Prevalence and outcomes of hypertension in pregnancy in non-metropolitan and metropolitan communities

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ABSTRACT

Objectives: Hypertension during pregnancy is a leading cause of birthing parent mortality and adverse pregnancy outcomes. Since non-metropolitan communities face higher rates of several risk factors for hypertension in pregnancy and shortages in obstetrical services, persons residing in non-metropolitan areas may be at increased risk for adverse events compared to those living in metropolitan areas. Our study objectives were to examine by non-metropolitan vs. metropolitan birthing parent residence (1) the prevalence of chronic hypertension (cHTN) and hypertensive disorders of pregnancy (HDP), and (2) the prevalence of cesarean delivery, preterm birth, low birth weight, APGAR < 7 at 5 min, NICU admission, and stillbirth/neonatal death among the group of birthing parents with cHTN and among the group of birthing parents with HDP.

Methods: Using U.S. Natality data from 2016 to 2018, we described the prevalence of cHTN and HDP and the association of each with several birthing parent and neonatal outcomes, stratified by non-metropolitan versus metropolitan county of birthing parent residence. Multivariable Poisson regression models were used to calculate adjusted prevalence ratios for these adverse outcomes.

Results: The prevalence of cHTN among pregnant individuals was 2.2% in non-metropolitan areas and 1.8% in metropolitan areas. For HDP, the prevalence was 7.4% in non-metropolitan areas and 6.6% in metropolitan areas. After adjusting for several sociodemographic characteristics among those with HDP, the prevalence ratio for an APGAR score < 7 at 5 min (aPR 1.34, 95% CI 1.29–1.38) and stillbirth/neonatal death (aPR 1.36, 95% CI 1.15–1.62) was increased among offspring born to birthing parents who resided in non-metropolitan counties. Similar results were seen among those with cHTN.

Conclusions: The prevalence of cHTN and HDP is elevated among birthing parents residing in non-metropolitan areas. Also, the prevalence of APGAR <7 and stillbirth/neonatal death following pregnancies complicated by hypertension were higher among neonates born to birthing parents residing in non-metropolitan areas. Further research should investigate the robustness of these findings using alternate definitions of rural and urban areas and the possible link between low APGAR score, low NICU admission, and stillbirth/neonatal death among birthing parents residing in non-metropolitan counties.

Introduction

Hypertensive disorders of pregnancy encompass gestational hypertension, pre-eclampsia, and eclampsia. These conditions are relatively common, complicating more than 1 in every 10 hospital deliveries in the US between 2005 and 2014 [1]. Hypertensive disorders of pregnancy are one of the leading causes of birthing parent mortality worldwide [2,3] and are associated with an increased rate of cesarean delivery, placental abruptio, disseminated intravascular coagulation, stroke, pulmonary edema, and renal failure [1,2,4,5]. These disorders have also been shown to increase the risk of intrauterine growth restriction, premature birth, and intrauterine fetal demise [2,6,7]. These adverse neonatal outcomes can have both short-term sequelae, such as respiratory distress syndrome and necrotizing enterocolitis, and long-term sequelae, including an increased risk of developing type 2 diabetes.
mellitus and hypertension as adults [6,8]. While chronic hypertension, defined as high blood pressure diagnosed prior to pregnancy or at less than 20 weeks gestation, is less common than the hypertensive disorders of pregnancy, it similarly increases the risk of these adverse birthing parent and neonatal outcomes.

Approximately 1 in every 6 American women live in non-metropolitan areas [9]. Compared with those residing in metropolitan areas, non-metropolitan residents have a greater frequency of numerous risk factors for hypertension in pregnancy including elevated body mass index, diabetes mellitus, chronic hypertension, tobacco use, poverty, and lower education level [9–13]. Historically, persons residing in non-metropolitan areas have the highest rates of pre-eclampsia, but the prevalence of pre-eclampsia in metropolitan areas has been increasing at a faster rate in recent years [1]. Notably, non-metropolitan areas have a shortage of obstetrical services, with over half of all non-metropolitan counties lacking an obstetric unit, and obstetrical units continue to close in disproportionate numbers in non-metropolitan areas [11,14–16]. Since any form of hypertension in pregnancy typically requires management by an obstetrician-gynaecologist [17], persons residing in non-metropolitan areas may be at increased risk for adverse outcomes compared to those living in metropolitan areas due to distance to appropriate level of obstetric care, though little published data exists.

Using county-level data from the National Center for Health Statistics, we examined differences in the prevalence and adverse pregnancy outcomes of chronic hypertension and hypertensive disorders of pregnancy according to birthing parent residence.

Materials and methods

Data source

We conducted a cross-sectional analysis of live births in the United States using a restricted-use version of National Center for Health Statistics (NCHS) Natality dataset with county identifiers for the calendar years 2016 through 2018 [18]. NCHS Natality is a 100% sample of birth certificate data [19] from all states, the District of Columbia, and the US territories. The Institutional Review Board at the University of Massachusetts Medical School determined that this study was exempt from further review.

Study population

All pregnant individuals who gave birth in the United States during the period 1 January 2016–31 December 2018 were eligible for study inclusion. A total of 11,564,457 live births occurred during this period. Births that occurred in US territories were excluded. In addition, pregnant individuals with missing or imputed values for birthing parent age, race, ethnicity, pre-pregnancy body mass index (BMI), tobacco use, gestational age, preexisting hypertension, pregnancy-induced hypertension, or eclampsia were excluded. In total, 1,512,395 records (13.1%) were excluded, with birthing parent race as the largest source of missingness (n = 713,179; 6.2%).

Study outcomes

All study outcomes were abstracted from birthing parent medical, prenatal, and delivery records as specified in the NVSS Guide for Completing the Facility Worksheets for the Certificate of Live Birth in the United States [20]. Those with chronic hypertension, gestational hypertension, or pre-eclampsia who developed eclampsia were included only in the eclampsia category. We created a composite variable of “any hypertensive disorder of pregnancy,” which included all births in which the pregnant individual was reported to have pregnancy-induced hypertension or eclampsia on the birth certificate given the inability to distinguish gestational hypertension and pre-eclampsia using birth certificate data and the overall low prevalence of eclampsia.

Preterm delivery (delivery at <37 weeks and 0 days gestation) and cesarean delivery were defined as our principal adverse birthing parent outcomes. Low birth weight (delivery weight <2500 grams regardless of gestational age at delivery), neonatal intensive care unit (NICU) admission, APGAR score less than seven at five minutes, and stillbirth/neonatal death were our primary neonatal adverse outcomes. Stillbirth/neonatal death was defined as infant not living at time of birth certificate reporting.

Study exposure

The 2013 Rural Urban Continuum Codes (RUCC) are described in greater detail in the 2013 NCHS Urban-Rural Classification Scheme for Counties [21]. Counties with a RUCC between 1 and 4 are classified as metropolitan counties, whereas counties with a RUCC 5 or 6 are classified as non-metropolitan counties. Using the 2013 Rural-Urban Continuum Codes and the reported birthing parent residence county, the RUCC and corresponding metropolitan/non-metropolitan classification
were assigned to each birth certificate record based on reported county of birthing parent residence [22].

**Study covariates**

Birthing parent age at delivery (<20 years, 20–34 years, ≥35 years), race (American Indian or Alaska Native (AIAN), Asian, Black, White, Native Hawaiian or other Pacific Islander (NHOPI), multi-racial), ethnicity (Hispanic, non-Hispanic), pre-pregnancy BMI (<18.5 kg/m², 18.5–24.9 kg/m², 25.0–29.9 kg/m², ≥30.0 kg/m²), formal education (high school/GED not completed, high school/GED completed, some college or higher), insurance (private, government, self-pay, other), and tobacco use (>1 cigarette per day in the 3 months prior to pregnancy, >1 cigarette per day in any trimester of pregnancy, no tobacco use) were treated as categorical variables. Region of birth (Northeast, South, Midwest, or West) was assigned based on census tract regions [23]. Pregnancy weight gain category (inappropriately low, appropriate, or inappropriately high) was assigned using the American College of Obstetricians and Gynecologists (ACOG) recommendations for pregnancy weight gain based on pre-pregnancy BMI and single/multiple gestation [24].

**Statistical analysis**

We report the distribution of birthing parent demographics and characteristics of the study population overall and among the subset of individuals with hypertension in pregnancy. We calculated the prevalence of chronic hypertension, aggregate gestational hypertension and pre-eclampsia, eclampsia, and any hypertensive disorder of pregnancy. In order to examine adverse outcomes among individuals with hypertension in pregnancy in relation to birthing parent residence, we calculated the prevalence, prevalence ratio (PR), and adjusted prevalence ratio (aPR) for pre-term delivery, cesarean delivery, low birth weight, APGAR score <7 at 5 min, NICU admission, and stillbirth/neonatal death stratified by non-metropolitan and metropolitan birthing parent residence. Any demographic or clinical variable with more than a 5% absolute difference between non-metropolitan and metropolitan pregnant individuals was included in the initial regression model. The final multivariable adjusted model used to calculate adjusted prevalence ratios included birthing parent age, pre-pregnancy BMI, birthing parent race/ethnicity, whether the individual smoked before or during pregnancy, and insurance type. Due to the large dataset, most differences observed were statistically significant. In order to focus on the outcomes with the most clinical relevance, those outcomes with a greater than 10% relative difference between groups were chosen for emphasis. All statistical analyses were performed in Stata/MP (16.1) and Microsoft Excel.

**Results**

**Study population characteristics**

There were a total of 9,880,689 eligible pregnant individuals and 10,052,063 eligible live births during the study period. The median age of the study sample was 29 years (IQR 25–33 years), 73.9% were white, 98.3% were singleton pregnancies, and the majority of births were by metropolitan-residing pregnant individuals (N=8,485,100, 85.9%). The demographic characteristics and risk factors for chronic hypertension and the hypertensive disorders of pregnancy differed by birthing parent residence (Supplementary Table 1). Individuals with chronic hypertension or a hypertensive disorder of pregnancy who resided in non-metropolitan areas were more likely to be white, on Medicaid, receiving WIC during pregnancy, and a tobacco user compared with individuals with chronic hypertension or a hypertensive disorder of pregnancy who lived in metropolitan areas.

**Prevalence of hypertension in pregnancy and associated adverse outcomes**

Approximately 67 in every 1000 births was complicated by a hypertensive disorder of pregnancy and 19 in every 1000 births was complicated by chronic hypertension. Chronic hypertension was more prevalent in non-metropolitan residing individuals compared to metropolitan-residing individuals (2.2% vs 1.8%), as was any hypertensive disorder of pregnancy (7.4% vs 6.6%) (Table 1).

The prevalence of each of the outcomes under study (cesarean delivery, preterm delivery, LBW, APGAR < 7 at 5 min, NICU admission, and stillbirth/neonatal death) was similar between birthing parents residing in metropolitan areas compared to non-

| Table 1. Prevalence of hypertension in pregnancy in non-metropolitan and metropolitan counties, 2016-2018. |
|---|---|---|---|
| **Non-metropolitan** | **Metropolitan** | **n** | **%** | **n** | **%** |
| Any hypertensive disorder of pregnancy | 102,765 | 7.4 | 583,640 | 6.6 |
| Gestational hypertension or pre-eclampsia | 99,154 | 7.1 | 546,442 | 6.4 |
| Eclampsia | 4,409 | 0.3 | 20,727 | 0.2 |
| Chronic hypertension | 30,069 | 2.2 | 155,635 | 1.8 |
metropolitan areas lived in non-metropolitan areas had an increased risk of hypertensive disorders of pregnancy who had chronic hypertension among pregnant individuals as an estimate that matches a slowly increasing trend in live births were complicated by chronic hypertension, as illustrated in the tables. Prevalence of hypertension in pregnancy

Table 2. Prevalence ratio of adverse pregnancy outcomes among individuals with hypertension in pregnancy according to birthing parent residence.

| Outcome                        | PR 95% CI | aPRa 95% CI |
|-------------------------------|-----------|-------------|
| **Any hypertensive disorder of pregnancy** |           |             |
| Cesarean delivery             | 1.02 (1.01–1.02) | 1.05 (1.04–1.06) |
| Preterm birth (<37 0/7 weeks) | 1.00 (0.99–1.02) | 1.08 (1.07–1.09) |
| **Neonatal adverse outcomes** |           |             |
| Any adverse neonatal outcome  | 0.91 (0.90–0.92) | 0.98 (0.97–0.99) |
| Low birth weight (<2500 g)    | 0.93 (0.92–0.94) | 1.06 (1.04–1.07) |
| APGAR < 7 at 5 min            | 1.32 (1.28–1.36) | 1.34 (1.29–1.38) |
| NICU admission                | 0.80 (0.79–0.82) | 0.85 (0.84–0.86) |
| Stillbirth/Neonatal death     | 1.18 (1.00–1.40) | 1.36 (1.15–1.62) |
| **Chronic hypertension**      |           |             |
| Cesarean delivery             | 1.04 (1.03–1.05) | 1.05 (1.04–1.06) |
| Preterm birth (<37 0/7 weeks) | 0.99 (0.97–1.01) | 1.06 (1.04–1.09) |
| Any adverse neonatal outcome  | 0.91 (0.89–0.92) | 0.96 (0.94–0.98) |
| Low birth weight (<2500 g)    | 0.91 (0.89–0.94) | 1.02 (0.99–1.05) |
| APGAR < 7 at 5 min            | 1.35 (1.28–1.42) | 1.37 (1.30–1.45) |
| NICU admission                | 0.80 (0.78–0.82) | 0.83 (0.81–0.85) |
| Stillbirth/Neonatal death     | 1.20 (0.98–1.48) | 1.32 (1.07–1.64) |

Metropolitan births is the reference group.
aAdjusted for birthing parent age, pre-pregnancy BMI, birthing parent race/ethnicity, smoker before or during pregnancy, and insurance type.

Discussion

In this study, the demographic differences observed among pregnant individuals residing in non-metropolitan versus metropolitan areas were similar overall to previously published reports. The estimates found for both chronic hypertension in pregnancy and hypertensive disorders of pregnancy continue to be slightly elevated among individuals residing in non-metropolitan areas. Notably, the prevalence of adverse pregnancy outcomes associated with hypertension were similar among birthing parents residing in non-metropolitan areas and birthing parents residing in metropolitan areas. The similarity in these prevalence estimates may hint at adaptations non-metropolitan communities have implemented. However, even the modestly increased prevalence ratios observed for low APGAR score and stillbirth/neonatal death among neonates born to birthing parents residing in non-metropolitan areas raise concern for the effects of obstetrical service shortages that disproportionately affect non-metropolitan areas.

Prevalence of hypertension in pregnancy

Overall, we observed very similar proportions of births complicated by hypertension among non-metropolitan and metropolitan residing individuals. We found the combined prevalence of gestational hypertension and pre-eclampsia to be 6.7%, which is consistent with other reports that estimate gestational hypertension and pre-eclampsia each complicate 2–3% of US births and have become increasingly prevalent over the last several decades [25–28]. Similarly, we found 1.9% of live births were complicated by chronic hypertension, an estimate that matches a slowly increasing trend in chronic hypertension among pregnant individuals as well [29,30].

The most recent Healthcare Cost and Utilization Project (HCUP) report on hospitalized deliveries from 2005 to 2014 showed that while the prevalence of pre-eclampsia was higher in non-metropolitan counties, the difference in pre-eclampsia prevalence between non-metropolitan and metropolitan groups was shrinking over this time period. Similarly, this study found hypertensive disorders of pregnancy to be more common in non-metropolitan birthing parents, but only by a small margin.
Pregnancy outcomes among individuals with chronic hypertension or hypertensive disorders of pregnancy

Among individuals with hypertensive disorders of pregnancy, we observed low APGAR score was 34% more prevalent and stillbirth/neonatal death was 36% more prevalent among offspring born to birthing parents who resided in a non-metropolitan area compared to those residing in a metropolitan area. This finding warrants attention as the combination of low APGAR scores and lower prevalence of NICU admission in non-metropolitan areas may hint at a lack of appropriate resources. It is important to note that the data only reflects neonates admitted to the NICU, either at delivery hospital or after transfer to hospital with a NICU, rather than NICU availability. In this current study, it is not possible to evaluate NICU availability. It is therefore important to further investigate the possible link between NICU availability, APGAR score, and stillbirth/neonatal death by county of birthing parent residence.

The other adverse outcomes studied including cesarean delivery, preterm birth, and low birth weight were similar among those with hypertension in pregnancy, according to county of birthing parent residence. This finding was unexpected given the literature on the increasing shortage of obstetrical services in non-metropolitan areas[11,12,31,32] and the association of increased distance to prenatal care with low birth weight and preterm birth [12,31]. Since non-metropolitan communities have been facing decreased access to hospital-based obstetric services for over a decade, it is possible that some of the adaptations advocated by changemakers in these communities, such as birth centers, telehealth utilization, and community outreach [11,12,31,33], may have had a protective effect against adverse birth outcomes.

The similar rates of both no prenatal care and late prenatal care initiation that we observed among women residing in non-metropolitan and metropolitan communities may support the idea that care gaps from obstetric unit closures were filled by other services in the community. Identification of the reasons for comparatively low rates of select adverse birthing parent and neonatal outcomes in non-metropolitan communities is an important area for further investigation, as any successful innovations made by non-metropolitan communities may be adapted by other communities.

Strengths and limitations

The use of a large national dataset is a major strength of this observational study. In addition, the use of birth certificate data rather than hospitalization or billing records helped capture a wider population, as studies based on hospitalization records are unable to account for home births and birthing center births.

However, we were unable to account for a number of important adverse outcomes associated with hypertension in pregnancy, such as iatrogenic vs. spontaneous preterm birth, prolonged birthing parent hospitalization, birthing parent stroke, or birthing parent death due to NCHS Natality variables. In addition, we were unable to analyze birthing parents with superimposed pre-eclampsia as a separate group though this subset of individuals has a different risk profile for adverse outcomes compared to either the cHTN or HDP groups. Furthermore, it is unclear from the facility instructions for completing the birth certificate whether this subset of individuals is included in the database as chronic hypertension or hypertensive disorders of pregnancy. This may introduce heterogeneity within the two groups and underestimate the differences calculated between the cHTN group and the HDP group. Finally, a more focused local approach to rural and urban classification may better identify nuances in adverse outcomes related to hypertension in pregnancy that our use of broad non-metropolitan and metropolitan categories was unable to characterize [11,31].

Conclusions

This study of hypertension in pregnancy using US birth certificate data is consistent with other recently published literature that shows an overall trend of increasing prevalence of both chronic hypertension and the hypertensive disorders of pregnancy. In addition, while low APGAR score and stillbirth/neonatal death were more common in offspring born to those with hypertension in pregnancy who resided in non-metropolitan counties, other adverse birthing parent and neonatal outcomes were equivalent. It will be important for future studies to investigate whether similar results are seen when analyzing the data using other definitions of rural and urban and if there are features of prenatal or obstetric care and resources in non-metropolitan communities that help account for the elevated prevalence of low APGAR score and stillbirth/neonatal death observed in the context of otherwise low overall risk of adverse birthing parent and neonatal outcomes.

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National Center for Health Statistics. [All-county natality files] (2016–2018), as compiled from data provided by the 57 vital
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