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Surveillance of Hypertension Among Women of Reproductive Age: A Review of Existing Data Sources and Opportunities for Surveillance Before, During, and After Pregnancy

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Abstract

Hypertension is one of the largest modifiable risk factors for cardiovascular disease in the United States, and when it occurs during pregnancy, it can lead to serious risks for both the mother and child. There is currently no nationwide or state surveillance system that specifically monitors hypertension among women of reproductive age (WRA). We reviewed hypertension information available in the Behavioral Risk Factor Surveillance System (BRFSS), National Health and Nutrition Examination Survey (NHANES), National Health Interview Survey (NHIS), and Pregnancy Risk Assessment and Monitoring System (PRAMS) health surveys, the Health care Cost and Utilization Project administrative data sets (National Inpatient Sample, State Inpatient Databases, Nationwide Emergency Department Sample, and State Emergency Department Database and the Nationwide Readmissions Database), and the National Vital Statistics System. BRFSS, NHIS, and NHANES and administrative data sets have the capacity to segment nonpregnant WRA from pregnant women. PRAMS collects information on hypertension before and during pregnancy only among women with a live birth. Detailed information on hypertension in the postpartum period is lacking in the data sources that we reviewed. Enhanced data collection may improve opportunities to conduct surveillance of hypertension among WRA.

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Keywords

hypertension; women of reproductive age; postpartum period; surveillance system; pregnancy

Introduction

Hypertension, or high blood pressure, is one of the largest modifiable risk factors for cardiovascular disease (CVD) in the United States[1] and is associated with serious health risks, including heart failure, stroke, and kidney disease.[2] As a result, the recent Surgeon General's Call to Action to Improve Maternal Health and an accompanying action plan released by the Department of Health and Human Services set targets for blood pressure control among women of reproductive age (WRA) as one of three actions for improvement.[3,4] Prevalence estimates of hypertension among nonpregnant WRA (ages 18–44 years) range from 9% to 11%.[5,6] Among nonpregnant WRA, hypertension prevalence increases with age and body mass index,[6,7] and it is highest among non-Hispanic black women.[6]

When hypertension occurs during pregnancy, particularly in its most severe forms, it is associated with increased risks of fetal death, preterm birth, maternal and infant morbidity, and maternal mortality.[8–12] Between 2007 and 2016, hypertensive disorders were the primary cause of 7.8% of maternal deaths in the United States,[13] and from 2011 to 2015, 64% of the deaths caused by hypertension occurred on the day of delivery to 6 days postpartum.[14] Among pregnancy-related deaths, a significantly higher proportion of black women and American Indian/Alaska Native women die due to hypertensive disorders of pregnancy (HDP) in comparison with white women.[13] History of HDP (including more severe forms such as preeclampsia and eclampsia) is also a risk factor for future CVD, including ischemic heart disease, stroke, and peripheral arterial disease, and cardiovascular mortality.[15,16] The rate of HDP per 10,000 deliveries has nearly doubled, increasing from 528.9 in 1993 to 912.4 in 2014.[17] Risk factors for HDP include having a body mass index ≥ 30 kg/m^2, systemic lupus erythematosus, type I or II diabetes mellitus, previous preeclamptic pregnancy, history of thrombophilia, entering pregnancy at advanced maternal age, preexisting chronic hypertension, family history of hypertension or preeclampsia, assisted reproductive technology,[18] multifetal gestation, and nulliparity.[19] Prevalence estimates of chronic hypertension among pregnant women range from 1% to 2%,[20] and women are increasingly likely to enter pregnancy with hypertension than in the past due to advancing maternal age,[21–23] increased obesity,[24] and potentially earlier onset of hypertension, including pediatric hypertension.[25]

These statistics call attention to the importance of public health surveillance of hypertension among WRA before, during, and after pregnancy. The aims of this commentary are to: (1) review and describe the data sources that currently include data on hypertension across the reproductive years, (2) identify gaps in available information, and (3) articulate opportunities to improve surveillance of hypertension among WRA before, during, and after pregnancy.

Definitions

In 2017, the American College of Cardiology and the American Heart Association updated the definitions for stage 1 and 2 hypertension.[26] They defined stage 1 hypertension as having a systolic blood pressure (SBP) of 130–139 millimeters of mercury (mm Hg) and a diastolic blood pressure (DBP) of 80–89 mm Hg. Stage 2 hypertension was defined as having an SBP of 140 mm Hg or more and a DBP of 90 mm Hg or more.

The American College of Obstetricians and Gynecologists (ACOG) classifies HDP into four categories: chronic hypertension, gestational hypertension, preeclampsia, and eclampsia

Data sources that collect information on hypertension among WRA before, during, and after pregnancy are given in Table 1.

Currently, there is no epidemiologic surveillance system in the United States specific to monitoring hypertension among WRA before, during, and after pregnancy. In this report, we review the hypertension information that is available in several health surveys and administrative data sets, and we describe the gaps and limitations of those data sources for conducting hypertension surveillance among WRA before, during, and after pregnancy.

Health surveys

The Behavioral Risk Factor Surveillance System (BRFSS) is an annual, jurisdiction-based, telephone-based survey that has collected self-reported data about the adult population's health, risk behaviors, current pregnancy status, and use of preventive services since 1984 in states, the District of Columbia, and some U.S. territories.[29] The rotating core BRFSS survey provides information during odd years (2005–present) on hypertension through the inclusion of questions on provider-diagnosed hypertension and medication use for hypertension, which can be categorized for nonpregnant WRA and pregnant women. Response options clarify if the provider-diagnosed hypertension only occurred during pregnancy (*i.e.*, HDP). Due to the rotation of questions related to hypertension only during odd years, the sample size for pregnant women diagnosed with hypertension or using medication for hypertension may produce small estimates unless survey years are combined. Optional modules that jurisdictions can choose to administer collect additional information about respondents' actions to control hypertension. Because the survey does not ask about postpartum status, data on hypertensive status in the postpartum period are unavailable.

The National Health and Nutrition Examination Survey (NHANES) is an in-person, population-based survey representative of a noninstitutionalized, civilian population of adults and children in the United States, which includes questionnaires, physical examinations, and clinical and laboratory measures related to select health conditions.[30] NHANES has collected data in 2-year survey cycles since 1999. NHANES captures pregnancy status at the time of survey by self-report or a positive laboratory test but does not collect any information on history of HDP. Because NHANES' questions on provider-diagnosed hypertension and examiner-measured blood pressure are consistent over the years, examination of national trends in hypertension prevalence, pharmacologic treatment, and control in pregnant women and nonpregnant WRA are possible. Since NHANES asks for the number of months since last delivery, estimates of hypertension among women during the

postpartum period are possible. Although NHANES increased the sample of pregnant women between 1999 and 2006, the number of pregnant women sampled in any one 2-year cycle is still relatively small and requires combining several years of data to product statistically stable estimates.

The National Health Interview Survey (NHIS) is an annual, household-based, in-person survey that has collected self-reported data on the health of the civilian noninstitutionalized U.S. population since 1957. Diagnosed hypertension is collected annually, and it is defined in the NHIS as having doctor-diagnosed hypertension in the past 12 months or taking prescription medication for their hypertension. Hypertension screening in the past 12 months is collected every other year as part of the survey's rotating core content. In addition to the survey's core questions, the NHIS includes questions that are sponsored on a periodic basis by other centers throughout CDC or other HHS agencies. For example, NHIS collected data on duration of time since last blood pressure check with blood pressure measurement at last check (2008, 2014, 2017, and 2019). Assessing prevalence of hypertension during pregnancy is possible, as NHIS has captured self-reported, current pregnancy status since 1997. Response options do not consistently clarify if the doctor-diagnosed hypertension only occurred during pregnancy (*i.e.*, HDP). Specifically, NHIS only asked about HDP in 1998, 2003, and 2008 as part of a sponsored supplement. Estimates of hypertension among postpartum women are possible since NHIS also collects month and year of last birth. NHIS does not oversample pregnant or postpartum women, and therefore, statistically stable estimates would require combining several years of data.

The Pregnancy Risk Assessment Monitoring System (PRAMS) is an annual, population-based, surveillance system that covers about 83% of recent U.S. births.[31] PRAMS is a survey only among women with a recent live birth and does not include other pregnancy outcomes such as stillbirth and miscarriage. PRAMS samples from the birth certificate and includes self-reported information on maternal behaviors, conditions, and experiences that occurred before, during, and after the most recent pregnancy. The PRAMS survey is revised periodically, and questionnaires from each phase include core questions asked by all states and optional standard questions states may choose to add. Information on self-reported hypertension before pregnancy is available as a core question of PRAMS Phase 7 and 8 (2012–present) and as optional standard questions of PRAMS Phase 5 and 6 (2004–2011). Information on self-reported hypertension, preeclampsia, or eclampsia during the current pregnancy is available as a core question of PRAMS Phase 5, 6, 8 (2004–2011, and 2016–present) and as optional standard questions of PRAMS Phase 7 (2012–2015). Information on whether a health care provider talked to you about controlling your hypertension before pregnancy is available as a core question of PRAMS Phase 8 (2016–present) and as optional standard questions of PRAMS Phase 6 and 7 (2009–2015). Finally, information about whether or not a woman visited a health care provider to be checked or treated for hypertension before pregnancy is available as a core question of PRAMS Phase 6 and 7 (2009–2015). While there are no core questions on hypertension during the postpartum period, New Hampshire has a state-specific question that asks about follow-up care for hypertension after the most recent pregnancy.[32] In addition, because PRAMS samples are based on birth certificates, selected variables from the birth certificate may be included in PRAMS analytic data described below.

Administrative data

The National Inpatient Sample (NIS), the State Inpatient Databases (SID), the Nationwide Emergency Department Sample (NEDS), the State Emergency Department Databases (SEDD), and the Nationwide Readmissions Database (NRD) are part of a series of administrative databases that provide hospital-abstracted data for the Health care Cost and Utilization Project (HCUP).[33] NIS is the largest, publicly available, all-payer national inpatient database in the United States and comparable state-level data are available through SID. NEDS is the largest all-payer emergency department database in the United States and comparable state-level data are available through SEDD. NIS and SID capture discharge data from health care encounters for inpatient stays, while NEDS and SEDD capture discharge data from emergency department visits. NRD draws its samples from the SID and is the only HCUP database that can be used to track national readmission rates for all patients. State-level data are not available with the NRD. Diagnostics and procedures reported in discharge abstracts are coded using the International Classification of Diseases, Clinical Modification (ICD-CM) criteria. Data stratification by age and sex is possible in these nationwide administrative surveillance systems, allowing data users to identify WRA. Based on an enhanced delivery identification method using a diagnostic and procedure code algorithm, NIS, SID, NEDS, and SEDD data can be used to estimate maternal morbidities, including hypertension, during delivery hospitalizations.[34] It is possible to get data on hypertension during the postpartum period from the NEDS, SEDD, NIS, and NRD. However, linking delivery hospitalizations with their respective postpartum hospitalizations is only possible with the NRD.

The National Vital Statistics System coordinates and compiles documentation and publication of births and other vital statistics data in the United States and works with states and the National Center for Health Statistics to make statistical data from birth certificates available.[35] The U.S. Standard Certificate of Live Birth (*i.e.*, birth certificate) includes data on every birth occurring in the United States each year, and the 2003 birth certificate includes information on maternal hypertension, and thus, it is another potential source of national-level prevalence data. Check boxes on the birth certificate allow for capture of prepregnancy (chronic) hypertension, gestational hypertension (pregnancy-induced hypertension, preeclampsia), and eclampsia. While there is low sensitivity with gestational hypertension reported on the birth certificate compared with medical record data,[36,37] it is important to note gestational hypertension is available on the birth certificate.

Gaps in Data

This review describes health surveys and administrative data sources that may be used for surveillance of hypertension before, during, and after pregnancy and shines a light on the limitations of using those data for that purpose. As stated previously, there is currently no nationwide or state surveillance system that monitors hypertension specifically among WRA before, during, and after pregnancy. For example, detailed information on specific hypertensive diagnoses (*i.e.*, chronic hypertension, gestational hypertension, and preeclampsia) is unavailable in some health surveys. Severity of hypertension and/or HDP, timing of the diagnosis (relative to pregnancy), and details about pharmacologic treatment

and control are unavailable in the health surveys and administrative data sets that we reviewed. In several health surveys (BRFSS, NHANES, and NHIS), data on pregnant women must be combined across several survey years to achieve statistically stable estimates. In addition, PRAMS, while collecting detailed information on hypertension before and during pregnancy, does not collect information on pregnancy outcomes such as stillbirth or miscarriage, limiting our ability to determine how hypertension during prepregnancy or pregnancy periods influences other pregnancy outcomes. A project in Utah adapting PRAMS methodology for stillbirth surveillance may fill gaps in this area.[38] Another important data gap is the lack of detailed information collected on hypertension in the postpartum period. Several of the national administrative data sets collect information on the postpartum period during emergency department visits (NEDS and SEDD) and postpartum hospitalizations (NRD, NIS, and SID), however, data can only be linked with respective delivery hospitalizations in the NRD. Unfortunately, state-level data rae not available with the NRD.

There are other limitations of using the administrative data sets for hypertension and HDP surveillance. Although the percentage of missing racial and ethnic data has decreased over the last two decades, data on race and ethnicity are still incomplete in these data sets.[39] For example, three states (Minnesota, North Dakota, and West Virginia) do not collect data on race and ethnicity.[40] In addition, no information is collected on Hispanic ethnicity in Louisiana or in a large hospital system in Utah.[40] Finally, the positive predictive value for specific types of HDP based on ICD-CM codes in administrative data sets varies, ranging from 45% (for mild preeclampsia) to 85% (for severe preeclampsia), and so, some estimates of HDP using administrative data may be biased.[41]

Opportunities for Conducting Surveillance of Hypertension Among WRA

Enhanced data collection of hypertension among WRA can provide insights about the underlying causes of increasing trends of HDP, and enrich evaluations of states' efforts to reduce maternal and neonatal morbidity and mortality caused by HDP. Our review of the data sources that currently collect information on hypertension highlights the opportunities for conducting surveillance of hypertension among WRA. Interactive tools could facilitate surveillance data analyses based on populations of interest (*i.e.*, geography, demographic characteristics, or time frame).[42] Algorithms are needed to improve and standardize the identification of pregnancy and postpartum hospitalizations in administrative data sets. With additional funding, administrative data sets and health surveys can collect more information on the severity of hypertension during pregnancy, the timing of diagnosis of hypertension relative to pregnancy, hypertension control status, and treatment. Finally, investments from partners interested in health services research could expand data collection to enable differentiation between chronic and gestational hypertension and oversampling of women during pregnancy and the postpartum period.

Conclusion

Hypertension is a leading cause of death in the United States and when it occurs during pregnancy, it results in significant maternal and fetal morbidity and mortality.[10–13] Given the

serious and long-term risks associated with hypertension among WRA, routine surveillance of hypertension diagnosis, treatment, and control in WRA before, during, and after pregnancy is needed. This report described the health survey and administrative data sources that epidemiologists and researchers can use for public health surveillance of hypertension among WRA. Routine monitoring of hypertension in WRA before, during, and after pregnancy can allow stakeholders to better estimate the population at-risk and highlight opportunities for improving care for women across the reproductive years.

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Table 1.

Definitions: Hypertensive Disorders of Pregnancy[27,28]

HDP	Description
Chronic hypertension[28]	Hypertension or elevated blood pressure (defined as SBP ≥140 mm Hg or DBP ≥90 mm Hg, or both, on two occasions at least 4 hours apart) diagnosed or present before pregnancy or before 20 weeks of gestation; or hypertension that is diagnosed for the first time during pregnancy and that does not resolve in the postpartum period.
Gestational hypertension[27]	Hypertension (defined as SBP ≥140 mm Hg or DBP ≥90 mm Hg, or both, on two occasions at least 4 hours apart) that is diagnosed during pregnancy (after 20 weeks of gestation), in women who were previously normotensive. Although usually blood pressure level returns to normal in the postpartum period, it may increase the risk of developing hypertension in later life.
Preeclampsia[27]	New-onset hypertension (defined as SBP ≥140 mm Hg or DBP ≥90 mm Hg) that occurs most often after 20 weeks of gestation and frequently includes new-onset proteinuria, or hypertension and other signs or symptoms of preeclampsia (*i.e.*, thrombocytopenia, renal insufficiency, impaired liver function, pulmonary edema) without proteinuria.
Eclampsia[27]	Convulsive manifestation of HDP and defined by new-onset tonic/clonic, focal, or multifocal seizures in the absence of other causative conditions.

DBP, diastolic blood pressure; HDP, hypertensive disorders of pregnancy; SBP, systolic blood pressure.