Platelets <100 10^9/L **5** Liver enzymes (AST/ALT)-2 times of upper limit **6** Severe persistent right upper quadrant or epigastric pain unresponsive to medications	O141 Preeclampsia, severe	Gestational hypertension: preeclampsia	**1** Preeclampsia ICD-9/10 codes between the gestational weeks of 20 weeks and 10 weeks after the delivery[66] or **2** Repeating BP (≥140/90 mm hg for SBP/DBP and occurred at least twice) within 3 days, and creatinine >1.1 mg/dL, platelets <100 × 10^9/L, liver enzymes (AST/ALT)-2 times of upper limit), within 3 days of the first repeating high blood pressure[66] or **3** Repeating BP (≥140/90 mm hg for SBP/DBP and occurred at

Clinical classification by Task Force on Hypertension in Pregnancy, 2013[15]	ICD-10-CM Official Guidelines for Coding and Reporting, 2023[51]	U.S. birth certificate, 2003[50]	Electronic medical records (examples)
7 Pulmonary edema **8** New-onset cerebral or visual disturbances			least twice) within 3 days, and ICD-9/10 codes for pulmonary edema, new-onset cerebral or visual disturbances (not because of alternative diagnoses), and more[51]
Among women with severe preeclampsia: HELLP syndrome	O142 HELLP syndrome	N/A	ICD-9/10 codes or algorithm-specific
N/A	O149 Unspecified preeclampsia	N/A	ICD-9/10 codes or algorithm-specific
Eclampsia	O15 Eclampsia	Eclampsia	ICD-9/10 codes or algorithm-specific
N/A	O16 Unspecified maternal hypertension	N/A	ICD-9/10 codes or algorithm-specific

ALT, alanine transaminase; AST, aspartate aminotransferase; BP, blood pressure; DBP, diastolic blood pressure; HELLP: hemolysis, elevated liver enzymes, and low platelet counts; ICD-10-CM, International Classification of Diseases Clinical Modification; SBP, systolic blood pressure.