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DISPARITIES IN HYPERTENSIVE DISORDERS OF PREGNANCY ACROSS THE LEVELS AND DIMENSIONS OF RURALITY

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ABSTRACT

Hypertensive disorders of pregnancy (e.g., gestational hypertension, preeclampsia, and eclampsia) are among the leading causes of maternal morbidity in the United States (Waterstone, Bewley, Wolfe, and Murphy 2001). Hypertensive disorders of pregnancy (HDP) have detrimental effects on both the mother and her infant (Bryson, Ioannou, Rulyak, and Critchlow 2003). Approximately 5 to 10 percent of pregnant women in the United States experience HDP (Bryson, Ioannou, Rulyak, and Critchlow 2003; Sibai, Ewell, Levine, Klebanoff, Esterlitz, Catalano, Goldenberg, and Joffe 1997).

Differentials in HDP have been well documented for women of various racial and ethnic groups, women of different socioeconomic statuses, and for those women participating in individual health risk behaviors. Despite the growing body of research on disparities in HDP, and the fact that 20 percent of births that occur in the United States are to women who live in rural areas (Lishner, Larson, Rosenblatt, and Clark 1999), very little attention has been paid to disparities in HDP in rural areas compared to more urbanized places. To date, research has not addressed geographical differentials in HDP due to individual and residential characteristics. This dissertation seeks to examine the extent to which the odds of a woman experiencing HDP differ by individual and residential/county-level characteristics.

Predictors of HDP may not be limited to individual-level maternal demographic and behavioral characteristics. The characteristics of counties in which women live also may affect the odds of a woman experiencing HDP. In addition, the effect of individual characteristics may vary from place to place and the impact of residential context may vary from person to person; therefore, it was necessary to test for cross-level interactions in order to tease out the relevant effects on health (Verheij 1996). In order to correctly account for the hierarchical nature of the hypothesized relationships and structure of the data, multilevel logistic regression models were estimated using data from the 2007 National Center for Health Statistics Non-Public-Use Natality Detail Files linked to characteristics of the women's county of residence across rural and urban areas of the United States.

This study goes beyond prior research on HDP by demonstrating how the combined attributes of the places in which women live (such as population density, isolation, and large distances between residences and health care services) affect the likelihood of a pregnant woman experiencing HDP. In addition, this dissertation builds upon previous research that has focused on rural/urban health disparities and disparities in pregnancy outcomes by considering how multiple indicators of rurality (i.e., ecological, occupational, and sociocultural dimensions) are associated with HDP.

Specifically, the results of this study identified that when women live in more rural areas they are more likely to experience HDP. After establishing this geographical disparity in HDP, further analyses revealed that the effect of individual maternal characteristics on HDP varied significantly by the level and dimension of rurality of the woman's residential county. By identifying these differences, more appropriate strategies for reducing the odds of HDP can be established through health policy and other initiatives.

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and ways of thinking, and has made it possible for me to gain invaluable spatial statistics skills. I am eternally grateful for Stephen supporting me with research assistantships over the summers throughout my time in graduate school. Without this support, I would not have been able to continue working on my research and building my spatial statistics skills. Stephen introduced me to and allowed me to get to know his amazing daughters, Kayleigh and Celine, who always bring a smile to my face and were always there to support me when I was presenting my posters. I am looking forward to continuing to work with Stephen in the future.

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given throughout the time spent in graduate school and throughout my life. “Anyone who ever gave you confidence, you owe them a lot.”—Truman Capote, *Breakfast at Tiffany’s* (1958), spoken by the character Holly Golightly.

Chapter 1

Disparities in Hypertensive Disorders of Pregnancy

Introduction

Hypertensive disorders of pregnancy (HDP) include gestational hypertension, preeclampsia, and eclampsia. Gestational hypertension, previously referred to as pregnancy-induced hypertension, is hypertension (i.e., high blood pressure) that occurs for the first time during the second half of pregnancy without the presence of proteinuria (i.e., excess protein in urine). Gestational hypertension is a temporary diagnosis that includes women who will eventually be diagnosed with preeclampsia or chronic hypertension, as well as women who are retrospectively diagnosed with temporary hypertension of pregnancy (Leeman and Fontaine 2008). Approximately 50 percent of women who are diagnosed with gestational hypertension between 24 and 35 weeks into their pregnancy develop preeclampsia (Barton, O'Brien, Bergauer, Jacques, and Sibai 2001).

Preeclampsia is a multi-organ disease process characterized by hypertension and proteinuria that occurs after 20 weeks of gestation (Barton et al. 2001). Eclampsia, on the other hand, is an eclamptic seizure that may appear unexpectedly in a patient with minimally elevated blood pressure and no proteinuria, or may be preceded by severe preeclampsia (Barton et al. 2001; Garovic, Bailey, Boerwinkle, Hunt, Weder, Curb, Mosley, Wiste, and Turner 2010). An eclamptic seizure lasts for 60 to 90 seconds, and during this time, the woman is unable to breathe (Barton et al. 2001).

Approximately 5 to 10 percent of pregnant women experience HDP (Bryson, Ioannou, Rulyak, and Critchlow 2003; Sibai et al. 1997). HDP are the second leading cause of maternal mortality, and account for 19 percent of pregnancy-related deaths for women after delivering a live birth and 20 percent of pregnancy-related deaths for women after delivering a still birth (Chang, Elam-Evans, Berg, Herndon, Flowers, Seed, and Syverson 2003; Fortner, Pekow, Whitcomb, Sievert, Markenson, and Chasan-Taber 2011).

HDP have detrimental effects on both the mother and her infant (Bryson, Ioannou, Rulyak, and Critchlow 2003), and are one of the leading causes of maternal morbidity (Waterstone, Bewley, Wolfe, and Murphy 2001). HDP can result in a variety of maternal health complications including seizures, stroke, hepatic failure, renal failure (Bryson, Ioannou, Rulyak, and Critchlow 2003; Walker 2000), and an increased risk for developing hypertension after age 40 (Garovic et al. 2010).

HDP are also associated with increased risks for the infant including preterm delivery, admission to the neonatal intensive care unit, and fetal death (Villar, Carroli, Wojdyla, Abalos, Giordano, Ba'aqeel, Farnot, Bergsj, Bakketeig, and Lumbiganon 2006). In the United States, the number of delivery hospitalizations with HDP is increasing, and hospitalizations with higher levels of HDP are more likely to have severe complications compared with hospitalizations without HDP (Kuklina, Ayala, and Callaghan 2009).

Differentials in HDP have been well documented for women of various racial and ethnic groups, women of different socioeconomic statuses, and for those women participating in individual health risk behaviors. Despite the growing body of research on disparities in HDP, and the fact that 20 percent of births that occur in the United States are to women who live in rural areas (Lishner, Larson, Rosenblatt, and Clark 1999), very little attention has been paid to disparities in HDP in rural areas compared to more urbanized places. The majority of health-related research has focused on urban residents, partially due to the convenience of data collection and study implementation in urban areas (Luo and Wilkins 2008), and the fact that data-use restrictions are placed on datasets that include rural samples in an effort to maintain rural residents' privacy and confidentiality.

The incidences of preterm deliveries and low birthweight infants have been increasing in the United States (Bailey and Cole 2009), and rates of preterm births and low birthweight infants are higher in remote rural regions that are not adjacent to urban areas compared to the rates in urban and rural-adjacent areas (Alexy, Nichols, Heverly, and Garzon 1997; Bailey and Cole 2009; Hillemeier, Weisman, Chase, and Dyer 2007; Hulme and Blegen 1999). These preterm and low birthweight infants may be linked to HDP. Therefore, gaining a better understanding of the factors associated with the likelihood of experiencing HDP among women who live in both rural and urban areas deserves further attention.

While rurality has been considered in previous health related research (Verheij 1996), less attention has been paid to rural/urban disparities in HDP. Some research has been conducted that focuses on rural/urban differences in birth outcomes. For example, Hillemeier and colleagues (2007) found that rural residence remained a significant determinant of preterm and low birthweight infants even after taking into account prenatal care receipt and the availability of physicians. Also, Sparks and colleagues (2009) found lower neonatal mortality in nonmetropolitan counties not adjacent to metropolitan areas; however, postneonatal mortality rates were higher in the most rural nonmetropolitan counties. While strong research has been done that focuses on rural/urban disparities in birth outcomes, more research is needed that focuses on rural/urban disparities in specific health risks, such as HDP.

There are no reliable tools for early clinical diagnosis of HDP, effective therapies to prevent HDP from occurring (Wolf, Shah, Jimenez-Kimble, Sauk, Ecker, and Thadhani 2004), and limited treatment options available for HDP (Fortner et al. 2011). Identifying factors associated with an increased risk of experiencing HDP is essential for improving maternal and infant health. In order to better understand the processes and mechanisms through which residence is associated with HDP, this dissertation examines both individual and residential characteristics and how they are associated with the odds of a woman experiencing HDP.

To date, research has not examined geographic differences in HDP as a function of spatial variation in individual and residential characteristics. This dissertation seeks to address the issue of variation in the odds of a woman experiencing HDP by examining how individual and residential/county-level characteristics contribute to these differences. This study goes beyond prior research on HDP by demonstrating how the attributes of rural areas such as low population density, isolation, and large distances between residences and health care services can affect the likelihood of a pregnant woman experiencing HDP.

In addition, this dissertation builds upon previous research that has focused on rural/urban health disparities and disparities in pregnancy outcomes by considering how multiple indicators of rurality are associated with HDP. Variation in these multiple dimensions of rurality may contribute to differences in the odds of a pregnant woman experiencing HDP. By understanding how the multiple dimensions of rurality are associated with HDP, we may be better able to address the needs of diverse rural communities and pinpoint particular characteristics of rural areas, which are associated with an increased likelihood of women experiencing HDP. The results from this study can be used to offer insight into how the odds of experiencing HDP can be reduced for women living in both rural and urban areas across the continental United States.

Research Framework

Previous studies on HDP have considered differentials in experiencing this disease by woman's racial/ethnic background and socioeconomic status; however, they have not yet examined how the local residential context affects the odds of a woman experiencing HDP. This dissertation builds upon prior research on HDP by testing whether rurality, health care service availability, and income inequality affect the odds of a pregnant woman experiencing this disorder.

Research Questions

In order to fully understand disparities in HDP, both health care availability and residential characteristics need to be considered. A theoretical framework that incorporates rurality, local health care availability, and income inequality with HDP was developed in this dissertation in order to guide the analytical approach that was implemented. With this theoretical framework in mind, I proposed three broad research questions about the relationships between HDP and individual characteristics and local residential conditions:

(1) Do the odds of experiencing HDP vary by the race/ethnicity, education, and prenatal care utilization of the woman?

(2) Do the odds of experiencing HDP vary by the level and dimension of rurality? If yes, can these observed effects of rurality be accounted for by health care service availability and income inequality?

(3) Does the effect of individual-level characteristics such as maternal race, ethnicity, and education on HDP vary by the characteristics of the residential context in which the woman lives?

Addressing these research questions provides insight into characteristics of places and women that may be most amenable to intervention or policy that would reduce rates of hypertensive disorders in pregnant women.

Summary of Research Approach and Objectives

To answer these research questions, multilevel logistic regression models of HDP for women who live in the continental United States and had a live birth at any time during the 2007 calendar year were estimated. In order to do so, data from the National Center for Health Statistics was merged with data on county measures of rurality, income inequality, and availability of health care in the woman's county of residence.

This study moves beyond prior research on HDP by considering the importance of health care availability and income inequality, and by estimating multilevel logistic regression models of HDP that include both individual-level predictors and measures of residential county conditions. By having data on the pregnant woman's county of residence, multilevel modeling provides the ability to examine whether the effects of individual-level characteristics of women on pregnancy-related risks vary across the levels and dimensions of rurality, availability of health care services, and income inequality. The capability to test for these cross-level interaction effects provides for the opportunity to pay special attention to the most vulnerable populations of women, because individual characteristics and conditions of the local residential context may affect these women and their HDP differently.

Dissertation Outline

This dissertation is organized in the following manner. In Chapter 2, "Factors Associated with Hypertensive Disorders of Pregnancy," a conceptual model that includes both maternal individual-level characteristics and county-level conditions is developed.

This conceptual model shows how individual-level and county-level characteristics are expected to directly affect HDP and how county-level characteristics also may indirectly affect the likelihood of a woman experiencing HDP through individual-level maternal characteristics. Following the conceptual model, theoretical explanations for how individual socioeconomic status and community level socioeconomic characteristics affect health generally. The theoretical explanations for how socioeconomic status affects health is used to organize a review of the literature on how socioeconomic status affects HDP. Previous literature that discussed plausible explanations for variations in HDP at both the individual-level and the residential context is reviewed next. Chapter 2 concludes with a discussion of the study hypotheses.

In Chapter 3, which is titled, "Data and Methodology," the secondary data sources and all measures that were used in the analyses are described. This chapter goes on to describe the statistical methodology that was used in this study and provides an explanation for why multilevel modeling techniques are appropriate for answering the proposed research questions. This chapter concludes with an explanation for how the cross-level interactions were tested in this study.

Chapters 4 and 5 titled, "Demographic and Behavioral Characteristics: The Relationship between Individual-level Characteristics and Hypertensive Disorders of Pregnancy" and "Rurality, Income Inequality, and Health Care Service Availability: How Residential Context is Associated with Hypertensive Disorders of Pregnancy," respectively, describe the results of the study. In Chapter 4, the descriptive statistics for the individual-level measures are discussed as well as the results of the individual-level logistic regression models. In Chapter 5, the descriptive statistics for the county-level measures are reported as well as the results of the multilevel logistic regression models. The results of the cross-level interactions also are discussed at the end of this chapter. Both of these chapters conclude with a brief discussion of the findings.

Chapter 6 titled “Discussion and Conclusion” wraps up the dissertation. This chapter includes a discussion of how this dissertation contributes to the fields of Rural Sociology and Demography. Because the results of this study can be used to help inform policy makers of the implications of ignoring how place can affect health generally, and specifically, how residential context affects the odds of a woman experiencing HDP, a discussion of how these results can be used to improve pregnancy-related health policy is included. This chapter concludes with a discussion of the study’s limitations as well as suggestions for ways to continue developing this line of research in the future.

Chapter 2

Factors Associated with Hypertensive Disorders of Pregnancy

Introduction

This chapter begins with a discussion of the conceptual framework that was developed to guide the literature review. Following the conceptual framework, the literature on the relationship between individual-level demographic and behavioral characteristics and health, in general, is reviewed. This section continues with a more specific discussion of how the individual-level maternal factors are associated with HDP. This is followed by a discussion of the community-level characteristics that are associated with health disparities, generally, as well as a more specific discussion of the relationship between residential characteristics and HDP. This review of the current literature provides both theoretical and empirical evidence of factors that may be associated with HDP.

Conceptual Framework

What is clear from the empirical evidence discussed in previous research is that health is shaped by many factors—some that cannot be changed such as age, sex, and genetics, and some that can be readily influenced such as behavior, health care, and living conditions (Braunstein and Lavizzo-Mourey 2011). The literature is increasingly showing how both socioeconomic status and race/ethnicity are related to and influence individual's health (Lantz, Lynch, House, Lepkowski, Mero, Musick, and Williams 2001). This notion, which was originally developed by Lieberson (1985) and House et al. (1990), and later extended and termed 'fundamental causes' by Link and Phelan (1995) shapes the experience of most diseases and risk factors for health (Lantz et al. 2001).

According to Link and Phelan (1995), the fundamental social cause of health inequalities has four essential features: it influences multiple disease outcomes, it affects these disease outcomes through multiple risk factors, it involves access to resources that can be use to avoid risks or to minimize the consequences of disease once it occurs, and the association between a fundamental cause and health is reproduced over time via the replacement of intervening mechanisms (Phelan, Link, and Tehranifar 2010: S29). Central to the theory of fundamental causes is the argument that socioeconomic status is a "fundamental" cause of health inequalities, because the association of socioeconomic status with overall health is persistent even in the face of dramatic changes in mechanisms linking socioeconomic status and health (Phelan, Link, and Tehranifar 2010). The impact of socioeconomic status on health is explainable "by the degree to which exposure to and experience of major health risk factors are structured by socioeconomic position" (Lantz et al. 2001: pg. 135). Changes in socioeconomic status in both individuals and populations can generate substantial change in exposure and experience of a wide range of risk factors in health (Lantz et al. 2001).

Socioeconomic status and race/ethnicity affect health through multiple potential pathways. Research has shown evidence of these multiple pathways influencing socioeconomic related differentials in health regardless of how socioeconomic status was measured (education, occupation, income, composite indices) (Seeman and Crimmins 2001). Some of these potential pathways are specific to the individual, others work through the environment, and some pathways interact between the individual and the environment in which he or she lives (Seeman and Crimmins 2001).

One important reason for why socioeconomic status is related to multiple disease outcomes through multiple pathways that change over time is that individuals and groups deploy resources (e.g., social connections, prestige, power, money, and knowledge) to avoid risks and adopt protective strategies (Phelan, Link, and Tehranifar 2010). According to the theory of fundamental causes, these resources operate at both individual and contextual levels.

> "At the individual level, flexible resources can be conceptualized as the 'cause of causes' or 'risk of risks' that shape individual health behaviors by influencing whether people know about, have access to, can afford, and receive social support for their efforts to engage in health enhancing or health-protective behaviors. In addition, resources shape access to broad contexts that vary dramatically in associated risk profiles and protective factors… In these circumstances, the person benefits in numerous ways that do not depend on his or her own initiative or ability to personally construct a health situation; it is an 'add on' benefit operative at the contextual level (Phelan, Link, and Tehranifar 2010:S30)."

According to Link and Phelan (1995), in order to accurately identify risk factors that are increasingly proximate to disease, researchers should "use an interpretive framework to understand why people come to be exposed to risk or protective factors and determine the social conditions under which individual risk factors are related to disease" (85). It is known that not all individuals who live in the same environment are affected by their environment in the same way, as well as the fact that not all individuals who live in the same environment will sustain health risks (Taylor, Repetti, and Seeman 1997). Therefore, in order to fully understand the mechanisms through which socioeconomic status affects health, it is necessary to consider the residential context in which people live, as well as possible interactions between individual and residential characteristics (e.g., how local conditions differentially affect individuals with varying characteristics (Seeman and Crimmins 2001).

Research is increasingly showing evidence that characteristics of communities in which Americans live are a strong predictor of health (Adler, Boyce, Chesney, Folkman, and Syme 1993; Adler and Ostrove 1999; Braunstein and Lavizzo-Mourey 2011; Link and Phelan 1995; Sternthal, Slopen, and Williams 2011). These community characteristics include features of the physical environment (e.g., parks, traffic conditions, the proximity to super markets, the existence of famers' markets, and the density of billboards advertising tobacco and alcohol products) and features of the social environment (e.g., the degree of trust and cooperation among neighbors and the existence of formal and informal social ties) (Williams 2011).

Differences in the quantity and quality of resources and opportunities that people have available in the place they live have led to an uneven distribution of health in the United States (Williams 2011). For example, social environments vary by socioeconomic status and this variation can affect the likelihood of individuals' exposure to both health-protecting resources and health-damaging conditions (Adler and Rehkopf 2008). Characteristics of communities can influence the degree to which health behaviors may be practiced, because neighborhoods with low socioeconomic status have fewer facilities and resources available (Taylor, Repetti, and Seeman 1997).

Disadvantaged social environments expose individuals to greater uncertainty, conflict, and threat, and these are the same places that often have inadequate resources to respond to these circumstances (Adler and Rehkopf 2008). The community conditions of an individual's environment can affect how much control individuals have and the degree of emotional and instrumental support that is available for them to cope with their exposure to conflict and threat (Adler and Ostrove 1999). Areas with high rates of crime and residential mobility can lead to individuals developing health-risk behaviors such as smoking and alcohol use as a way of coping with stress (Taylor, Repetti, and Seeman 1997). Stress is an important link between an individual's social environment and their health status (McEwen 1998).

Not only can community characteristics influence both health status and health behaviors, but they can also influence access to health care (Krieger, Chen, Waterman, Rehkopf, and Subramanian 2005; Litaker and Love 2005). Characteristics of places can influence the availability and accessibility of health care resources and the quality of employment opportunities, which are a vital source of health insurance coverage (Litaker, Koroukian, and Love 2005).

While there is no previously established theory that links health care service availability and residential context with HDP, there is a large literature that links health care service use and availability with health more generally. Because the research to date has not adequately addressed rural/urban and other local residential context differentials in HDP, the literature discussed in this chapter focuses on how these factors affect health generally, with inference made to HDP.

From the empirical evidence identified in the reviewed literature, I developed a conceptual framework to guide this study that includes both individual- and county-level characteristics. The conceptual model displayed in Figure 2-1 assumes that women are embedded in their residential county. This conceptual model assesses the relative importance of the proposed predictors of HDP. For the conceptual framework, individual maternal factors include demographic and behavioral characteristics (inside the ring with the solid line). Residential context includes the dimensions of rurality, income inequality, and availability of health care (inside the ring with the dashed line).

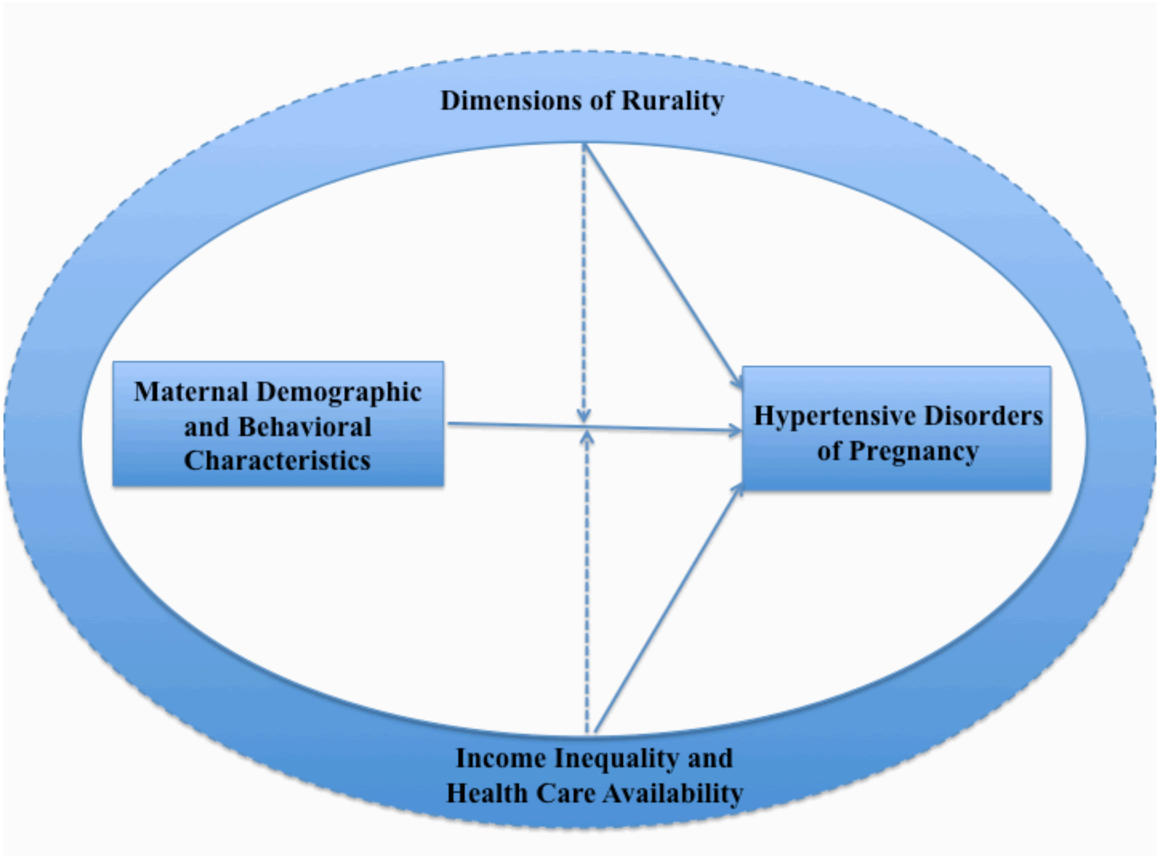

Figure 2-1: Conceptual Model of Hypertensive Disorders of Pregnancy

The literature has showed that individual maternal characteristics should be directly associated with HDP (as shown by the solid arrow). Beyond the individual-level, the dimension of rurality, income inequality, and health care availability are expected to be associated with variation in the odds of a woman experiencing HDP across counties. In addition, the characteristics of counties (e.g., dimensions of rurality, income inequality, and health care availability) are anticipated to interact with individual maternal characteristics and HDP (as shown by the dashed line).

Both maternal individual-level characteristics and residential context are expected to be directly associated with HDP (solid arrows). Residential characteristics such as income inequality and health care availability may influence the odds of a woman experiencing HDP through their effect on individual behaviors and opportunities (shown by the dashed arrow. Individual-level and residential characteristics thus can interact to affect the odds of a woman experiencing HDP (dashed arrow).

For example, income inequality in a county can have an indirect effect on a pregnant woman's medical risk. If a pregnant woman is living in a county with few resources due to high income inequality and is not able to get the financial and emotional support that she needs, she may not be as aware of the importance of maintaining a healthy lifestyle and receiving preventative services as she would be if she were living in a county with low income inequality. An example of a direct effect would be when health care providers are not available in a county and women are not able to receive the medical services they need to help prevent HDP. The relationships displayed in the figure will be tested in this study.

Individual-level Demographic and Behavioral Characteristics and Hypertensive Disorders of Pregnancy

Prior research has documented large and persistent racial, ethnic, and socioeconomic disparities in health and use of health care in the United States (Adler, Boyce, Chesney, Cohen, Folkman, Kahn, and Syme 1994; Adler et al. 1993; Adler and Newman 2002; Adler and Ostrove 1999; Adler and Rehkopf 2008; Blumenthal and Kagen 2002; Brewster, Taherzadeh, Volger, Clark, Rolf, Wolf, VanBavel, and van

Montfrans 2010; Herd, Goesling, and House 2007; House 2002; Link and Phelan 1995; Taylor, Repetti, and Seeman 1997; Ver Ploeg and Perrin 2004). While the causes of these disparities are still not well understood, there is an extensive body of literature from a number of disciplines (e.g., rural sociology, sociology, demography, public health, health policy, psychology, geography, and economics) that is focused on finding and understanding the determinants of these health disparities.

Individual-level Characteristics: Demographic Characteristics

The individual-level factors that have been found to be associated with differentials in health in general, and the odds of a woman experiencing HDP more specifically, are discussed in this section. To date, there has been a substantial amount of research that has investigated the association between individual characteristics and health outcomes. The following sections describe the relationship between individual-level characteristics and health. Maternal age, race, and ethnicity, marital status, and maternal education and their relationship with health and HDP are reviewed.

Maternal Age

Maternal age is an important factor when considering differentials in HDP. Some research has found that women experiencing gestational hypertension tend to be younger (Chang et al., 2010), with those pregnant women under 19 years of age the most likely to experience this risk (Bryson, Ioannou, Rulyak, and Critchlow 2003). Other studies report higher odds of experiencing gestational hypertension among women with a higher maternal age (Villar et al. 2006). Yet other studies identified the risk of experiencing pregnancy-related hypertension, preeclampsia, and eclampsia to be the highest among both the youngest women (teenagers) and the oldest women (over 40 years of age) (Miller, Cao, Wen, Yang, Lafleche, and Walker 2010; Tanaka, Jaamaa, Kaiser, Hills, Soim, Zhu, Shcherbatykh, Samelson, Bell, and Zdeb 2007; Yang, Wen, Smith, Chen, Krewski, Chen, and Walker 2006). Clearly, the research shows that both extremes of the childbearing age distribution are a potential risk factor for a woman experiencing HDP. It is not clear whether these risks differ by where women live or if these are largely biologically determined processes.

Race and Ethnicity

Race and ethnicity are often considered in studies of health, and the literature has well documented disparities in health outcomes among different racial and ethnic groups, as well as disparities within broad racial and ethnic group categories (Pol and Thomas 2001; Schoenbaum and Waidmann 1997; Ver Ploeg and Perrin 2004). Racial groups are based on one or more distinguishable attributes, which are considered to be important in the particular society that is being considered (Pol and Thomas 2001). Skin color is the most important factor in racial categorization in the United States (Pol and Thomas 2001). Race is considered a biosocial attribute (Pol and Thomas 2001). Ethnicity, on the other hand, is based on cultural heritage, where members of distinct ethnic groups share a common cultural tradition, such as values, norms, or language (Pol and Thomas 2001).

Black women are more likely to experience morbidity during pregnancy compared to white women (Byant et al. 2010), while Hispanic and Asian women have lower risks of maternal morbidities when compared with white women (Harper, Espeland, Dugan, Meyer, Lane, and Williams 2004). Specifically, racial and ethnic disparities have been identified for various HDP (Alexander and Cornely 1987). Black women have a greater risk of developing HDP compared to white women (Bryant et al. 2005; Chang, Muglia, and Macones 2010; Samadi, Mayberry, Zaidi, Pleasant, McGhee Jr, and Rice 1996; Tanaka et al. 2007), and this risk is increasing over time for both groups (Brewster et al. 2010). Black women develop fatal preeclampsia at a rate of 4.5 times higher than white women (Brewster et al. 2010). Black women are also more likely to enter into pregnancy with existing hypertension compared to white women (Brewster et al. 2010). Hispanic women demonstrate a lower incidence of pregnancy-related hypertension compared to white women; however, they experience similar rates of preeclampsia (Wolf et al. 2004).

The largest racial differences in health in the US are found between whites and African Americans, while less distinct differences are found for Native Americans and Asians (Pol and Thomas 2001). Hispanic immigrants, especially those from Mexico, have lower levels of socioeconomic status and less access to healthcare compared to whites; however, their levels of health are equivalent or even superior (Abraido-Lanza, Dohrenwend, Ng-Mak, and Turner 1999; Markides and Eschbach 2005). This is referred to as the Hispanic Paradox. While the reasons for these health disparities among different racial and ethnic groups are not fully understood, several plausible explanations have been discussed in the literature.

Several explanations for racial/ethnic disparities in health have been offered in the literature. For example, individuals who belong to a racial/ethnic minority group tend to live in more health-damaging residential environments compared to whites, which makes them face higher levels of multiple types of acute and chronic stressors, including stress due to racial and ethnic discrimination (Sternthal, Slopen, and Williams 2011; Williams, Mohammed, Leavell, and Collins 2010). This is believed to result in poorer health. Other explanations will be examined in the sections to follow. The important thing to note is that even after differences in education, income, occupation, and health care access have been taken into account, race continues to be an important predictor of health status. Therefore, a better understanding of racial and ethnic disparities in health, in general, and HDP, more specifically, is needed. With better understanding of racial and ethnic disparities in HDP, more specifically, and how they are affected by characteristics of the places in which individuals live, is needed. With better understanding of racial and ethnic disparities in HDP, it will be easier to identify ways to reduce these racial and ethnic disparities and decrease the odds of women experiencing HDP.

Marital Status

Marital status is an important factor that is often considered in studies on health. This factor was considered in one of the earliest sociological studies (1897), where Durkheim found marital status to be a factor for identifying differences in suicide rates (Durkheim and Simpson 1951). Marital status has more recently been found to be a significant predictor of both physical and mental health, and many consider it to be one of the best predictors of health status and health behaviors (Pol and Thomas 2001). While some exceptions do exist by health outcome, in general, studies show that health status is higher among those who are married in the United States than for those of any other marital status (Pol and Thomas 2001).

Marital status has been used when examining disparities in HDP. Those women who are not married are more likely to experience early-onset pre-eclampsia (Chang, Muglia, and Macones 2010). How marital status affects HDP may operate through behavioral characteristics such as smoking and prenatal care utilization. For example, women living with the father of their child receive more social support and are less likely to engage in health risk behaviors during pregnancy (e.g., smoking during pregnancy or not receiving adequate prenatal care) (Albrecht, Miller, and Clarke 1994), which may reduce the odds of experiencing HDP.

Socioeconomic Status and Health

Higher socioeconomic status associated with better health status is a relationship that has been observed across a wide variety of populations and geographical locations (Lantz et al. 2001; Link and Phelan 1995). Socioeconomic status is conventionally measured in terms of indicators such as education, occupation, or income (Seeman and Crimmins 2001). Using these indicators, there is an extensive body of literature that has identified that lower socioeconomic status is associated with poorer health outcomes (Adler et al. 1994; Adler et al. 1993; Lantz et al. 2001). The literature also shows that the differentials between socioeconomic status and health may be widening (Seeman and Crimmins 2001).

But how does socioeconomic status "get under the skin" (Taylor, Repetti, and Seeman 1997)? While more research is needed to understand the mechanisms through which socioeconomic status affects differentials in health, several plausible explanations have been offered in the literature. Current discussions of how socioeconomic status is associated with health at the individual-level, or more specifically, how an individual's socioeconomic status within the larger society affects his or her health, frequently include gradients in: "(1) chronic and acute stressors (at both the individual and broader environmental level), (2) coping resources, and (3) health habits and other lifestyle characteristics" (Seeman & Crimmins, 2001: pg. 100). Research has shown that there are differences in the levels of exposure to both chronic and acute stressors by socioeconomic status (Turner and Lloyd 1995) and these differences are hypothesized to contribute to health differentials by socioeconomic status (Seeman and Crimmins 2001).

The association of lower socioeconomic status with fewer coping resources has been suggested to explain the socioeconomic differentials in health. Individuals with lower socioeconomic statuses tend to have fewer resources (e.g., social ties or contact with formal social institutions) that they can use for help coping with events (Turner and Marino 1994). In addition, lower socioeconomic status has been associated with characteristics that have been found to be risk factors for health or as moderators of the relationship between stress and health including lower self-esteem, fewer feelings of self-worth, less optimism, and a weaker sense of control (Seeman and Crimmins 2001; Turner and Marino 1994). On the other hand, those individuals with higher socioeconomic status (e.g., more education and greater occupational autonomy) have been shown to develop greater cognitive flexibility and more positive self-perceptions (Seeman and Crimmins 2001).

While other measures of socioeconomic status (e.g., income, wealth, occupation) are useful for predicting population health, education is the single most important indicator of health status in the United States when compared to other measures of socioeconomic status such as income or employment (Adler and Rehkopf 2008; Pol and Thomas 2001). Education is a determinant of an individual's employment and economic situation (Adler and Newman 2002; Herd, Goesling, and House 2007), both of which are linked to health through work conditions, income, and levels of consumption (Duncan, Daly, McDonough, and Williams 2002). Employment status often determines an individual's ability to obtain health insurance, which is an important determinant of having a regular source of health care (Rask, Williams, Parker, and McNagny 1994; Weinick, Zuvekas, Drilea, and United States Agency for Health Care Policy Research 1997). An individual's income is also important because it influences whether one can afford to pay insurance co-pays or premiums and unexpected medical expenses (Litaker, Koroukian, and Love 2005).

Education also is associated with health through health behaviors. Differences in levels of educational attainment can contribute to differences in income, health-related behaviors (e.g., diet, exercise, and smoking), which can lead to poorer health (Ver Ploeg and Perrin 2004). Educated individuals are more likely than others to exercise, eat low-fat diets, avoid smoking, and utilize preventative care. In addition, individuals with higher education levels are more likely to rate themselves as being in better health compared with those with less education (National Center for Health Statistics 2007b).

Educational attainment is also associated with future-oriented behaviors. These behaviors increase individuals' motivation to acquire skills that lower the costs of learning pertinent health information and to invest in personal health (House 2008: 18). More educated individuals also are better able to read and understand health information and to question their health care providers.

Maternal Education

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Mother's education is the most common measure of socioeconomic status that is used in the maternal and infant health literature. This is probably due to the fact that this is the only measure of socioeconomic status that is available on the birth certificate. It also is associated with health status and behaviors.

In their study of Hispanic women, Fortner and colleagues (2011) identified those women who have not completed a high school education as those who were the most likely to develop HDP. Using a sample of Dutch pregnant women, Silva and colleagues (2008) found that women with low and mid-low levels of education had a higher risk of developing gestational hypertension than women with higher levels of education.

The level of education a mother has completed may influence whether she makes healthy choices during her pregnancy, such as avoiding health-risk behaviors and receiving appropriate health care. As education has been shown to be an important predictor of health, it may be that pregnant women with a higher level of education experience reduced odds of experiencing HDP, and that this relationship may vary by the conditions of the residential context in which the woman lives. This relationship is described later in this chapter.

Individual-level Characteristics: Behavioral Characteristics

Individual characteristics and constraints from the environment work together to affect the likelihood of individuals participating in health-related risk behaviors such as alcohol and tobacco use, lack of exercise, and poor dietary practices (Adler and Ostrove 1999). The following sections include a discussion of the relationship between individual-level characteristics and health. Specifically, behavioral characteristics examined include cigarette smoking, maternal weight gain and parity, and prenatal care utilization. This section also includes a discussion of behavioral characteristics and how they are associated with HDP.

Cigarette Smoking

Empirical evidence from both cross-sectional and longitudinal studies has shown that behaviors such as tobacco use are associated with a variety of health risks (U.S. Department of Health and Human Services 2000), and some researchers have suggested that these health behaviors account for the social inequalities in health (Satel 1996). However, other research has shown that these behavioral risk factors only account for a small portion of the increased risk of poor health associated with low socioeconomic status (Lantz, House, Lepkowski, Williams, Mero, and Chen 1998; Lantz et al. 2001; Lynch, Kaplan, and Salonen 1997).

While these behaviors may only account for a small portion of the differences in health, it should be noted that a higher prevalence of unhealthy behaviors such as smoking is more common among individuals with lower socioeconomic statuses (Adler et al. 1994). For example, rates of cigarette smoking vary by levels of education. Among persons 25 years of age and older, 32 percent of those without a high school degree smoked cigarettes compared to 11 percent of those who are college graduates (Eberhardt, Ingram, Makuc, Pamuk, Freid, Harper, Schoenborn, and Xia 2001). Cigarette smoking also varies by race and ethnicity with differences in cigarette smoking prevalence ranging from 16.9 percent for Asians and Pacific Islanders to 34.1 percent for Native Americans (Singer and Ryff 2001).

Smoking during pregnancy is associated with many harmful pregnancy and birth outcomes (Fingerhut, Kleinman, and Kendrick 1990; U.S. Department of Health and Human Services 2001b), and cigarette smoke exposure during pregnancy is a risk factor for the child's later physical and psychological development (Batstra, Hadders-Algra, and Neeleman 2003; U.S. Department of Health and Human Services 2001a). Surprisingly, while cigarette smoking during pregnancy is associated with numerous poor health outcomes for both the mother and her child, research has shown smoking during pregnancy to have a protective effect for HDP (Hammoud, Bujold, Sorokin, Schild, Krapp, and Baumann 2005; Zhang, Klebanoff, Levine, Puri, and Moyer 1999). The risk of preeclampsia is 32 percent lower among women who smoke during pregnancy compared to women who do not smoke during pregnancy (Conde-Agudelo, Althabe, Belizan, and Kafury-Goeta 1999). However, it should be noted that the incidence of adverse pregnancy outcomes is more than doubled among women with preeclampsia who smoke compared to women with preeclampsia who do not smoke (Miller et al. 2010).

Maternal Weight Gain and Parity

Another important behavioral characteristic that is discussed in the maternal health literature is maternal nutrition during pregnancy. Information on maternal nutrition is not often available; therefore, maternal weight gain during pregnancy has been used as an indirect measure the mother's nutrition and health during her pregnancy (Finch 2003).

Research has shown that women who gain more than two pounds per week are at an increased risk of experiencing HDP (Morris, Jacobson, Anand, Ewell, Hauth, Curet, Catalano, Sibai, and Levine 2001; Sibai et al. 1997). This suggests that HDP may be more common among women with high weight gain during pregnancy compared to those women experiencing an average or low weight gain during pregnancy.

In studies on infant and maternal health, birth parity also must be considered. Research has shown that HDP are more common among women having their first birth (American Pregnancy Association 2012; Fortner et al. 2011). In addition, HDP are often defined as a syndrome of first pregnancies (Chang, Muglia, and Macones 2010; Luo, An, Xu, Larante, Audibert, and Fraser 2007). Therefore, both maternal weight gain and parity are important factors to consider, in order to gain a better understanding of how these individual-level factors are associated with the odds of a woman experiencing HDP.

Prenatal Care Utilization

Receiving prenatal care on time and regularly throughout pregnancy is key for a mother to avoid experiencing medical risks during her pregnancy. Prenatal care can help identify risk factors associated with pregnancy complications that may occur at any time during the pregnancy (Laditka, Laditka, Mastanduno, Lauria, and Foster 2005; Lauderdale, VanderWeele, Siddique, and Lantos 2010).

Previous research has reported multiple risk factors for why women first receive prenatal care after the recommended first trimester of pregnancy or not at all. For example, women may have low levels of education, which leads them to obtain jobs without health insurance coverage or the flexibility to take time off for medical appointments and treatment (Ayoola, Nettleman, Stommel, and Canady 2010; Sunil, Spears, Hook, Castillo, and Torres 2010). If women have low incomes or are unemployed, they may not have access to an adequate means of transportation to get to their prenatal care appointments (Phillippi 2009).

Prenatal care utilization varies substantially among racial and ethnic groups. African American women receive significantly less prenatal care and are more likely to have pregnancy complications compared to white women (Laditka, Laditka, Bennett, and Probst 2005; LaVeist, Keith, and Gutierrez 1995a; Lu and Halfon 2003). Asian, Pacific Islander, and white women are the most likely to receive prenatal care during the first trimester of pregnancy (Agency for Healthcare Research Quality 2004). In addition, in 1999, only 70 percent of American Indian women compared to 91 percent of Cuban and Japanese women received early prenatal care (Eberhardt et al. 2001). Mexican Americans have the lowest rates of prenatal care use out of any racial/ethnic group in the United States (Singer and Ryff 2001).

Complications during pregnancy do arise, and some of these complications may be associated with inadequate prenatal care (Laditka et al., 2005; Peck and Alexander 2003). Prenatal care is essential for identifying risk factors associated with pregnancy complications, but these complications may occur at any time throughout the pregnancy (Laditka et al. 2005; Lauderdale, VanderWeele, Siddique, and Lantos 2010).

Surprisingly, women who received adequate prenatal care are more likely to experience HDP compared to women with inadequate prenatal care (Bryson, Ioannou, Rulyak, and Critchlow 2003).

This does not, by any means, suggest that prenatal care utilization has detrimental effects on a woman's health, or causes women to experience HDP. This finding could be due to the way in which the adequacy of prenatal care variable is measured in the analyses. Adequacy of prenatal care is often measured by the month the woman began attending prenatal care appointments and the number of appointments the woman attended, adjusted for gestational age (Kotelchuck 1994a; Kotelchuck 1994b). Women who experience complications during pregnancy may be attending more prenatal care appointments because of their condition. The number of prenatal care appointments attended is captured in the measurement of the adequacy of prenatal care index. The Adequacy of Prenatal Care Index does not take into account the quality of the prenatal care that was provided or the health of the woman.

Rural/Urban Residence, Income Inequality, and Health Care Availability and Their Relationship with Health and Hypertensive Disorders of Pregnancy

Research is increasingly showing evidence that characteristics of the places in which Americans live are a strong predictor of health (Adler et al. 1993; Adler and Ostrove 1999; Braunstein and Lavizzo-Mourey 2011; Link and Phelan 1995; Sternthal, Slopen, and Williams 2011). The following section includes a discussion of why residential context may be associated with HDP. Specifically, the dimensions of rurality, income inequality, and the availability of health care and the possible relationship with HDP are discussed.

County-level Characteristics: Dimensions of Rurality

The American rural population has been identified as a priority population affected by health disparities (Peck and Alexander 2003). Past research has shown that rural residents are in poorer health and have less access to health care compared to those living in urban areas (Institute of Medicine of the National Academies 2005; Mainous and Kohrs 1995; Ricketts 2000; Ziller, Coburn, Anderson, and Loux 2008). Less research has focused on health inequalities in rural areas compared to urban areas. Rural areas are continuously evolving and becoming more diverse and complex (Wallace, Grindeanu, and Cirillo 2004). Because of the increasing diversity and changing economic conditions across the United States, research is needed to better understand health disparities across the multiple levels and dimensions of rurality.

Historically, women from urban areas faced worse health outcomes compared to their rural counterparts due to crowding, poor water quality, and harmful environmental conditions during the pre- and early industrial stages of development (Cutler and Miller 2005). However, this pattern has reversed in some areas in more recent decades, because of improvements in the standard of living in urban areas including the wide availability of water and sanitation infrastructures (Cutler and Miller 2005), while in other areas health disparities among rural and between rural and urban populations have remained the same or increased (Glasgow, Johnson, and Morton 2004b).

In order to determine whether the odds of a woman experiencing HDP vary across rural and urban areas, the complex concept of rurality must first be considered. Rural areas are not homogenous. In fact, there is substantial diversity across rural places and among people who live in rural areas (Morton 2004). The concept of rurality has been defined in a variety of ways over the years (Glasgow, Johnson, and Morton 2004a); however, most social scientists who study rural areas acknowledge that rurality is a multidimensional concept (Lichter and Brown 2011).

Most argue that what it means to be rural includes multiple dimensions, such as differences in occupations, environment, social mobility, migration patterns, and social interactions (Bealer, Willits, and Kuvlesky 1965; Miller and Luloff 1981; Willits and Bealer 1967; Willits, Bealer, and Timbers 1990). While there is no consensus on how many different dimensions actually encompass the complex concept of rurality, there seems to be some agreement that rurality is comprised of ecological, occupational, and sociocultural dimensions (Bealer, Willits, and Kuvlesky 1965). The ecological, occupational, and sociocultural dimensions of rurality and how they are associated with HDP were examined in this study.

Ecological Dimension of Rurality

The ecological dimension of rurality is comprised of the spatial distribution of the population across geographical units. The ecological dimension of rurality is the dimension that is most commonly used to distinguish rural from urban areas, with the general consensus that rural areas are smaller in population size and are less densely populated when compared to more urban areas (Lichter and Brown 2011). Rural areas are thought to be geographically and socially isolated from centers of power and influence, which often originate from urban areas (Lichter and Brown 2011: pg. 5).

The ecological dimension of rurality may contribute to disparities in health outcomes for a number of reasons. Low population density is a problem for rural areas (Cordes 1989). Many rural areas are sparsely populated and do not have a sufficient population base to support quality healthcare (Glasgow, Johnson, and Morton 2004a). Smaller and more dispersed populations make it more expensive to provide basic infrastructure such as educational, social, and health services (Simpson, DesHarnais, Jacobs, and Menapace 1994). The social isolation that is inherent in many rural areas is associated with less formal health insurance coverage, less access to public health programs, and no public transportation for health care services (Snyder and McLaughlin 2004).

The smaller and the more isolated a rural community is, the more difficult it is to provide basic health care services and ensure that the basic health care needs of residents are met (Rosenblatt 2002). The population of a county may determine whether the county can support its own health care providers or even a hospital. It may also influence the distance residents need to travel to seek health care. When rural residents live in areas that cannot support the health care industry due to the low and dispersed population, and their residence is not located in close proximity to a large population center, individuals may not be able to get the health care they need to maintain or improve their health.

Limited health care services are not the only form of infrastructure that is lacking in rural areas. Areas with low population densities and limited proximity to urban areas face food insecurity. Food insecurity and hunger is common in rural areas, even in those areas with farming as the economic base (Morton, Worthen, and Weatherspoon 2004). When individuals do not have sufficient amounts of food, this leads to poor health, impaired quality of life, and the reduced capacity to resist infections (Sahyoun and Basiotis 2001).

Rural areas are typically envisioned as idyllic and relatively stress free (Bealer, Willits, and Kuvlesky 1965; Sorokin and Zimmerman 1929); however, research shows that rural women experience stressors equal to or even greater than those reported by women living outside of rural areas (Weisman, Hillemeier, Chase, Dyer, Baker, Feinberg, Symons Downs, Parrott, Cecil, and Botti 2006). Rural women have to travel the furthest distances to deliver their infants (Hulme and Blegen 1999) and obtain other obstetric services, which could be part of the reason behind this increased stress. If a woman is living in a county with a higher ecological dimension of rurality, this may increase her likelihood of experiencing HDP. As discussed, low population density, social isolation, and proximity to urban areas can all contribute to health disparities.

Occupational Dimension of Rurality

In addition to rural areas having a dispersed population and being geographically and socially isolated from centers of power, rural areas can also be distinguished by their economic activities and by the goods and services that are produced there (Lichter and

Brown 2011). The occupational dimension of rurality consists of whether the livelihood of the community is based in the primary industries—agriculture, mining, fishing, and forestry (Bealer, Willits, and Kuvlesky 1965). In addition to occupations based in the primary industries, rural areas also have a small number of jobs and firms. The firms often are comprised of small-scale establishments and the local economy lacks economic diversity (Lichter and Brown 2011).

The occupational composition of rural areas can have detrimental effects on health. Natural resource extraction often occurs in isolated communities where very few other employment opportunities are available (Schulman and Slesinger 2004). Rural places have lower levels of white-collar occupations compared with urban areas (Morton 2004). Rural areas are dominated by less diversified economies, as well as stagnant or declining economies (Morton 2004). People who work in the farming, fishing, logging, and mining occupations are embedded in a social and economic context of increasing worker powerlessness, changing working conditions, and industrial restructuring (Schulman and Slesinger 2004). Communities comprised of these types of economies and occupations lead to lower household incomes, reduced tax revenues to support health services, and heightened stresses to mental health, all of which can contribute to poor health outcomes (Morton 2004).

Areas that are dominated by agriculture, forestry, fishing, and mining are characterized by health risks that are not apparent in more urbanized areas (Hendryx, O'Donnell, and Horn 2008; Villarejo 2003). There are many health and occupational hazards associated with the extraction of food from the soil, lumber from the forests, minerals from the earth, and fish from the sea (Schulman and Slesinger 2004). Tools, machines, chemicals, and equipment that are used as part of the rural extraction labor process are very dangerous to health (Schulman and Slesinger 2004). The extractive industries are concentrated in a variety of different ecological and environmental conditions, and products and working conditions are not standardized and vary greatly across different areas (Schulman and Slesinger 2004).

Environmental contamination can occur through a variety of mediums (Ahern, Mullett, MacKay, and Hamilton 2011), one of which is the agricultural industry. The agricultural industry relies heavily on pesticides (e.g., insecticides, fungicides, growth regulators, repellants, and herbicides) to increase production and protect stored crops(Schulman and Slesinger 2004). Humans can be exposed to these agricultural pesticides through a number of mediums such as their diet, occupation, and through the air (Schulman and Slesinger 2004). The runoff from the farm industry pollutes the soil and water in some rural watersheds (Glasgow, Johnson, and Morton 2004a), and can pose health risks to those women who live near fields that are sprayed or live where runoff occurs (Frank, McKnight, Kirkhorn, and Gunderson 2004; Ricketts 2000; Stokes and Brace 1988). In fact, the primary cause of non-point source contamination of drinking water (the source of drinking water for 90 percent of rural Americans) is agricultural pesticides. Even if women are not working in the agricultural industry themselves, they can be exposed to pesticides through the environment (e.g., home proximity to fields, contaminated water or soil) or occupational take-home exposure (e.g., pesticide-contaminated clothing and shoes, pesticides being stored at home) (Curwin, Sanderson, Reynolds, Hein, and Alavanja 2002; Schulman and Slesinger 2004).

Environmental contamination also occurs through the extraction industry. Significant environmental toxicity has been found in coal mining and processing areas. The processing of coal involves the use of toxic chemicals, equipment powered by diesel engines, dust from coal trucks and trains, dust from unpaved haul roads, and mining explosives, all of which contribute to environmental pollution (Ahern, Mullett, MacKay, and Hamilton 2011). In addition to contaminating the air, coal processing contaminates the water. Chemical compounds used in the coal preparation process contaminates billions of gallons of water with toxic trace elements, which can affect the drinking water system (Ahern, Mullett, MacKay, and Hamilton 2011).

Large-scale concentrated animal feeding operations cause other environmental health risks for those living in these areas. Areas that are dominated by concentrated animal feeding operations have odor pollution, which may result in decreases in neighborliness, social cohesion, and trust, increases in social conflict, and alienation (DeLind 1995; DeLind 1998). The negative impacts of concentrated animal feeding operations can have detrimental effects for generating the economic and medical infrastructures that are needed for healthy rural residents (Hodne 2004).

As discussed, there are significant health risks that are associated with living in areas that are dominated by occupations that are based in the primary industries. When individuals are working in agricultural, forestry, fishing, and mining dominated areas this lessens the share of those working in professional occupations. Individuals working in some extractive occupations have lower salaries and are not provided with health insurance, both of which can have harmful effects on health. Women living in counties with a higher occupational dimension of rurality may be more likely to experience HDP, due to the possibly greater environmental health risks and less access to employer provided insurance in these areas.

Sociocultural Dimension of Rurality

Compared to the previous two dimensions of rurality, the sociocultural dimension of rurality is more difficult to define (Bealer, Willits, and Kuvlesky 1965). The social dimension encompasses actions and behavioral traits, while the cultural dimension encompasses common values and shared ideas that guide interactions within the community (Bealer, Willits, and Kuvlesky 1965).

There are various reasons to expect variations in health across levels of the sociocultural dimension of rurality. Even though rural areas are portrayed as pleasant areas for country living, rural areas tend to have poorer housing and a lack of access to adequate resources (Krout 2004). They also tend to have higher poverty rates and lower family incomes than urban areas (Snyder and McLaughlin 2004). These aspects of rural areas have been found to have negative impacts on health (Krout 2004; Morton 2004). Many Americans face these same challenges, but rural culture, physical environments, social and economic organizations, and lifestyles contribute to these differentials in health across rural and urban areas and within rural areas (Krout 2004).

People who live in rural areas are “embedded” in a unique social system that shapes behaviors and the availability of resources, which in turn affect health (Krout 2004). Cultural differences in rural areas may be associated with poorer health. There are agrarian ties to food and a traditional emphasis on eating in rural societies that may influence nutrition, diet, and body weight (McIntosh and Sobal 2004). Rural residents consume more sodium, cholesterol, and saturated fat than those who live in urban areas (Nayga Jr and Capps Jr 1994). Individuals from rural areas have higher caloric intakes and significantly lower intakes of Vitamin C compared to individuals from urban areas (Windham, Wyse, and Hansen 1983).

Rural residents experience social, cultural, and economic disadvantages that can increase their risks for adverse health consequences more than those faced by urban residents (Glasgow, Johnson, and Morton 2004a). Persistent rural poverty affects rural landscapes and compromises the health of rural Americans, especially rural minorities that experience particularly high poverty rates (Glasgow, Johnson, and Morton 2004a). Access to higher education also tends to be lower in rural areas, which contributes to rural residents having less education compared to their urban counterparts (Gibbs, Swaim, and Teixeira 1998). In addition, at the post-secondary school level, rural adults have lower educational attainment compared to their urban counterparts (Lichter and Brown 2011). Women with low educational attainment may have less ability to effectively utilize health care services (Sparks, McLaughlin, and Stokes 2009). Areas with low educational attainment are associated with lower earnings and a lower likelihood of having health insurance coverage (Sparks, McLaughlin, and Stokes 2009).

If women are living in areas with a high proportion of individuals with low levels of education, they may not have the opportunity to interact with women who are aware of the benefits of receiving adequate and timely prenatal care and the importance of avoiding health-risk behaviors during pregnancy. Even if women are aware of the importance of practicing good health behaviors and receiving the proper health care during pregnancy, they may not have employer provided health insurance available to them. Health insurance availability through employers tends to be higher in areas with jobs that are attainable by those with higher levels of education or where jobs are unionized. These jobs are less likely to be available in more rural areas.

Levels and Dimensions of Rurality and How They Might Interact with Individual Maternal Characteristics to Affect the Odds of Experiencing Hypertensive Disorders of Pregnancy

Research has shown that the relationship between socioeconomic status and health can be accounted for in part, by differences in health behaviors, psychological, and social factors; however, all variance is not explained (House 1992; Weinstein, Toy, Sandberg, Neumann, Evans, Kuntz, Graham, and Hammitt 2001). In order to fully understand how socioeconomic status affects health, it is necessary to consider characteristics of the environments as well as possible interactions between individual-level characteristics and the environment (Weinstein et al. 2001). By understanding how these two levels (individual and residential context) work together, it is possible to describe how health is affected by both individual social characteristics and the residential context in which individuals live (Adler and Ostrove 1999).

Research has shown that, in general, minorities have lower health statuses than non-Hispanic whites regardless of place of residence. Different minority groups are concentrated in different regions of the country, and the historical, social, cultural, and economic attributes that can affect health vary across the different racial and ethnic groups (Glasgow, Johnson, and Morton 2004a). Despite this, prior research has not provided a thorough examination of how rural residence interacts with minority race/ethnicity to affect health outcomes for those individuals (Glasgow, Johnson, and Morton 2004b).

Individual characteristics and characteristics of the place in which an individual lives have been found to combine to affect the likelihood of individuals participating in health-related risk behaviors such as tobacco use (Adler and Ostrove 1999). For example, the level of rurality in which a person lives is associated with variations in cigarette smoking prevalence. Both female adolescents (19 percent) and female adults (27 percent) living in the most rural counties are more likely to smoke cigarettes than their urban counterparts (11 percent and 20 percent, respectively) (Eberhardt et al. 2001). As for pregnant women, approximately 10.4 percent smoke (U.S. Department of Health and Human Services 2011); however, research has shown that this is even higher among women living in rural areas (Bailey and Cole 2009; Bullock, Mears, Woodcock, and Record 2001; Stevens, Colwell, and Hutchison 2010).

Considering that there are differences in individual maternal characteristics across rural and urban areas, this leads to the hypothesis that the effect of individual maternal characteristics on HDP may vary as well. To date, research has not investigated whether or not the effects of individual maternal characteristics on HDP vary across the levels and dimensions of rurality, but the literature discussed in this section suggests that they do.

County-level Characteristics: Income Inequality

In order to gain a better understanding of socioeconomic status and health, the consequences of relative socioeconomic inequalities across and within communities for health also need to be considered (Weinstein et al. 2001). The relative distribution of income within a community, or income inequality, has been found to be associated with differentials in a variety of health outcomes (Weinstein et al. 2001), including mortality (Kaplan, Pamuk, Lynch, Cohen, and Balfour 1996; Kennedy, Kawachi, and Prothrow-Stith 1996; Lynch, Kaplan, Pamuk, Cohen, Heck, Balfour, and Yen 1998; Lynch, Smith, Kaplan, and House 2000; McLaughlin and Stokes 2002; McLaughlin, Stokes, and Nonoyama 2001; Yang, Chen, Shoff, and Matthews 2012) and poor self-rated health (Kennedy, Kawachi, Glass, and Prothrow-Stith 1998).

Greater income inequality in a place is likely to increase a low-income individual's sense of relative deprivation and relative disadvantage, because those individuals who are more disadvantaged may feel left behind the rest of society (Wilkinson 2006), especially when the gap between them and those at the higher end of the income distribution is large. A stronger sense of relative deprivation can result in stress, anxiety, and depression (Wilkinson 2006). These higher levels of stress that are the result of individuals living in communities with a more inequitable distribution of income (Kaplan et al. 1996; Kawachi, Kennedy, Lochner, and Prothrow-Stith 1997) can translate into detrimental health-risk behaviors such as smoking, excessive alcohol consumption, and antisocial behavior among those of lower income or socioeconomic status (Kawachi, Levine, Miller, Lasch, and Amick III 1994).

Because there is always someone who is richer, the negative effect of higher income inequality on health applies to those individuals in the lower class, but also applies to those individuals in the upper class (Lynch and Kaplan 1997). In a community with high income inequality, it can be difficult for individuals to establish friendships, affiliations, social trust, and reciprocity. Underinvestment in infrastructure, services, and cooperative organizations in a community because of high inequality undermines the development of self-esteem, mutual respect, and confidence in residents (Kawachi, Kennedy, Lochner, and Prothrow-Stith 1997; Marmot 2004).

Another way that income inequality can affect health is through the underinvestment in health-related resources (Kawachi, Kennedy, Lochner, and Prothrow-Stith 1997; Lynch and Kaplan 1997; Wilkinson 1997). A more equal income distribution is associated with more people with health insurance, higher educational expenditures per capita, more library books per capita, lower rates of violent crimes, and a smaller proportion of the population in jail (Kaplan et al. 1996). The investment in social programs in areas with less income inequality is a type of wealth redistribution policy where, by providing access to these services, the sense of relative deprivation of those with lower incomes can be lessened (Kaplan et al. 1996), reducing potential conflict over resources and access to services.

Therefore, higher income inequality can have a negative effect on health by causing anxiety, stress, and a sense of relative deprivation, which can lead to smoking and alcohol consumption, as well as through an underinvestment in health-related resources and other infrastructure and services in the community. While the relationship between income inequality and HDP has not previously been examined, previous research has established that higher income inequality is associated with higher rates of mortality, poor self-rated health, and low birth weight infants (Kaplan et al. 1996). In light of these previous findings, living in a county with high income inequality, may directly contribute to an increased likelihood of experiencing HDP or may indirectly affect the odds of women experiencing HDP through an increase in individual health-risk behaviors such as smoking and alcohol consumption or an underinvestment in resources.

County-level Characteristics: Availability of Health Care Services

Another factor that is believed to partially contribute to the differences in health by socioeconomic status is availability of and access to quality health care (Seeman and Crimmins 2001). Even with federally funded programs such as Medicaid and Medicare in the United States, individuals with lower socioeconomic statuses continue to have differential (less) access to quality medical resources (Seeman and Crimmins 2001).

Health insurance coverage affects access to health care. Nonelderly Americans who live in rural counties are more likely to be uninsured than those who live in urban counties (Eberhardt et al. 2001). Among those Americans with low incomes, those who live in the South and West are more likely to be uninsured compared to those who live in the Northeast and Midwest (Eberhardt et al. 2001). Rural residents are also more likely to not have health insurance coverage compared to their urban counterparts (18.7 and 16.3 percent, respectively) (Vistnes, Zuvekas, United States Agency for Health Care Policy Research, and Medical Expenditure Panel Survey 1999).

Differences in health insurance coverage also exist across racial and ethnic groups. For example, in 2001, among individuals under 65 years of age, those living without health insurance coverage included 34.8 percent of Hispanics, 19.3 percent of African Americans, 17.1 percent of Asians, and 14.7 percent of whites (Ver Ploeg and Perrin 2004). Differences in health insurance coverage within racial and ethnic groups also exist. For example in 2004-2006, among Asian Americans, 31 percent of Koreans; 21 percent of Vietnamese; 20 percent of Indians, Pakistanis, Bangladeshis; 17 percent of Cambodians, Laotians; 16 percent of Chinese; 14 percent of Filipinos; and 12 percent of Japanese had no health insurance coverage (The Henry J. Kaiser Family Foundation 2008). However, even among those who are insured, differences in health care treatment can contribute to racial and ethnic health disparities (Ver Ploeg and Perrin 2004). For example, one study found that among Medicare beneficiaries, black patients were less likely than white patients to receive breast cancer screening, even after controlling for socioeconomic status (Schneider, Zaslavsky, and Epstein 2002).

Economic characteristics of places are associated with health care availability, independent of an individual's own economic circumstances (Litaker, Koroukian, and Love 2005). Changing economic conditions of an area accompanied by increasing social disinvestment may lead to a reduced ability to retain existing and attract new health care providers (Litaker, Koroukian, and Love 2005). When health care providers leave communities it can have large effects on the people and places left behind. Residents are left with fewer health care options (Litaker, Koroukian, and Love 2005), which can lead to unmet health care needs. Individuals living in areas with few physicians must travel farther to obtain needed services (Eberhardt et al. 2001), especially specialized treatments.

The nation's physicians are unequally distributed throughout the United States. Twenty percent of the United States population lives in rural America, while only 11 percent of its physicians practice there (Ricketts 2000). The smaller and the more isolated a rural community is, the more difficult it is to provide basic health care services and ensure that the basic health care needs of residents are met (Rosenblatt 2002). Smaller and more dispersed populations make it more expensive to provide basic infrastructure such as educational, social, and health services (Simpson, DesHarnais, Jacobs, and Menapace 1994). These factors leave residents with fewer quality health care options and limited opportunities to resolve health care issues when they arise (Litaker, Koroukian, and Love 2005). The quality of health care services is a crucial determinant of whether individuals will benefit from their interactions with the health care system (Rosenblatt 2002).

Research has shown that rural residents are more likely than urban residents to report having a regular source of health care (Reschovsky and Staiti 2005), but this may be the result of rural residents having limited options for health care, which makes naming a regular source of care easier. In fact, in some rural areas, more than 50 percent of rural patients rely on only one hospital to receive care (Roh and Lee 2006). Having limited hospital choices is even more of a problem if the hospital available does not provide high quality health care or a full range of services (Goldman and Dudley 2008). Research shows that rural residents receive medical care of lower quality compared to their urban counterparts (Brasure, Stensland, and Wellever 2000; Coburn, Wakefield, Casey, Moscovice, Payne, and Loux 2004; Culler, Atherly, Walczak, Davis, Hawley, Rask, Naylor, and Thorpe 2006; Goldman and Dudley 2008; Thiemann, Coresh, Oetgen, and Powe 1999), especially for those residents who need the care of specialists (Rosenblatt 2002).

In rural areas with less than adequate health care services, rural residents may bypass their local health care providers, because they are concerned with the quality of care they will receive (Liu, Bellamy, and McCormick 2007; Rosenblatt 2002). When patients bypass rural hospitals, the extra travel time can lead to delays in care and an increase in stress and cost of care (Nesbitt, Larson, Rosenblatt, and Hart 1997). Those rural residents who are more likely to bypass the care offered in rural areas tend to be younger, and the willingness to travel for alternative health care services tends to decline with age (Adams and Wright 1991; McDaniel, Gates, and Lamb Jr 1992). Patients who bypass rural health care are also more likely to either be covered by managed or commercial health insurance (Radcliff, Brasure, Moscovice, and Stensland 2003). If rural hospitals are not serving patients with commercial health insurance, it can be very difficult to finance the costs to maintain the health care facility (McDaniel, Gates, and Lamb Jr 1992) and rural obstetric services (Bronstein and Morrisey 1991).

Laditka and colleagues (2005) found, however, that the odds of having a potentially avoidable maternity complication were lower for women delivering in rural hospitals. This was the case for all women and for those women who were insured by Medicaid. Among a sample of women who lived in rural Washington, those women with little or no obstetric services available in their communities were more likely to deliver outside of their communities and have more complicated labors and premature deliveries compared to those women with more accessible obstetric services and who delivered at local hospitals (Nesbitt et al., 1990). Thus, availability of good prenatal care seems especially important.

Women living in rural areas face additional burdens when trying to seek health care. These additional burdens include a lack of public transportation systems in rural areas (Probst, Laditka, Wang, and Johnson 2007). Modes of public transportation are very limited in rural areas; in fact, even members of rural households who do not own a car only travel by public transportation one percent of the time (Pucher and Renne 2004).

Often times, rural residents depend on family or friends for transportation, which can cause problems when seeking health care, because they may be limited by the distance they can travel, the time of day they are able to travel, or route friends or family members are willing to drive (Probst, Laditka, Wang, and Johnson 2007). This can be especially problematic for those women with more complex medical conditions, because they are more likely to need to travel further distances to seek care (Adams and Wright 1991) and to do so more frequently.

For all travel reasons, rural residents travel an average of 38 percent more miles per day than their urban counterparts, and this distance is even greater for the rural poor population who travels 59 percent more miles per day (Pucher and Renne 2004). They also travel further distances when seeking health care, with rural residents traveling 17.5 miles compared to 8.3 miles for urban residents (Probst, Laditka, Wang, and Johnson 2007).

With additional travel distances, this also leads to additional time spent seeking health care. Trips to health care providers by rural residents average 31.4 percent longer than trips for urban residents (27.2 and 20.7 minutes, respectively) (Probst, Laditka, Wang, and Johnson 2007). In addition, rural residents are also more likely to report the price of gasoline as a problem for seeking health care compared to urban residents (Probst, Laditka, Wang, and Johnson 2007).

It is also common for minorities to face transportation difficulties when accessing health care. Minorities are more likely to use public transportation and report longer travel distances for non-work related trips than whites (Polzin, Chu, and Rey 1999). Probst and colleagues (2007) identified African Americans to have longer travel times when seeking health care compared to whites (29.1 minutes and 20.6 minutes, respectively), but found no differences in travel times among other racial/ethnic groups compared to whites. They also report African Americans and Hispanics to be more likely to use public transportation or walk when traveling for health care (16.5 and 24 percent, respectively) than whites who use these forms of transportation when travelling for care 3.6 percent of the time (Probst, Laditka, Wang, and Johnson 2007). This may be problematic because transportation barriers to health care are associated with a decrease in utilization, lower rates of preventative care, and reduced compliance to treatment regimens (Coronado, Thompson, Koepsell, Schwartz, and McLerran 2004).

Access to maternal health care is a public health concern in the United States (Cohen and Coco 2009), especially in rural areas (Hulme and Blegen 1999). There has been a decline in maternity care clinicians and obstetricians in rural communities, areas where physicians may already be in short supply (Nesbitt et al., 1990). The scarcity in OB/GYN physicians and fewer resources in rural areas can lead to women not being able to establish a relationship with a particular health care provider or build a comprehensive health care program (Eberhardt et al. 2001).

When an individual has an identifiable regular source of health care, it gives him or her the opportunity to resolve health care issues when they arise, benefit from coordinating care, and receive preventative services (Ettner 1996; Mueller, Ortega, Parker, Patil, and Askenazi 1999; Weinick, Zuvekas, Drilea, and United States Agency for Health Care Policy Research 1997). Individuals without a regular source of health care report lower satisfaction with the services they receive (Rubin, Gandek, Rogers, Kosinski, McHorney, and Ware 1993) and have unmet health care needs (Weinick, Zuvekas, Drilea, and United States Agency for Health Care Policy Research 1997).

Metropolitan counties have a much higher rate of obstetricians and gynecologists compared to nonmetropolitan counties. In 1998, there were 16.7 obstetricians and gynecologists per 100,000 population in metropolitan counties compared to 5.9 obstetricians and gynecologists per 100,000 population in nonmetropolitan counties (Eberhardt et al. 2001). This difference is important, because research has found that a higher rate of obstetricians/gynecologists (OB/GYN) doctors in a county is associated with a lower percentage of women receiving late or no prenatal care (Shoff, Yang, and Matthews 2012). Initiation of prenatal care in the first trimester of pregnancy is an important aspect of infant and maternal well-being (Epstein, Grant, Schiff, and Kasehagen 2009). If health care providers are not available to provide adequate prenatal care, this may increase the risk of women experiencing HDP.

Miller and colleagues (1996) found that women who live in rural areas are more likely to receive prenatal care late or not at all, regardless of their maternal risk profile.

This finding could be the result of a number of factors. For instance, when compared to women from urban areas, women from rural areas are more likely to not have health insurance coverage, and to be poor, less educated, and younger, which are all risk factors for not receiving prenatal care on time (Hulme and Blegen 1999; Larson and Correa-de-Araujo 2006). In addition, fewer OB/GYN physicians practicing in rural areas can lead to greater transportation barriers and greater difficulties accessing prenatal care for rural women (Braveman, Marchi, Egerter, Pearl, and Neuhaus 2000; Davis, Baksh, Bloebaum, Streeter, and Rolfs 2004).

Family physicians have decreased their contribution to prenatal care from 17.3 percent of total visits from 1980 through 1992, to 10.2 percent of visits between 1993 and 1999 (Guirguis-Blake, Fryer, Deutchman, Green, Dovey, and Phillips 2002) and to 6.1 percent in 2003 to 2004 (Cohen and Coco 2009). The decline in family physicians performing prenatal care has occurred at even greater rates in non-metropolitan areas from 38.6 percent of visits in 1995 through 1996 to 12.9 percent of visits in 2003 through 2004 (Cohen and Coco 2009). This is the case, despite the fact that physicians practicing in rural areas see more patients than their urban counterparts (Bronstein, Johnson, and Crayton Jr 1997).

Even though family physicians have decreased their contribution to prenatal care over the years (Guirguis-Blake et al. 2002), family physicians are taking on some of the maternity care that is no longer being handled by obstetricians, especially in rural areas (Cohen and Coco 2009; Hueston 1991; Nesbitt and Baldwin 1993). In non-metropolitan areas, prenatal care visits are 5.6 times more likely to occur with a family physician compared with an obstetrician (Cohen and Coco 2009).

In their study that examined trends in birth locations across rural and urban areas of California, Hughes and colleagues (2008) found that more women from rural areas delivered in urban than rural hospitals. They also identified that one-third of all rural hospital deliveries were to women who lived in urban areas (Hughes, Zweifler, Garza, and Stanich 2008). The women who delivered at rural hospitals were more likely to smoke during their pregnancy, have more pregnancy-related complications, have inadequate prenatal care, and have government insurance (Hughes, Zweifler, Garza, and Stanich 2008).

Understanding how availability of health care is associated with the odds of experiencing HDP is important. By having a better understanding of how the availability of health care in an area affects the odds of a woman experiencing HDP, then we may be able to find ways to reduce the amount of women experiencing HDP in the future.

Hypotheses

This study investigates whether the odds of a woman experiencing HDP vary by the level and dimension of rurality, income inequality, and health care availability. Examining differences in HDP across different types of rural settings requires consideration of residential characteristics in addition to rurality, such as income inequality and availability of health care. Because environments do not affect all individuals who live in a particular place in the same way (Taylor, Repetti, and Seeman 1997), this study tests for cross-level interactions in order to determine whether demographic or behavioral characteristics of women, such as race, ethnicity, and whether they engage in health-risk behaviors such as smoking, on HDP vary across the levels and dimensions of rurality and by the level of income inequality and availability of health care in the residential county.

As described in the literature review, previous studies suggest or find that how individual-level characteristics are associated with HDP might differ across the types of places in which individuals live. Because of this, individual-level, residential county-level, and cross-level hypotheses were tested in this study. The null hypothesis in each case is that the relationship between the explanatory variables and the dependent variable is zero. Table 2.1 displays each of the alternative hypotheses or the expected relationship between HDP and the individual and county variables and cross-level interactions. The odds of experiencing HDP vary by the race and ethnicity of the woman, with African American and American Indian/Alaskan Native women having a higher risk of experiencing HDP compared to white women (H1). Compared to white women, Asian women have a lower risk of experiencing HDP (H1a). Hispanic women have a lower risk of experiencing HDP compared to non-Hispanic women (H1b).

Table 2.1 Individual-level, residential county-level, and cross-level hypotheses

	Individual-level hypotheses
H1	African American and American Indian/Alaskan Native women have higher risks of experiencing HDP, compared to white women.
H1a	Asian women have a lower risk of experiencing HDP, compared to white women.
H1b	Hispanic women have a lower risk of experiencing HDP compared to non-Hispanic women.
H2	Women with lower levels of educational attainment are more likely to experience HDP compared to women with a bachelor's degree or higher.
H2a	Compared to women with a bachelor's degree or higher, women with lower levels of education are more likely to experience HDP, even after controlling for individual health risk behaviors, including maternal smoking during pregnancy and not receiving adequate prenatal care.
H3	Women who receive timely and adequate prenatal care are less likely to experience HDP.
	Residential county-level hypotheses
H4	Women who live in the most rural counties are more likely to experience HDP.
H4a	Women who live in the most rural counties are more likely to experience HDP, even after controlling for individual demographic characteristics (e.g., marital status and maternal education).
H4b	Women who live in the most rural counties are more likely to experience HDP, even after controlling for individual health risk behaviors (e.g., maternal smoking during pregnancy and inadequate prenatal care utilization).
H4c	The inclusion of other county-level characteristics, such as income inequality and access to health care can reduce, but will not eliminate the effect of rural residence on HDP.
H5	The odds of experiencing HDP will be higher for those women who live in a county with greater income inequality.
H6	Women living in counties with greater availability of health care are less likely to experience HDP.
	Cross-level hypotheses
H7	African American women who live in counties with a higher level of rurality are more likely to experience HDP than their counterparts who live in less rural areas.
H8	The protective effect of prenatal care utilization on HDP is not as strong for those women who live in rural areas as it is for all women.
H9	The effect of individual-level characteristics on HDP will vary by the level of availability of health care that is present in the residential county.
H9a	The positive effect of education on HDP is even stronger among those women who live in a county with a greater availability of health care.

Women with lower levels of educational attainment are more likely to experience HDP compared to women with a bachelor's degree or higher (H2), and this association holds even after controlling for individual health risk behaviors, including maternal smoking during pregnancy and not receiving adequate prenatal care (H2a). Women who receive timely and adequate prenatal care are less likely to experience HDP (H3).

As previously noted, residential county-level hypotheses were tested in this study. The odds of a woman experiencing HDP vary by the level and dimension of rurality, with women who live in the most rural counties more likely to experience HDP (H4), even after controlling for individual demographic characteristics (e.g., marital status and maternal education) (H4a) and individual health risk behaviors (e.g., maternal smoking during pregnancy and inadequate prenatal care utilization) (H4b). The inclusion of other county-level characteristics, such as income inequality and the availability of health care can reduce the effect of rural residence, but will not eliminate the effect of rural residence on HDP (H4c).

The odds of experiencing HDP will be higher for those women who live in a county with greater income inequality (H5). Women living in counties with greater availability of health care are less likely to experience HDP (H6), because health care availability is an important determinant of health status (Probst, Laditka, Wang, and Johnson 2007).

Also tested in this study were hypotheses about cross-level interactions. Specifically, the effect of individual-level characteristics of women on HDP will vary by the level and dimension of rurality in the residential county. African American women who live in counties with a higher level of rurality are more likely to experience HDP than their counterparts who live in less rural areas (H7). In addition, the protective effect of prenatal care utilization on HDP is not as strong for those women who live in rural areas as it is for all women (H8), which is likely because of differences in quality of care. It was also hypothesized that the effect of individual-level characteristics on HDP will vary by the level of availability of health care that is present in the residential county (H9). More specifically, the positive effect of education on HDP is even stronger among those women who live in a county with a greater availability of health care (H9a).

Conclusion

This chapter began with a discussion of the conceptual framework that was used to guide this study. Following the discussion of the conceptual framework, the literature on the relationship between individual-level demographic and behavioral characteristics and their relationship with health, in general, was reviewed. This chapter continued with a more specific review of the individual-level factors associated with HDP. It also included a discussion of the community-level characteristics that are associated with health disparities, generally, as well as a more specific discussion of the relationship between residential characteristics and HDP. This review of the current literature provided both theoretical explanations and empirical evidence of the factors associated with HDP. This chapter concluded with a discussion of the individual-level, residential county-level, and cross-level hypotheses that were tested in this study. The data, measures, and methodology that were used in this study are discussed in the next chapter.

Chapter 3

Data and Methodology

Introduction

Chapter 3 focuses on the secondary data sources, measures, and methodology used in this dissertation. This chapter includes a description of the secondary data sources that were used to construct the individual-level and county-level measures, a detailed description of how the variables were measured for the analysis, and concludes with a detailed discussion of the analytic strategy. The multilevel logistic regression model equations that were used to test the hypotheses state above are presented and described at the end of this chapter.

Data Sources and Sample

Individual-level Data Source

The data used in this study was derived from multiple secondary data sources. The primary secondary data source that was used is the National Center for Health Statistics Non-Public-Use Natality Detail Files with county identifiers for all counties in the United States. The non-public use data file was necessary for this study, because it includes data on women who reside within rural counties. In the public-use natality data files, the geographic detail is restricted so that it only includes data for those women who reside in counties with a total population of 100,000 or more residents according to the 2000 Census (National Center for Health Statistics 2007a). A research proposal and detailed plan for how the data would be kept secure and confidential was submitted to and approved by the National Center for Health Statistics in order to obtain the non-public use detailed natality data file.

The National Center for Health Statistics compiles information from the standard birth certificate to create the data, which were prepared from individual records processed by each registration area through the Vital Statistics Cooperative Program (National Center for Health Statistics 2007a). The data file includes information on women and their pregnancies including, but not limited to the woman's state and county of residence, age, race, ethnicity, highest level of education completed, marital status, and pregnancy complications (Pol and Thomas 2001). The data are based on a 100 percent sample of live births occurring within the United States (National Center for Health Statistics 2007a). These data files include information on all live births that occurred within the United States (births to both United States residents and nonresidents). These analyses are restricted to women who reside within the continental United States and gave birth during the 2007 calendar year. Both the dependent and independent individual-level variables were derived from this data source, which includes demographic and behavioral characteristics of the woman as well as information on whether the woman experienced any complications throughout her pregnancy, including HDP, which is the focus of this study.

In the United States, there are currently two different versions of the birth certificate that are being used—the 1989 Revised Birth Certificate and the 2003 Revised Birth Certificate—both of which are included in the detailed natality data file. In order to utilize data on all women in the continental United States, variables were recoded to keep the measures as consistent as possible regardless of the version of the United States Certificate of Live Birth that was used to record the information when the infant was born. More detail on the construction of these measures that varied across the version of birth certificate is provided in the following section.

County-level Data Sources

The American Community Survey 2005-2009 5-year county-level estimates were used to create the county-level measures of rurality and income inequality (U.S. Census Bureau 2005-2009). Religious affiliation adherence data from the Association for Religious Data Archives 2000 county-level files were used in addition to the American Community Survey data in creating the sociocultural dimension of rurality measure (Association of Religious Data Archives 2000). County-level data from the Area Resource File was used to create the measure of health care availability in 2007 (Area Resource File 2008).

Measuring Residential Context

The different levels and dimensions of rurality, income inequality, and health care availability are measured using county-level data. Controlling for residential characteristics is important in order to properly assess the impact of rurality and to understand the implications for practice and policy (Hillemeier, Weisman, Chase, and Dyer 2007).

Individual-level data are aggregated by the census and are made available at multiple geographic scales. These levels of aggregation are not simply 'spatial resolutions' or 'units of analysis' used by the census, but rather they usually relate to the working of the federal and local government (Subramanian, Duncan, and Jones 2001). Furthermore, each level of aggregation may reflect a level at which different processes operate (Blakely and Woodward 2000).

The county was chosen as the level at which residential characteristics were measured in this study for a few important reasons. The county is the geographic identifier that is attainable through the National Center for Health Statistics Non-Public-Use Detailed Natality Files Data Users Agreement (National Center for Health Statistics 2007a). I believe the county is an appropriate level of geography for measuring residential context for the following reasons. First, county governments play a specific role within the federalist system, because they coordinate regional planning across lower levels of government (e.g., municipalities) as well as mediate between local residents and higher levels of government (e.g., state and national) (Lichter and Brown 2011; Lobao and Kraybill 2005). Second, counties more accurately represent health care service markets than do lower levels of geography such as census blocks or census tracts (Laditka, Laditka, and Probst 2005; Simpson, DesHarnais, Jacobs, and Menapace 1994). Third, counties can offer more insight into the variation that exists in income inequality across space when compared to states and they are large enough to reflect the income differentials that exist across neighborhoods and communities within counties. Finally, counties were selected as the level of analysis at which residential characteristics are measured, because they allow for an investigation of how differences in the levels and dimensions of rurality are associated with the odds of a woman experiencing HDP.

Sample

The 2007 National Center for Health Statistics detailed natality files is a 100 percent sample of live births that occurred within the United States. This file includes information on 4,378,696 births. This analysis was restricted to United States residents who reside within the continental United States. After excluding births to women who are non-United States residents and women who are residents of Alaska and Hawaii, the sample size included 4,286,080 births. This analysis was also restricted to singleton births. After twins, triplets, and other multiple births were excluded from the data file, the sample included 4,141,521 births. Because this analysis was restricted to singleton births, this also means that the sample includes 4,141,521 women.

HLM 6 uses listwise deletion to handle missing data (HLM 2008). Listwise deletion, also known as case deletion or complete case analysis, is a method for handling missing data that excludes the observations from the analysis that have a missing value on any of the variables that are included in the analysis (Hawthorne and Elliot 2005; Schafer and Graham 2002). After women with missing data were excluded from the analyses, the sample size included 3,451,782 women.

The percentage of missing data for each of the individual-level variables is reported in Table 3.1. Although 17 percent of cases were excluded from the analyses due to missing data, the percentage of missing data for each of the individual-level predictors as well as the outcome variable were low. For example, the percentage of missing data on the dependent variable, HDP, was 0.48. The maternal demographic characteristics had missing values for less than 2 percent of the cases. There were between 5 and 7 percent of cases missing on the maternal behavioral characteristics (i.e., maternal smoking during pregnancy, maternal weight gain, and prenatal care utilization). Some caution should be given when interpreting the results for these measures.

Table **3.1** Frequency and percentage of missing data for each of the individual-level variables

Variable	**Frequency Missing**	**Percentage Missing**
HDP	19,822	0.48
Age	0	0.00
Race	0	0.00
Ethnicity	29,544	0.71
Marital status	0	0.00
Education	50,603	1.22
Smoking	272,496	6.58
Weight gain	257,957	6.23
Prenatal care	215,890	5.21
Parity	20,222	0.49

HLM automatically excludes the individual-level cases from the analysis when there is not an efficient amount of level-1 cases per level-2 to adequately estimate the models. There were 638 cases excluded from the analyses for this reason. In other words, 638 women lived in a county that did not have a sufficient amount of individual-level cases for the multilevel model to be estimated, which resulted in a sample size of 3,451,144 women. There are 3,109 counties in the continental United States; however, there were 11 counties excluded from the analyses, because there were an insufficient amount of women who gave birth. This resulted in 3,096 counties included in the multilevel models. Table 3.2 compares the individual-level descriptive statistics for the listwise deletion and missing data samples. The majority of the variables were nearly stable across the samples, with the exception of black, Hispanic, married, and mother from California. More caution needs to be taken when drawing conclusions from the findings on these variables.

Table 3.2 Descriptive statistics of hypertensive disorders of pregnancy and the independent variables at the individual-level for the listwise deletion sample and missing data sample

	Sample	
	Listwise Deletion	Missing Data
	Proportion	
Individual-level measures (N=3,451,144)		
Hypertensive disorders of pregnancy	0.04	0.04
Maternal age (Age 20-34=reference)		
Age 19 or younger	0.11	0.11
Age 35 and older	0.14	0.14
Race (White=reference)		
Black	0.16	0.21
American Indian/Alaskan Native	0.01	0.01
Asian	0.06	0.06
Ethnicity		
Hispanic	0.25	0.30
Marital status		
Married	0.60	0.54
Maternal education (BA or higher=reference)		
Less than High School	0.21	0.25
High school/GED	0.29	0.30
Some college/Associate's degree	0.24	0.24
Maternal smoking during pregnancy		
Mother smokes	0.09	0.08
Mother from California	0.14	0.26
Weight gain during pregnancy (Average weight gain=reference)		
Low weight gain	0.14	0.14
High weight gain	0.20	0.22
Parity		
First birth	0.41	0.40
Prenatal Care Utilization (Inadequate=reference)		
Intermediate care	0.13	0.11

Adequate care	0.40	0.37
Adequate plus care	0.32	0.31

Note: The values represent the proportion of the groups coded 1 on each category.

Measures

This section includes a detailed description of how each of the variables was measured for the analyses. The measurement of the dependent variable is presented first, followed by a description of each of the individual-level predictors. At the end of this section, each of the county-level predictor variables was described.

A detailed description of the dependent variable, HDP, is presented here. Following the description of the dependent variable, a detailed description of each of the individual-level independent variables is provided. The individual-level independent variables include measures of maternal demographic and behavioral characteristics.

Dependent Variable

The dependent variable, *hypertensive disorders of pregnancy (HDP)*, is a dichotomous measure representing whether or not the woman experienced gestational hypertension (preeclampsia) or eclampsia during her pregnancy. A woman was assigned a coding of 1 on this variable if she experienced a hypertensive disorder of pregnancy and coded 0 if she did not. Following Chang et al. (2010), a hypertensive disorder of pregnancy includes those women who had the condition of pregnancy associated hypertension (also referred to in the literature as gestational hypertension, pregnancy-induced hypertension, and preeclampsia) or eclampsia.

Individual-Level Independent Variables

Maternal age at the time of birth was measured as a set of two dichotomous variables. In anticipation of a nonlinear relationship between maternal age and HDP, the maternal age measure includes dichotomous variables for women less than 20 years of age, women ages 20 to 34 years of age (reference group), and women older than 34 years of age at the time of the infant's birth.

Dichotomous variables representing various racial groups categorized by self-reported *race* were included in the models. Dichotomous variables for black, American Indian/Alaskan Native, and Asian were included in the models with white as the reference category. A dichotomous measure of Hispanic ethnicity was also included in the models. Women who self-reported any Hispanic background were coded as "1" on this measure, regardless of their racial background.

Previous research has shown that unmarried women are more likely to experience pre-eclampsia compared to married women (Chang, Muglia, and Macones 2010). A measure of marital status was included in the models. To control for the *marital status* of the woman, a dichotomous variable indicating whether the woman was married at the time of the birth was included in the analysis.

The mother's highest level of education at the time of the infant's birth was used as a measure of socioeconomic status. *Maternal education* is reported in the detailed natality files differently for the 1989 Revision and the 2003 Revision versions of the birth certificate. For the 1989 Revision, maternal education includes 17 education categories ranging from no formal schooling to five or more years of college education. For these analyses, the years of education were recoded in order to reflect the education categories of the 2003 Revision. Therefore, maternal education was measured as a set of dichotomous variables that include: less than a high school education, high school degree, some college or associate's degree, and bachelor's degree or higher (reference group).

In order to determine that the recoded years of education in the 1989 Revision adequately matched the education categories of the 2003 Revision, preliminary analyses (not shown) were estimated with the full individual-level model (discussed below) with the 1989 Revision and the 2003 Revision samples estimated separately. A test for the equality of coefficients (Clogg, Petkova, and Haritou 1995):

Formula 3.1

$$Z = \frac{b_1 - b_2}{\sqrt{SEb_1^{\,2} + SEb_2^{\,2}}}$$

was performed in order to ensure that there were no significant differences in each of the education measures across the 1989 Revision sample and 2003 Revision sample models. This statistical test is the best available test for the equality of coefficients for large sample sizes (Paternoster, Brame, Mazerolle, and Piquero 1998), which is the case for this study. Using this formula to test for the significance of the difference between the education coefficients in the 1989 Revision sample and the education coefficients in the 2003 Revision sample indicated that the standard deviation is unbiased (Brame, Paternoster, Mazerolle, and Piquero 1998; Paternoster, Brame, Mazerolle, and Piquero

1998). No significant differences in the estimated coefficients were identified, indicating that the recoded years of education in the 1989 Revision adequately match the education categories of the 2003 Revision; the 2003 Revision measurement of maternal education is used in all subsequent models.

Variables were included in the analysis to measure the behavioral health characteristics of a woman during her pregnancy. The Adequacy of Prenatal Care Utilization (APNCU) Index, a measure of prenatal care adequacy, was included in the models. The APNCU uses two measures, the month the woman began attending prenatal care appointments, and the number of prenatal care visits the woman attended, which are adjusted for the length of gestation (Kotelchuck 1994a; Kotelchuck 1994b). The APNCU was recoded for this analysis as a set of dichotomous variables: *inadequate prenatal care utilization* (prenatal care begun after the 4th month or less than 50 percent of recommended visits received [reference category]), *intermediate prenatal care utilization* (prenatal care begun by the 4th month and 50 percent through 79 percent of recommended visits received), *adequate prenatal care utilization* (prenatal care begun by the 4th month and 80 percent through 109 percent of recommended visits received), and *adequate plus prenatal care utilization* (prenatal care begun by the 4th month and 110 percent or more of recommended visits received).

Self-reported information about cigarette smoking is included in the detailed natality files for women from every state with the exception of California. In order to include women who live in the state of California in the analyses, two dichotomous variables, *smokes* and *California*, were included in the models. The *smokes* measure indicates whether the woman smoked any number of cigarettes during her pregnancy, and the *California* measure indicates whether the woman is a resident of the state of California (the only state where smoking status is not reported). Both of these dichotomous measures (smokes and California) were compared to non-smokers (reference group) in the models.

The birth records do not include information on the woman's nutritional status throughout her pregnancy, but they do provide information on weight gain during pregnancy, which has previously been used as a proxy for maternal nutritional status in previous studies on maternal health (Sparks, McLaughlin, and Stokes 2009). Following Sparks (2009), *maternal weight gain* during pregnancy was measured as a set of three dichotomous variables: low weight gain (15 pounds or less), average weight gain (16 through 40 pounds), and high weight gain (40 pounds or more), with average weight gain as the reference category.

Previous studies have reported HDP to be more common among women having their first birth compared with women having a higher order birth (American Pregnancy Association 2012). Therefore, a dichotomous variable, *first birth*, was included in the models that indicates whether this birth is the woman's first (coded 1) or higher order birth (coded 0).

County-level Measures

Principal components analysis was used to determine which county-level measures were included in the different dimensions of rurality (ecological, occupational, and sociocultural). Because I wanted to examine measures of 'rurality,' those variables where higher scores indicated more urban (e.g., population density) were transformed using an inverse transformation prior to including them in the principal components analysis. This allowed for each of the dimensions of rurality to all be measured in the same direction.

The *ecological dimension of rurality* included population density (the inverse of the total population living in the county divided by the land area in miles of the county; factor loading: 0.773), workers who work outside of their county (the percentage of the working population in the county that works outside of their residential county; factor loading: -0.743), workers using public transportation (the inverse of the percentage of workers in the county who commute to work using public transportation; factor loading 0.237). The ecological dimension of rurality had an eigenvalue of 1.210 and explained 40.323 percent of the variance. The descriptive statistics for each of the variables that went into the ecological dimension of rurality measures as well as the other county-level composite measure used in this study are displayed in Table 3.3.

Table 3.3 Descriptive statistics for the variables that go into the county-level composite measures

Variables	Mean	Standard Deviation
	Minimum	*Maximum*
Ecological Dimension of Rurality		
Population density (inverse)	0.10	0.28
	0.00	*4.33*
% Work outside county	34.13	17.75
	1.50	*92.16*
% Use public transportation for work (inverse)	99.02	3.04
	38.46	*100.00*
Occupational Dimension of Rurality		
% Professional/managerial occupations (inverse)	70.44	6.37
	33.80	*88.63*
% Construction/mining occupations	11.65	3.43
	1.73	*27.47*
% Farming/forestry/fishing occupations	2.12	2.67
	0.00	*37.89*
Sociocultural Dimension of Rurality		
Bachelors degree or higher (inverse)	81.34	8.51
	30.53	*95.43*
Poverty rate	15.45	0.06
	0.00	*52.38*
% Married ages 15-24	9.53	6.72
	0.00	*79.59*
% Religious adherents	51.11	19.04
	0.00	*100.00*
Availability of Health Care		
OB/GYN physicians per 1,000 population	0.05	0.07
	0.00	*90.00*
Medical doctors per 1,000 population	1.22	1.51
	0.00	*29.35*
% Population under 65 year insured	68.19	7.15
	28.31	*87.91*

Non-Health Provider Shortage Area	26.00	43.70
	0.00	*1.00*

The *occupational dimension of rurality* included professional/managerial occupations (the inverse of the percentage of the civilian population ages 16 years of age and older who are in the workforce and are employed in professional or managerial occupations; factor loading 0.846), construction/mining occupations (the percentage of the civilian population ages 16 years of age and older who are in the workforce and employed in construction or mining occupations; factor loading 0.846) and farming, forestry, or fishing occupations (the percentage of the civilian population ages 16 years of age or older in the workforce and employed in agriculture, forestry, or fishing occupations: factor loading 0.044). The occupational dimension of rurality has an eigenvalue of 1.434 and 47.793 percent of the variance is explained.

The *sociocultural dimension of rurality* was comprised of both social and cultural attributes, and included measures of education (the inverse of the percentage of the population ages 25 years of age or older in a county with a bachelors or higher degree: factor loading 0.867), poverty (the percentage of the total population in a county for whom the poverty status was determine and is below the poverty level: factor loading 0.699), early marriage (the percentage of the population ages 15 through 24 years of age and married: factor loading 0.450), and religious adherents (the percentage of the population ages 5 years of age and older who adheres to any major religion: factor loading 0.161). The sociocultural dimension of rurality has an eigenvalue of 1.470 and explains 36.740 percent of the variance.

The measure of income inequality that was used in this analysis is the *Gini index*. The Gini coefficient is a ratio, which ranges from 0 to 1. The numerator is the area between the Lorenz Curve of the household income distribution and the uniform distribution line, and the denominator is the area under the uniform distribution line. Therefore, a smaller Gini coefficient indicates a more even distribution of household income. The Gini index is calculated by multiplying the Gini coefficient by 100, and hence, values can range from 0 (perfect income equality) to 100 (extreme income inequality).

Principal components analysis was used to determine the county-level *availability of health care* measure. The availability of health care measure included measures of OB/GYN physicians (the number of Obstetrician/Gynecologists per 1,000 population in a county; factor loading 0.914), medical doctors (the number of medical doctors per 1,000 population in a county; factor loading 0.910), health insurance (the percentage of the population under 65 years of age in a county with health insurance coverage; factor loading 0.383), hospital beds (the number of hospital beds per 1,000 population in a county; factor loading 0.316), non-health provider shortage areas (counties were not considered to be whole or part health provider shortage areas; factor loading 0.285). The eigenvalue for the availability of health care measure is 1.993 and explains 39.856 percent of the variance.

Methodology

The methodology that was used for this dissertation is described in this section. First, a discussion of the analytical approach is presented. This includes a discussion of the sets of regression analyses that were estimated for this dissertation. Following this discussion, the equations for each of the models that were estimated in the dissertation are presented. A detailed description of each of these equations is provided.

Analytical Approach

In order to examine the factors associated with the odds of a woman experiencing HDP, two separate sets of regression analyses were conducted. First, individual-level characteristics of women based on data on women who lived and delivered a live birth during the 2007 calendar year within the continental United States were included in a model predicting the odds of a woman experiencing HDP. Individual-level demographic and behavioral characteristics were considered in this model. These results are presented in Chapter 4.

Second, because a two-level hierarchical structure characterizes this data, with pregnant women nested within their county of residence, the individual-level data are clustered. Observations within clusters, or women living within the same county, tend to be exposed to similar residential environments compared to those chosen at random. The residential clustering makes the common methods of estimation, such as logistic regression, inappropriate for this study, because the observations are not mutually independent. If the clustered nature of the data were to be ignored, this would result in biased standard errors and the likely overestimation of statistical significance.

Multilevel modeling techniques provide several advantages over traditional regression techniques (e.g., ordinary least squares regression or logistic regression), including the ability to partition the variance within and between the level-2 unit of analysis, which in this case is the mother's county of residence (Ulmer and Johnson 2004). This allows researchers to determine the amount of variation that exists at each level of the analysis (Ulmer and Johnson 2004). Considering that women are nested within the counties in which they reside, exposure to the factors for HDP may be similar, and this needs to be accounted for in the analyses. Multilevel modeling techniques are uniquely useful when associations of interest arise from within counties, and for identifying whether residential context has an impact on an individual's health status, even after individual characteristics are controlled (Subramanian, Duncan, and Jones 2001).

In addition, because predictors of HDP may not be limited to individual-level maternal demographic and behavioral characteristics, multilevel logistic regression models were estimated to identify whether the characteristics of counties in which women live affect the odds of a woman experiencing HDP. The multilevel models were estimated in HLM 6 (HLM 2008). By estimating the models using this software, robust standard errors and unbiased estimates of the relationships with HDP were provided, because a random component specific to each county (u_{0j}) is added to the intercept (Raudenbush and Bryk 2002).

As previously noted, the dependent variable examined in this study, *HDP*, was measured as a dichotomous variable, where a woman is assigned a value of 1 if she has experienced a hypertensive disorder of pregnancy (gestational hypertension (preeclampsia) or eclampsia) and assigned a value of 0 if she has not. The Bernoulli distribution is used for these analyses, because this type of estimation allows for the dependent variable to have a value of 0 or 1.

In order to further examine whether multilevel modeling is an appropriate analytic strategy for this study, a null model with no explanatory variables included in the model was estimated. This basic model (Equation 3.1) was used to establish justification for multilevel modeling in this study:

Equation 3.1

Level-1 model

$$n_{ij} = \log\left(\frac{\phi_{ij}}{1-\phi_{ij}}\right) = \beta_{oj} + r_{ij}$$

Level-2 model

$$\beta_{oj} = \gamma_{00} + u_{oj}$$

Combined model

$$n_{ij} = \log\left(\frac{\phi_{ij}}{1-\phi_{ij}}\right) = \gamma_{00} + u_{0j} + r_{ij}$$

where

n_{ij}	is the log odds of experiencing HDP for the *i*th woman in the *j*th county
ϕ_{ij}	is the probability of reporting HDP
r_{ij}	is the random effect for the *i*th woman in the *j*th county
γ_{00}	is the intercept in the data
u_{oj}	is the random effect for the *j*th county

The null model results, which are presented in Table 4.2, included a statistically significant variance of the intercept, which indicated that multilevel modeling was an appropriate analytical approach for this study. The null model is the equivalent of a one-way analysis of variance (ANOVA). A statistically significant intercept indicates the proportion of women experiencing HDP (i.e., proportion of women who are coded as 1) is significantly different across counties. The random effect represents the between county variance. Since the results of the null model indicated that multilevel modeling was an appropriate analytical approach, this study investigated the relationship between individual- and county-level predictors of HDP among both rural and urban women across the continental United States utilizing multilevel modeling techniques.

After determining that multilevel modeling was an appropriate analytical technique for this study, all individual-level covariates were included in the model:

Equation 3.2

Level-1 model

$$n_{ij} = \log\left(\frac{\phi_{ij}}{1-\phi_{ij}}\right) = \beta_{0j} + \beta_{1j}x_{Age19orYounger} + \beta_{2j}x_{Age35orOlder} + \beta_{3j}x_{Black} + \beta_{4j}x_{AIAN} + \beta_{5j}x_{Asian} +$$
$$\beta_{6j}x_{Hispanic} + \beta_{7j}x_{Married} + \beta_{8j}x_{LessThanHS} + \beta_{9j}x_{HighSchool} + \beta_{10j}x_{SomeCollege} + \beta_{11j}x_{Smokes} +$$
$$\beta_{12j}x_{California} + \beta_{13j}x_{LowGain} + \beta_{14j}x_{HighGain} + \beta_{15j}x_{FirstBirth} + \beta_{16j}x_{Intermediate} + \beta_{17j}x_{Adequate} +$$
$$\beta_{18j}x_{AdequatePlus} + r_{ij}$$

Level-2 model

$$\beta_{0j} = \gamma_{00} + u_{0j}$$
$$\beta_{1j} = \gamma_{10}$$
$$\beta_{2j} = \gamma_{20}$$
$$\beta_{3j} = \gamma_{30}$$
$$\beta_{4j} = \gamma_{40}$$
$$\beta_{5j} = \gamma_{50}$$
$$\beta_{6j} = \gamma_{60}$$
$$\beta_{7j} = \gamma_{70}$$
$$\beta_{8j} = \gamma_{80}$$
$$\beta_{9j} = \gamma_{90}$$
$$\beta_{10j} = \gamma_{100}$$
$$\beta_{11j} = \gamma_{110}$$
$$\beta_{12j} = \gamma_{120}$$
$$\beta_{13j} = \gamma_{130}$$
$$\beta_{14j} = \gamma_{140}$$
$$\beta_{15j} = \gamma_{150}$$
$$\beta_{16j} = \gamma_{160}$$
$$\beta_{17j} = \gamma_{170}$$
$$\beta_{18j} = \gamma_{180}$$

Combined model

$$n_{ij} = \log\left(\frac{\phi_{ij}}{1-\phi_{ij}}\right) = \gamma_{00} + u_{0j} + \gamma_{10}x_{Age19orYounger} + \gamma_{20}x_{Age35orOlder} + \gamma_{30}x_{Black} + \gamma_{40}x_{AIAN} +$$
$$\gamma_{50}x_{Asian} + \gamma_{60}x_{Hispanic} + \gamma_{70}x_{Married} + \gamma_{80}x_{LessThanHS} + \gamma_{90}x_{HighSchool} + \gamma_{100}x_{SomeCollege} +$$
$$\gamma_{110}x_{Smokes} + \gamma_{120}x_{California} + \gamma_{130}x_{LowGain} + \gamma_{140}x_{HighGain} + \gamma_{150}x_{FirstBirth} + \gamma_{160}x_{Intermediate} +$$
$$\gamma_{170}x_{Adequate} + \gamma_{180}x_{AdequatePlus} + r_{ij}$$

where

n_{ij} is the log odds of experiencing HDP for the *i*th woman in the *j*th county

ϕ_{ij} is the probability of reporting HDP

r_{ij} is the random effect for the *i*th woman in the *j*th county

γ_{00} is the intercept in the data

γ_{10} is the fixed effect of age 19 or younger

γ_{20} is the fixed effect of age 35 or older

γ_{30} is the fixed effect of Black

γ_{40} is the fixed effect of American Indian/Alaskan Native

γ_{50} is the fixed effect of Asian

γ_{60} is the fixed effect of Hispanic

γ_{70} is the fixed effect of married

γ_{80} is the fixed effect of less than high school

γ_{90} is the fixed effect of high school or equivalent degree

γ_{100} is the fixed effect of some college or Associate’s degree

γ_{110} is the fixed effect of smokes

γ_{120} is the fixed effect of California

γ_{130} is the fixed effect of low weight gain

γ_{140} is the fixed effect of high weight gain

γ_{150} is the fixed effect of first birth

γ_{160} is the fixed effect of intermediate prenatal care utilization

γ_{170} is the fixed effect of adequate prenatal care utilization

γ_{180} is the fixed effect of adequate plus prenatal care utilization

u_{oj} is the random effect for the *j*th county

The model in Equation 3.2 allows for the first three hypotheses of this study to be tested. These are the hypotheses that maternal demographic and behavioral characteristics are associated with HDP.

Fundamental to developing a multilevel model is the specification of the models at each level and the combination of these models into an overall model. The micromodel (level-1) represents the 'within-place' equation and the macromodel (level-2) represents the 'between-place' equation (Subramanian, Duncan, and Jones 2001). In this case, the level-2 measures were added to the model and Equation 3.2 was expanded into Equation 3.3:

Equation 3.3

$$n_{ij} = \log\left(\frac{\phi_{ij}}{1-\phi_{ij}}\right) = \gamma_{00} + u_{0j} + \gamma_{10}x_{Age19orYounger} + \gamma_{20}x_{Age35orOlder} + \gamma_{30}x_{Black} + \gamma_{40}x_{AIAN} + \gamma_{50}x_{Asian} + \gamma_{60}x_{Hispanic} + \gamma_{70}x_{Married} + \gamma_{80}x_{LessThanHS} + \gamma_{90}x_{HighSchool} + \gamma_{100}x_{SomeCollege} + \gamma_{110}x_{Smokes} + \gamma_{120}x_{California} + \gamma_{130}x_{LowGain} + \gamma_{140}x_{HighGain} + \gamma_{150}x_{FirstBirth} + \gamma_{160}x_{Intermediate} + \gamma_{170}x_{Adequate} + \gamma_{180}x_{AdequatePlus} + \sum \gamma_{01}\omega_{lj} + r_{ij}$$

where

γ_{01} is the direct effect of county characteristics *l*

ω_{lj} is the county characteristic feature *l* of the *j*th county

β_{kj} is the fixed effect of woman covariate *k*

x_{ijk} is the covariate *k of* woman *i* in county *j*

The impact of individual characteristics may vary from place to place and the impact of residential context may vary from person to person; therefore, it is necessary to test these cross-level interactions in order to tease out the relevant effects on health (Verheij 1996). Therefore, this study tested possible cross-level interactions, because interactions between individual- and county-level characteristics deserve special attention. Living in a particular type of area (e.g., a more rural area or an area with less availability of healthcare) may be related to other types of individual-level variables as they affect health (Verheij 1996). To test whether county characteristics moderate the relationships between race and ethnicity and HDP for example, the interactions between maternal race and ethnicity and county characteristics need to be considered in the multilevel logistic regression model:

Equation 3.4

$$\beta_{Black,j} = \gamma_{30} + \sum \gamma_{Black,l}\omega_{lj} + u_{3j}$$
$$\beta_{AIAN,j} = \gamma_{40} + \sum \gamma_{AIAN,l}\omega_{lj} + u_{4j}$$
$$\beta_{Asian,j} = \gamma_{50} + \sum \gamma_{Asian,l}\omega_{lj} + u_{5j}$$
$$\beta_{Hispanic,j} = \gamma_{60} + \sum \gamma_{Hispanic,l}\omega_{lj} + u_{6j}$$

where

$\gamma_{Black,l}$ is the moderating effect of Black of the county feature *l*

$\gamma_{AIAN,l}$ is the moderating effect of American Indian/Alaskan Native of the county feature *l*

$\gamma_{Asian,l}$ is the moderating effect of Asian of the county feature *l*

$\gamma_{Hispanic,l}$ is the moderating effect of Hispanic of the county feature *l*

$$n_{ij} = \log\left(\frac{\phi_{ij}}{1-\phi_{ij}}\right) = \gamma_{00} + u_{0j} + \gamma_{10}x_{Age19orYounger} + \gamma_{20}x_{Age35orOlder} +$$
$$\left(\gamma_{30} + \sum \gamma_{Black,l}\omega_{lj} + u_{3j}\right)x_{Black} + \left(\gamma_{40} + \sum \gamma_{AIAN,l}\omega_{lj} + u_{4j}\right)x_{AIAN} +$$
$$\left(\gamma_{50} + \sum \gamma_{Asian,l}\omega_{lj} + u_{5j}\right)x_{Asian} + \left(\gamma_{60} + \sum \gamma_{Hispanic,l}\omega_{lj} + u_{6j}\right)x_{Hispanic} +$$
$$\gamma_{70}x_{Married} + \gamma_{80}x_{LessThanHS} + \gamma_{90}x_{HighSchool} + \gamma_{100}x_{SomeCollege} +$$
$$\gamma_{110}x_{Smokes} + \gamma_{120}x_{California} + \gamma_{130}x_{LowGain} + \gamma_{140}x_{HighGain} + \gamma_{150}x_{FirstBirth} +$$
$$\gamma_{160}x_{Intermediate} + \gamma_{170}x_{Adequate} + \gamma_{180}x_{AdequatePlus} + \sum \gamma_{01}\omega_{lj} + r_{ij}$$

If $\gamma_{Black,l}$, $\gamma_{AIAN,l}$, $\gamma_{Asian,l}$, or $\gamma_{Hispanic,l}$ are found to be statistically significant, then this indicates that the associations of these maternal factors and HDP vary as a function of the county characteristics measures.

In addition to testing whether county characteristics moderate the relationships between race and ethnicity and HDP, I also tested whether county characteristics moderate the relationships between maternal education and HDP. The interactions between maternal education and county characteristics were tested using the multilevel logistic regression model:

Equation 3.5

$$\beta_{LessThanHS,j} = \gamma_{80} + \sum \gamma_{LessThanHS,l}\omega_{lj} + u_{8j}$$
$$\beta_{HighSchool,j} = \gamma_{90} + \sum \gamma_{HighSchool,l}\omega_{lj} + u_{9j}$$
$$\beta_{SomeCollege,j} = \gamma_{100} + \sum \gamma_{SomeCollege,l}\omega_{lj} + u_{10j}$$

where

$\gamma_{LessThanHS,l}$ is the moderating effect of less than high school of the county feature *l*

$\gamma_{HighSchool,l}$ is the moderating effect of high school or equivalent degree of the county feature *l*

$\gamma_{SomeCollege,l}$ is the moderating effect of some college or Associate's degree of the county feature *l*

$$n_{ij} = \log\left(\frac{\phi_{ij}}{1-\phi_{ij}}\right) = \gamma_{00} + u_{0j} + \gamma_{10}x_{Age19orYounger} + \gamma_{20}x_{Age35orOlder} + \gamma_{30}x_{Black} + \gamma_{40}x_{AIAN} +$$
$$\gamma_{50}x_{Asian} + \gamma_{60}x_{Hispanic} + \gamma_{70}x_{Married} + \left(\gamma_{80} + \sum \gamma_{LessThanHS,l}\omega_{lj} + u_{8j}\right)x_{LessThanHS} +$$
$$\left(\gamma_{90} + \sum \gamma_{HighSchool,l}\omega_{lj} + u_{9j}\right)x_{HighSchool} + \left(\gamma_{100} + \sum \gamma_{SomeCollege,l}\omega_{lj} + u_{10j}\right)x_{SomeCollege} +$$
$$\gamma_{110}x_{Smokes} + \gamma_{120}x_{California} + \gamma_{130}x_{LowGain} + \gamma_{140}x_{HighGain} + \gamma_{150}x_{FirstBirth} +$$
$$\gamma_{160}x_{Intermediate} + \gamma_{170}x_{Adequate} + \gamma_{180}x_{AdequatePlus} + \sum \gamma_{01}\omega_{lj} + r_{ij}$$

If $\gamma_{LessThanHS,l}$, $\gamma_{HighSchool,l}$, or $\gamma_{SomeCollege,l}$ are found to be statistically significant, then this indicates that the associations of these maternal factors and HDP vary as a function of the county characteristics measures. This study also tests cross-level interactions for the dimensions of rurality with maternal age, marital status, maternal smoking during pregnancy, maternal weight gain, and prenatal care utilization. In addition, this study tests whether the effect of each of these individual-level characteristics on HDP vary across the level of health care that is available in the woman's residential county. The equations for each of these models are not displayed here, but are available upon request.

Conclusion

This chapter included information about the secondary data sources that were used to construct the individual-level and county-level measures, a detailed description of how the variables were measured for the analysis, presented the descriptive statistics, and concluded with a detailed discussion of the analytic strategy and multilevel logistic regression model equations that were used to test the proposed hypotheses.

The results of the individual-level models are presented in Chapter 4: "Demographic and Behavioral Characteristics: The Relationship between Individual-level Characteristics and Hypertensive Disorders of Pregnancy." The results of the multilevel logistic regression models that include the dimensions of rurality and the other county-level measures are presented in Chapter 5: "Rurality, Income Inequality, and Health Care Service Availability: How Residential Context is Associated with Hypertensive Disorders of Pregnancy." In addition, the results of the cross-level interaction effects are also presented in Chapter 5, followed by a discussion of these results. These models show how the effects of the individual-level characteristics vary across the levels and dimensions of rurality and across the level of health care that is available in the mother's county of residence.

Chapter 4

Demographic and Behavioral Characteristics:
The Relationship between Individual-level Characteristics and Hypertensive Disorders of Pregnancy

Introduction

This chapter reports the descriptive statistics for the dependent variable, HDP, as well as for each of the individual-level measures of mother's characteristics included in the analyses. The results of the descriptive statistics are displayed in Table 4.1 and are discussed in the following section. In addition, the results of the multilevel logistic regression models that include only the individual-level predictors are displayed in Table 4.2. The results of these models are discussed in the final section.

Individual-level Measure Descriptive Statistics

The descriptive statistics for the measure of HDP as well as the descriptive statistics for each of the individual-level independent variables are displayed in Table 1. The means and standard deviations for each of the measures are reported in the table. Each of the measures used in these analyses is measured as a dichotomous variable, the mean values represent the proportion of the women with the characteristics reported coded as 1. As shown in Table 1, on average, 4 percent of women who live in the continental United States in 2007 and delivered a singleton live birth experienced HDP. While this average is slightly lower than the 5 to 10 percent of women that has been reported in the previous literature (Bryson, Ioannou, Rulyak, and Critchlow 2003; Sibai et al. 1997), this difference may be attributable to the fact that the results presented here are restricted to women who delivered singleton births. The risk of a woman experiencing HDP is higher among woman carrying multiple babies (Senat, Ancel, Bouvier-Colle, and Breart 1998), likely accounting for the small difference in the results presented here and the results presented in previous studies.

The women in this sample varied across the demographic characteristics examined. As for maternal age, 11 percent of the women were 19 years of age or younger, and 14 percent of women were 35 years of age or older, with 75 percent in the 20 to 34 year age group (the reference category in the regression models). The women in this sample also varied across racial and ethnic groups. Sixteen percent of women were Black, one percent of women were American Indian or Alaskan Native, and 6 percent of women were Asian. White women, the reference group, comprised 77 percent of the sample. Regardless of their racial background, 25 percent of women reported Hispanic ethnicity and 75 percent of women were non-Hispanic (the reference category in the regression models).

Sixty percent of the women in this sample were married at the time of their infant's birth. Twenty-one percent of women had less than a high school degree, 29 percent of women had a high school diploma or an equivalent degree, and 24 percent of women had some college education or an Associate's degree. The rest, those with four years of college or more, comprised 26 percent of the women.

As for the maternal health risk behaviors, 9 percent of women smoked while they were pregnant and 14 percent of women were from the state of California where maternal smoking status is not reported on the birth certificate. On average, 14 percent of women had low weight gain during pregnancy, and 20 percent of women had high weight gain during pregnancy. The rest, 66 percent, had average maternal weight gain. Forty-one percent of the women in the sample were delivering their first birth. As for prenatal care utilization, 13 percent of women in the sample received intermediate prenatal care, 40 percent of women received adequate prenatal care, and 32 percent of women received adequate plus prenatal care. Fifteen percent of women had inadequate care (the reference group).

Table 4.1 Descriptive statistics of hypertensive disorders of pregnancy and the independent variables at the individual-level

Variables	Proportion
Individual-level measures (N=3,451,144)	
Hypertensive disorders of pregnancy	0.04
Maternal age (Age 20-34=reference)	
Age 19 or younger	0.11
Age 35 and older	0.14
Race (White=reference)	
Black	0.16
American Indian/Alaskan Native	0.01
Asian	0.06
Ethnicity	
Hispanic	0.25
Marital status	
Married	0.60
Maternal education (BA or higher=reference)	
Less than High School	0.21
High school/GED	0.29
Some college/Associate's degree	0.24
Maternal smoking during pregnancy	
Mother smokes	0.09
Mother from California	0.14
Low weight gain	0.14
High weight gain	0.20
Parity	
First birth	0.41
Prenatal Care Utilization (Inadequate=reference)	
Intermediate care	0.13
Adequate care	0.40
Adequate plus care	0.32

Note: The values represent the proportion of the groups coded 1 on each category.

Multilevel Logistic Regression Results

The results of the null model and the multilevel logistic regression model that include only the individual-level predictors are discussed in the following sections. The results of these models are displayed in Table 4.2.

Null Model Results

The results of the null model (i.e., the model with no explanatory variables included in the model) and the multilevel logistic regression model with individual women's characteristics predicting the odds of a woman experiencing HDP are presented in Table 4.2. In addition, these results are discussed in this chapter. The intercept in the null model was statistically significant, which indicated that the proportion of women who experienced HDP is significantly different across counties. The random effect (i.e., intercept variance component) represents the between county variance, which in this case is 19 percent. The results of the model estimating the individual-level maternal demographic and behavioral characteristics and their relationship with the odds of experiencing HDP are discussed in the following sections.

Table 4.2 Multilevel logistic regression models predicting the odds of hypertensive disorders of pregnancy with women's characteristics

Variables	Null Model	Model II
Individual-level measures (N=3,451,144)		
Intercept	0.05***	0.02***
Maternal age (Age 20-34=reference)		
Age 19 or younger		0.85***
Age 35 and older		1.33***
Race (White=reference)		
Black		1.20***
American Indian/Alaskan Native		1.22***
Asian		0.60***
Ethnicity		
Hispanic		0.87***
Marital status		
Married		1.05***
Maternal education (BA or higher=reference)		
Less than High School		1.05***
High school/GED		1.18***
Some college/Associate's degree		1.23***
Maternal smoking during pregnancy		
Mother smokes		0.81***
Mother from California		0.54***
Weight gain during pregnancy (Average weight gain=reference)		
Low weight gain		1.14***
High weight gain		1.56***
Parity		
First birth		2.04***
Prenatal Care Utilization (Inadequate=reference)		
Intermediate care		0.73***
Adequate care		0.86***
Adequate plus care		1.69***
Variance Components		

Intercept	0.19***	0.18***

Note: Results are reported in Odds Ratios; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Individual-level Model Results

The results of the multilevel logistic regression models that included only individual-level predictors are presented and discussed in this section.

Maternal Demographic Characteristics

A statistically significant relationship was identified between each of the maternal demographic characteristics and HDP. For those women who are 19 years of age or younger, the odds of experiencing HDP are approximately 16 percent lower than they are for women 20 to 34 years of age. On the other hand, women who are 35 years of age or older are approximately 33 percent more likely to experience HDP compared to women who are 20 through 34 years of age.

When compared to white women, Black women are approximately 20 percent and American Indian/Alaskan Native women are approximately 22 percent more likely to experience HDP. However, Asian women are 40 percent less likely to experience HDP compared to white women. Compared to non-Hispanic women, Hispanic women are 13 percent less likely to experience HDP.

Married women are 5 percent more likely to experience HDP compared to women who were not married at the time their infant was born. As for the relationship between maternal education and HDP, in general, those women with less education were more likely to experience this disease. Specifically, compared to women with a bachelor's or higher degree, women with less than a high school degree are 5 percent more likely to experience HDP, women with a high school degree or an equivalent degree are 18 percent more likely to experience HDP, and women with some college education or an Associate's degree are 23 percent more likely to experience HDP.

Maternal Behavioral Characteristics

Each of the maternal behavioral characteristics considered in this study is significantly associated with HDP. As identified in previous studies, women who smoke during their pregnancy are less likely to experience HDP. Specifically, those women who smoked while they were pregnant are 19 percent less likely to experience hypertensive disorders during their pregnancy. In addition, mothers who lived in California, which is the only state where maternal smoking status is not reported, are 46 percent less likely to experience HDP.

Maternal weight gain during pregnancy, which was treated as a proxy for maternal nutritional status, was significantly associated with HDP. Women whose weight gain during pregnancy was low are 14 percent more likely to experience HDP and women whose weight gain during pregnancy was high are 56 percent more likely to experience HDP compared to women whose weight gain during pregnancy was average.

As the literature suggested, women who are pregnant with their first baby are significantly more likely to experience HDP. When compared to women who were pregnant with their second, third, or higher order birth, women who were pregnant with their first birth are over two times more likely to experience HDP.

Prenatal care utilization was significantly associated with HDP. Compared to women who received inadequate prenatal care, women who received intermediate prenatal care are approximately 27 percent less likely to experience HDP and women who received adequate prenatal care are 14 percent less likely to experience HDP. Women who received adequate plus prenatal care are approximately 69 percent more likely to experience HDP compared to women who received inadequate prenatal care. Women who experience complications during pregnancy may be attending more prenatal care appointments because of their condition, and the number of prenatal care appointments attended is captured in the measurement of the adequacy of prenatal care index. The adequacy of prenatal care was measured by the month the woman began attending prenatal care appointments and the number of appointments the woman attended, adjusted for gestational age, but does not take into account the woman's condition (Kotelchuck 1994a; Kotelchuck 1994b). In addition, the Adequacy of Prenatal Care Index does not take into account the quality of the prenatal care that was provided. Therefore, women who received adequate plus prenatal care could be the women who received poorer quality care.

Conclusions

This chapter described the descriptive statistics for the dependent variable, HDP, as well as each of the individual-level measures included in the analyses. It also reported the results of the multilevel logistic regression models that include only the individual-level predictors. All of the individual-level predictors were significantly associated with HDP. The results of the multilevel logistic regression models that include both the individual- and county-level predictors are presented and described in the following chapter. The following chapter also includes a discussion of the multilevel logistic regression models that test for the cross-level interaction effects.

Chapter 5

Rurality, Income Inequality, and Health Care Service Availability: How Residential Context is Associated with Hypertensive Disorders of Pregnancy

Introduction

This chapter presents the results of the descriptive statistics for the county-level measures included in the analyses. These are displayed in Table 5.1. In addition, the results of the multilevel logistic regression models that include both the individual-level predictors and each dimension of rurality estimated separately are displayed in Table 5.2. The results of these models are discussed following the descriptive statistics results section. In Table 5.3, the results of the models that include the dimensions of rurality simultaneously (Model I), with income inequality (Model II), and availability of health care (Model III) are displayed. In addition, the results of the models that include the cross-level interactions are also discussed in this chapter and the results of these models are displayed in Tables 5.4-5.17.

County-level Measure Descriptive Statistics Results

The dimensions of rurality and the availability of health care measures were created using principal components analysis. These measures have a mean of 0 and a standard deviation of 1. As previously noted, the Gini index values can range from 0 (perfect income equality) to 100 (extreme income inequality). The Gini index for the average county in the continental United States is 43.

Table 5.1 Descriptive statistics of the county-level variables

Variables	Mean *Minimum*	Standard Deviation *Maximum*
County-level measures (N=3,096)		
Dimensions of rurality		
Ecological dimension†	0.00	1.00
	-4.62	*10.24*
Occupational dimension†	0.00	1.00
	-4.62	*3.95*
Sociocultural dimension†	0.00	1.00
	-4.61	*3.25*
County characteristics		
Gini index	0.43	0.04
	0.27	*0.62*
Availability of health care†	0.00	1.00
	-1.69	*15.12*

Note: † indicates the variable is a composite measure that was created from principal components analysis.

Multilevel Logistic Regression Results

Dimensions of Rurality and Their Association with Hypertensive Disorders of Pregnancy

In Table 5.2, the results of the multilevel logistic regression models predicting the odds of HDP with the individual-level and county-level dimensions of rurality measures are displayed. The dimensions of rurality measures were included in the models independently, so their unique effect on HDP could be determined. The ecological dimension of rurality was included in Model I, the occupational dimension was included in Model II, and the sociocultural dimension was in Model III. The inclusion of each of the dimensions of rurality measures did not affect the estimated coefficients for the individual-level characteristics when compared to the model with only individual counties, so these are not described in the text, but they are reported in the tables.

Table 5.2 Multilevel logistic regression models of the effects of the ecological, occupational, and sociocultural dimensions of rurality on hypertensive disorders of pregnancy

Variables	Model I	Model II	Model III
Individual-level measures (N=3,451,144)			
Intercept	0.02***	0.02***	0.02***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.84***	0.84***	0.84***
Age 35 and older	1.33***	1.33***	1.33***
Race (White=reference)			
Black	1.20***	1.20***	1.19***
American Indian/Alaskan Native	1.21***	1.22***	1.21***
Asian	0.60***	0.60***	0.60***
Ethnicity			
Hispanic	0.87***	0.87***	0.87***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.05***	1.05***
High school/GED	1.18***	1.18***	1.18***
Some college/Associate's degree	1.23***	1.23***	1.23***
Maternal smoking during pregnancy			
Mother smokes	0.81***	0.81***	0.81***
Mother from California	0.54***	0.56***	0.57***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.14***	1.14***
High weight gain	1.56***	1.56***	1.56***
Parity			
First birth	2.04***	2.04***	2.04***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.73***	0.73***	0.73***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.69***	1.69***	1.69***

County-level measures (N=3,096)			
Dimensions of Rurality			
Ecological Dimension†	1.04***		
Occupational Dimension†		1.07***	
Sociocultural Dimension†			1.07***
Variance Components			
Intercept	0.18***	0.17***	0.17***

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

As reported in Table 5.2, each of the dimensions of rurality is significantly associated with HDP. Controlling for the individual-level covariates, a one standard deviation increase in the ecological dimension of rurality increases the odds of a woman experiencing HDP by 4 percent. In Model II, a one standard deviation increase in the occupational dimensions of rurality is associated with a 7 percent increase in the odds of a woman experiencing HDP. Model III shows that a one standard deviation increase in the sociocultural dimension of rurality is associated with an increase in the odds of a woman experiencing HDP by 7 percent.

Dimensions of Rurality and Other Residential County Characteristics and Their Relationship with Hypertensive Disorders of Pregnancy

In the models reported in Table 5.3, each of the three dimensions of rurality was included in the models simultaneously. When the dimensions of rurality were included in the models simultaneously with no other county-level predictors (Model I), each of the dimensions of rurality has the same effect on HDP. Specifically, with every one standard deviation increase in the ecological, occupational, or sociocultural dimension of rurality in a county, the odds of a woman experiencing HDP increase by 4 percentage points.

The county-level measure of income inequality was included in the model with the three dimensions of rurality in Model II; however, the Gini index was not significantly related to HDP. As the Gini index was not significantly related to HDP while controlling for rurality, as well as when it is included in the model with no other county-level covariates or when it is included in the model with rurality and availability of health care (results not shown), the Gini index was not included in any of the other models tested in this study.

The availability of health care measure was added to the model with the dimensions of rurality measures in Model III. When controlling for availability of health care in the county, the effect of the occupational dimension of rurality on HDP was slightly reduced (3 percent increase), while the effect of the ecological and sociocultural dimensions on HDP remained the same (4 percent increase). With every one standard deviation increase in the availability of health care in a county, the odds of a woman experiencing HDP decreased by 3 percentage points.

Table 5.3 Multilevel logistic regression models of the effects of rurality, income inequality, and availability health care on hypertensive disorders of pregnancy

Variables	Model I	Model II	Model III
Individual-level measures (N=3,451,144)			
Intercept	0.02***	0.03***	0.02***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.84***	0.84***	0.84***
Age 35 and older	1.33***	1.33***	1.33***
Race (White=reference)			
Black	1.20***	1.20***	1.20***
American Indian/Alaskan Native	1.21***	1.21***	1.21***
Asian	0.60***	0.60***	0.60***
Ethnicity			
Hispanic	0.87***	0.87***	0.87***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.05***	1.05***
High school/GED	1.17***	1.17***	1.17***
Some college/Associate's degree	1.23***	1.23***	1.23***
Maternal smoking during pregnancy			
Mother smokes	0.81***	0.81***	0.81***
Mother from California	0.56***	0.57***	0.56***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.14***	1.14***
High weight gain	1.56***	1.56***	1.56***
Parity			
First birth	2.04***	2.04***	2.04***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.73***	0.73***	0.73***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.69***	1.69***	1.69***
County-level measures (N=3,096)			

Dimensions of Rurality			
Ecological Dimension†	1.04**	1.04**	1.04**
Occupational Dimension†	1.04**	1.03*	1.03*
Sociocultural Dimension†	1.04***	1.05***	1.04**
County characteristics			
Gini index		0.54	
Availability of health care†			0.97*
Variance Components			
Intercept	0.17***	0.17***	0.17***

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Do the Individual-level Predictors of Hypertensive Disorders of Pregnancy Vary Across the Levels and Dimensions of Rurality?

For each of the cross-level interactions that are tested in this study, the model is first estimated with a random error term included in the model for the cross-level interaction. By including the random error term in the model, this allows the slopes to vary (i.e., the effect can vary within counties). In the event that the variance component for the cross-level interaction is not statistically significant, this means that the effect does not significantly vary within counties. In this case, the model needs to be re-estimated with the random error term removed from the cross-level interaction so that the slopes are no longer allowed to vary. Once the random error is removed from the cross-level interaction, the model only allows the intercept to vary. The effect can vary *across* counties, but can no longer vary *within* counties. To summarize, first the model is tested for *within* and *between* county variations. If it is identified that this is not the case and that there is only *between* county variation (as indicated by the non-significant variance component), the model is re-estimated with the random error term removed from the cross-level interaction.

In the following section, both a and b versions of the tables are presented for the instances where the models needed to be estimated a second time with the random error term for the cross-level interaction removed from the model. When this occurs, the initial model results (with the random error term included in the cross-level interaction) are presented in table *a*, and the second model results (the model with the random error term of the cross-level interaction removed from the model) are presented in table *b*.

Effect of Maternal Age on Hypertensive Disorders of Pregnancy Across the Levels and Dimensions of Rurality

Table 5.4a reports the results of the cross-level interactions that include the random error term in the model. In Model I, the cross-level interactions of maternal age and the ecological dimension of rurality were tested. The variance component for age 19 years of age or younger is not statistically significant, which means that the effect does not significantly vary within counties. This effect is re-estimated and the results are presented in Table 5.4b and discussed later. For those women who are 35 years of age or older, the odds of experiencing HDP are 33 percent higher than they are for women 20 through 34 years of age. However, for those women 35 years of age or older who live in county with a high score on the ecological dimension of rurality, the odds of experiencing HDP are even greater (37 percent).

In Model II, the cross-level interactions of maternal age and the occupational dimension of rurality were tested. In this model, both the variance component for women 19 years of age or younger and for women 35 years of age or older were not statistically significant. The cross-level interactions of maternal age and the sociocultural dimension of rurality were tested in Model III. As was found in Model II, both the variance component for women 19 years of age or younger and for women 35 years of age or older were not statistically significant. For all variance components that were not statistically significant, the random error terms were removed from the models and the models were re-estimated. The results of the models without the random error terms are presented in Table 5.4b.

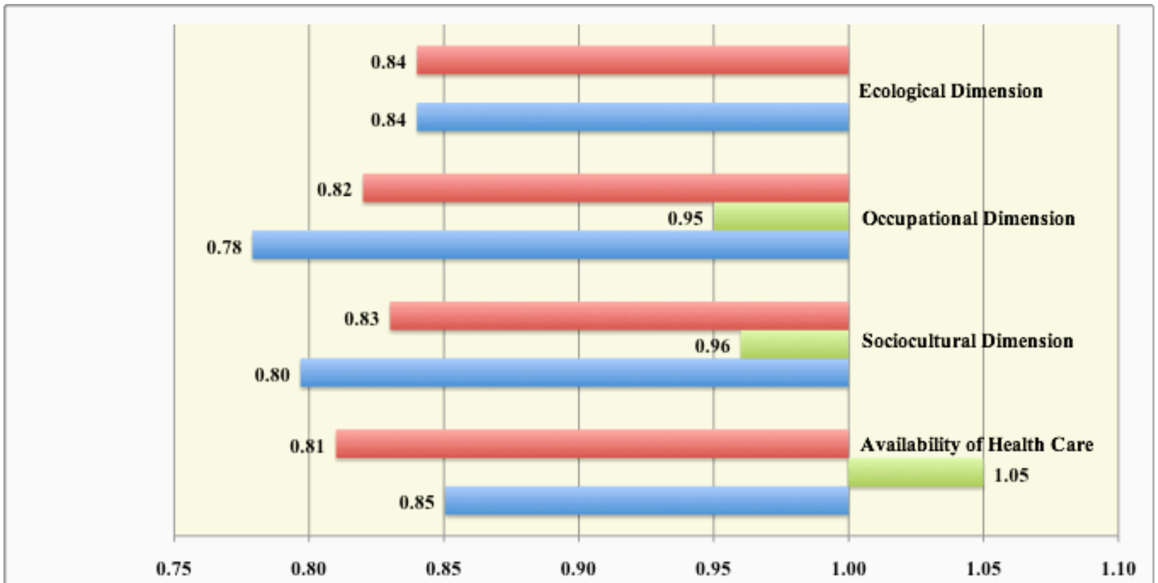
Table 5.4a Multilevel logistic regression models of how the effect of maternal age on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

Variables	Model I	Model II	Model III
Individual-level measures (N=3,451,144)			
Intercept	0.03***	0.03***	0.03***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.84***	0.83***	0.83***
Age 35 and older	1.33***	1.37***	1.40***
Race (White=reference)			
Black	1.19***	1.19***	1.19***
American Indian/Alaskan Native	1.20***	1.20***	1.20***
Asian	0.61***	0.61***	0.61***
Ethnicity			
Hispanic	0.87***	0.87***	0.87***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.05***	1.05***
High school/GED	1.17***	1.17***	1.17***
Some college/Associate's degree	1.22***	1.22***	1.22***
Maternal smoking during pregnancy			
Mother smokes	0.81***	0.81***	0.81***
Mother from California	0.56***	0.56***	0.56***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.14***	1.14***
High weight gain	1.55***	1.55***	1.55***
Parity			
First birth	2.02***	2.02***	2.02***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.74***	0.74***	0.74***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.67***	1.68***	1.68***
County-level measures (N=3,096)			

Direct Associations			
Dimensions of Rurality			
Ecological Dimension†	1.03**	1.04**	1.04**
Occupational Dimension†	1.03*	1.02$^{\psi}$	1.03*
Sociocultural Dimension†	1.04**	1.04**	1.03*
County characteristics			
Availability of health care†	0.97**	0.97*	0.97**
Moderating Associations			
Age 19 or younger*Ecological Dimension†	0.99		
Age 35 and older*Ecological Dimension†	1.03**		
Age 19 or younger*Occupational Dimension†		0.95***	
Age 35 and older*Occupational Dimension†		1.06***	
Age 19 or younger*Sociocultural Dimension†			0.96***
Age 35 and older*Sociocultural Dimension†			1.07***
Variance Components			
Intercept	0.17***	0.17***	0.17***
Age 19 or younger	0.02	0.02	0.02
Age 35 and older	0.02**	0.02	0.02

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

In Model IV of Table 5.4b, the results show that women who are 19 years of age or younger are 16 percent less likely to experience HDP compared to women age 20 through 34 years of age. The cross-level interaction between age 19 years of age and younger and the ecological dimension of rurality is not statistically significant indicating that the effect of age 19 years or younger on HDP does not vary by the level of the ecological dimension of rurality. This model also shows that women who are 35 years of age or older are 33 percent more likely to experience HDP compared to women 20 through 34 years of age. However, for those women 35 years of age or older who live in a county with a high ecological dimension of rurality, the odds of experiencing HDP are 38 percent higher than they are for women age 20 through 34 years of age. In order to interpret the effect of the cross-level interactions, the odds ratio for the main effect of the individual-level variable (women 35 years of age or older; odds ratio: 1.33) must be multiplied by the odds ratio of the cross-level interaction (women 35 years of age or older*ecological dimension of rurality; odds ratio: 1.04), which in this case is 1.33*1.04=1.38. By multiplying the odds ratio of the main effect for women 35 years of age with the odds ratio for the cross-level interaction of women 35 years of age and the ecological dimension of rurality, you find the odds ratio for women 35 years of age or older who live in a county with a high ecological dimension of rurality. For ease of interpretation of these effects, figures displaying the odds ratios for the main effect, interaction effect, as well as multiplicative effect (main effect odds ratio multiplied by interaction odds ratio) that is used for the interpretation of the cross-level interaction are provided for each of the cross-level interactions tested in this study. Figure 5-1 shows these effects for maternal age 19 or younger.



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	0.81	0.83	0.82	0.84
Interaction	1.05	0.96	0.95	Not Significant
Interpretation	0.85	0.80	0.78	0.84

Odds Ratios

Figure 5-1: Effects of Age 19 or Younger on Hypertensive Disorders of Pregnancy

The cross-level interactions of maternal age and the occupational dimension of rurality without the random error terms included were tested in Model V. Here, the results show that women 19 years of age or younger are 18 percent less likely to experience HDP compared to women 20 through 34 years of age (odds ratio: 0.82). However, for those women 19 years of age or younger who live in counties with a high occupational dimension of rurality, the odds of experiencing HDP are 22 percent lower than they are for women 20 through 34 years of age (odds ratio: 0.95).

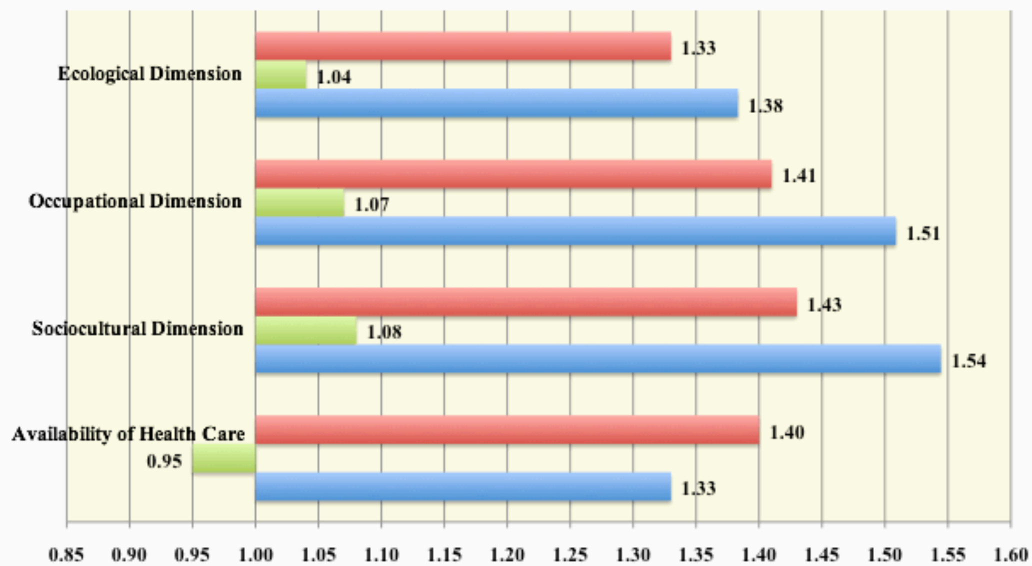
Table 5.4b Multilevel logistic regression models of how the effect of maternal age on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

Variables	Model IV	Model V	Model VI
Individual-level measures (N=3,451,144)			
Intercept	0.03***	0.02***	0.02***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.84***	0.82***	0.83***
Age 35 and older	1.33***	1.41***	1.43***
Race (White=reference)			
Black	1.19***	1.19***	1.20***
American Indian/Alaskan Native	1.21***	1.21***	1.21***
Asian	0.60***	0.60***	0.60***
Ethnicity			
Hispanic	0.87***	0.87***	0.87***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.05***	1.05***
High school/GED	1.17***	1.17***	1.17***
Some college/Associate's degree	1.23***	1.23***	1.23***
Maternal smoking during pregnancy			
Mother smokes	0.81***	0.81***	0.81***
Mother from California	0.56***	0.56***	0.56***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.14***	1.14***
High weight gain	1.56***	1.56***	1.56***
Parity			
First birth	2.04***	2.05***	2.05***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.73***	0.73***	0.73***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.68***	1.69***	1.69***
County-level measures (N=3,096)			

Direct Associations			
Dimensions of Rurality			
Ecological Dimension†	1.03**	1.04**	1.04**
Occupational Dimension†	1.03*	1.03$^{\psi}$	1.03$^{\psi}$
Sociocultural Dimension†	1.04**	1.04**	1.03*
County characteristics			
Availability of health care†	0.97**	0.97**	0.97*
Moderating Associations			
Age 19 or younger*Ecological Dimension†	0.98$^{\psi}$		
Age 35 and older*Ecological Dimension†	1.04**		
Age 19 or younger*Occupational Dimension†		0.95***	
Age 35 and older*Occupational Dimension†		1.07***	
Age 19 or younger*Sociocultural Dimension†			0.96***
Age 35 and older*Sociocultural Dimension†			1.08***
Variance Components			
Intercept	0.17***	0.17***	0.17***
Age 19 or younger	---	---	---
Age 35 and older	0.03**	---	---

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

In addition, women 35 years of age or older are 41 percent more likely to experience HDP compared to women 20 through 34 years of age (see Figure 5-2). However, for those women 35 years of age or older who are living in counties with a high occupational dimension of rurality, the odds of experiencing HDP are even greater. Specifically, for those women who are 35 years of age or older and live in a county with a high occupational dimension of rurality, the odds of experiencing HDP are greater by 51 percent compared to what they are for women 20 through 34 years of age (odds ratio: 1.07). Therefore, while the occupational dimension of rurality has a protective effect for women 19 years of age or younger, the occupational dimension of rurality has an adverse impact on HDP for women 35 years of age or older.



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	1.40	1.43	1.41	1.33
Interaction	0.95	1.08	1.07	1.04
Interpretation	1.33	1.54	1.51	1.38

Odds Ratios

Figure 5-2: Effects of Age 35 and Older on Hypertensive Disorders of Pregnancy

The results of Model VI that include the cross-level interactions of maternal age and the sociocultural dimension of rurality are very similar to the results of Model V that include the cross-level interactions of maternal age and the occupational dimension of rurality. Specifically, the odds of experiencing HDP are 17 percent lower for women 19 years of age or younger compared to what they are for women 20 through 34 years of age (odds ratio: 0.83). However, for those teenage women who live in counties with a higher sociocultural dimension of rurality, the odds of experiencing HDP are 20 percent lower than they are for women 20 through 34 years of age (odds ratio: 0.96).

The results of Model VI in Table 5.4b also show that women 35 years of age or older are 43 percent more likely to experience HDP compared to women 20 through 34 years of age (odds ratio: 1.43). Then again, those women who are 35 years of age or older that live in a county with a high sociocultural dimension of rurality are 54 percent more likely to experience HDP compared to women 20 through 34 years of age (odds ratio: 1.08).

Effect of Maternal Race and Ethnicity on Hypertensive Disorders of Pregnancy Across the Levels and Dimensions of Rurality

This study also examined how the effects of maternal race and ethnicity on HDP vary across the levels and dimensions of rurality. The results of these models are displayed in Tables 5.5a and 5.5b. The variance components for American Indian/Alaskan Native women are not statistically significant in the ecological, occupational, or sociocultural dimension of rurality models (Models I-III). The results of these models are displayed in Table 5.5a. The random error terms for the American Indian/Alaskan Native women and dimensions of rurality interactions were excluded from Models IV-Models VI in Table 5.5b.

Table 5.5a Multilevel logistic regression models of how the effect of maternal race and ethnicity on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

Variables	Model I	Model II	Model III
Individual-level measures (N=3,451,144)			
Intercept	0.03***	0.03***	0.03***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.85***	0.85***	0.85***
Age 35 and older	1.32***	1.32***	1.32***
Race (White=reference)			
Black	1.14***	1.11***	1.12***
American Indian/Alaskan Native	1.14***	1.15***	1.15***
Asian	0.59***	0.62***	0.60***
Ethnicity			
Hispanic	0.83***	0.82***	0.82***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.05***	1.05***
High school/GED	1.16***	1.16***	1.16***
Some college/Associate’s degree	1.21***	1.21***	1.21***
Maternal smoking during pregnancy			
Mother smokes	0.81***	0.81***	0.81***
Mother from California	0.60***	0.60***	0.60***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.13***	1.13***	1.13***
High weight gain	1.53***	1.53***	1.53***
Parity			
First birth	1.98***	1.98***	1.98***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.75***	0.75***	0.75***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.65***	1.65***	1.65***

County-level measures (N=3,096)			
Direct Associations			
Dimensions of Rurality			
Ecological Dimension†	1.04***	1.04***	1.04***
Occupational Dimension†	1.03*	1.04**	1.03*
Sociocultural Dimension†	1.03**	1.04**	1.05***
County characteristics			
Availability of health care†	0.97**	0.97**	0.97**
Moderating Associations			
Black*Ecological Dimension†	0.98^{ψ}		
AIAN*Ecological Dimension†	1.05		
Asian*Ecological Dimension†	0.98		
Hispanic*Ecological Dimension†	0.97*		
Black*Occupational Dimension†		0.94***	
AIAN*Occupational Dimension†		0.99	
Asian*Occupational Dimension†		1.03^{ψ}	
Hispanic*Occupational Dimension†		0.95***	
Black*Sociocultural Dimension†			0.95***
AIAN*Sociocultural Dimension†			0.98
Asian*Sociocultural Dimension†			1.00
Hispanic*Sociocultural Dimension†			0.95***
Variance Components			
Intercept	0.16***	0.16***	0.16***
Black	0.05***	0.04***	0.04***
American Indian/Alaskan Native	0.11	0.12	0.12
Asian	0.04***	0.04***	0.04***
Hispanic	0.08***	0.08***	0.08***

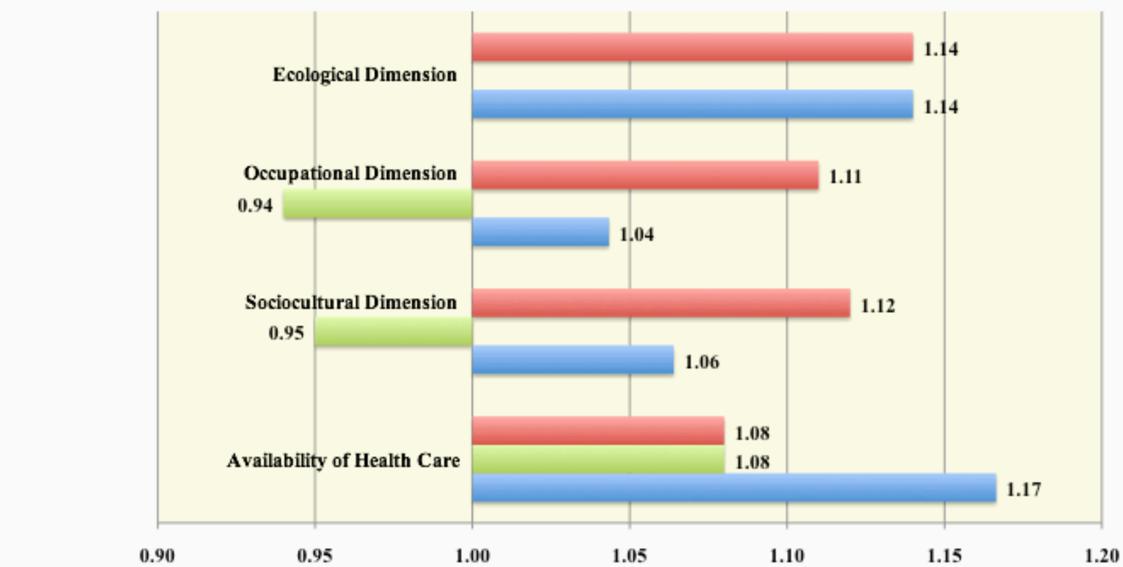
Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Table 5.5b Multilevel logistic regression models of how the effect of maternal race and ethnicity on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

Variables	Model IV	Model V	Model VI
Individual-level measures (N=3,451,144)			
Intercept	0.03***	0.03***	0.03***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.84***	0.84***	0.84***
Age 35 and older	1.33***	1.33***	1.33***
Race (White=reference)			
Black	1.14***	1.11***	1.12***
American Indian/Alaskan Native	1.15***	1.18***	1.17***
Asian	0.59***	0.62***	0.60***
Ethnicity			
Hispanic	0.82***	0.81***	0.80***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.05***	1.05***
High school/GED	1.16***	1.16***	1.16***
Some college/Associate's degree	1.21***	1.21***	1.21***
Maternal smoking during pregnancy			
Mother smokes	0.81***	0.81***	0.81***
Mother from California	0.58***	0.58***	0.58***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.14***	1.14***
High weight gain	1.54***	1.54***	1.54***
Parity			
First birth	2.00***	2.00***	2.00***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.74***	0.74***	0.74***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.66***	1.66***	1.66***
County-level measures (N=3,096)			

Direct Associations			
Dimensions of Rurality			
Ecological Dimension†	1.04***	1.04***	1.04***
Occupational Dimension†	1.03*	1.04**	1.03*
Sociocultural Dimension†	1.03**	1.04**	1.05***
County characteristics			
Availability of health care†	0.97**	0.97**	0.97**
Moderating Associations			
Black*Ecological Dimension†	0.98$^{\psi}$		
AIAN*Ecological Dimension†	1.11**		
Asian*Ecological Dimension†	0.98		
Hispanic*Ecological Dimension†	0.97*		
Black*Occupational Dimension†		0.94***	
AIAN*Occupational Dimension†		0.99	
Asian*Occupational Dimension†		1.03$^{\psi}$	
Hispanic*Occupational Dimension†		0.95***	
Black*Sociocultural Dimension†			0.95***
AIAN*Sociocultural Dimension†			0.97
Asian*Sociocultural Dimension†			1.00
Hispanic*Sociocultural Dimension†			0.95***
Variance Components			
Intercept	0.16***	0.16***	0.16***
Black	0.05***	0.04***	0.04***
American Indian/Alaskan Native	---	---	---
Asian	0.04***	0.04***	0.04***
Hispanic	0.08***	0.08***	0.08***

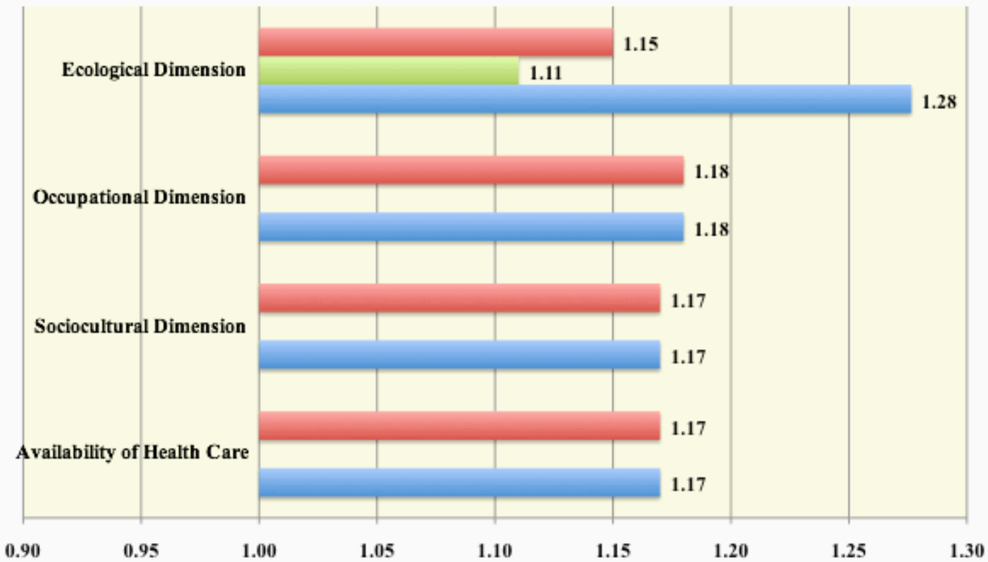
Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	1.08	1.12	1.11	1.14
Interaction	1.08	0.95	0.94	Not Significant
Interpretation	1.17	1.06	1.04	1.14

Odds Ratios

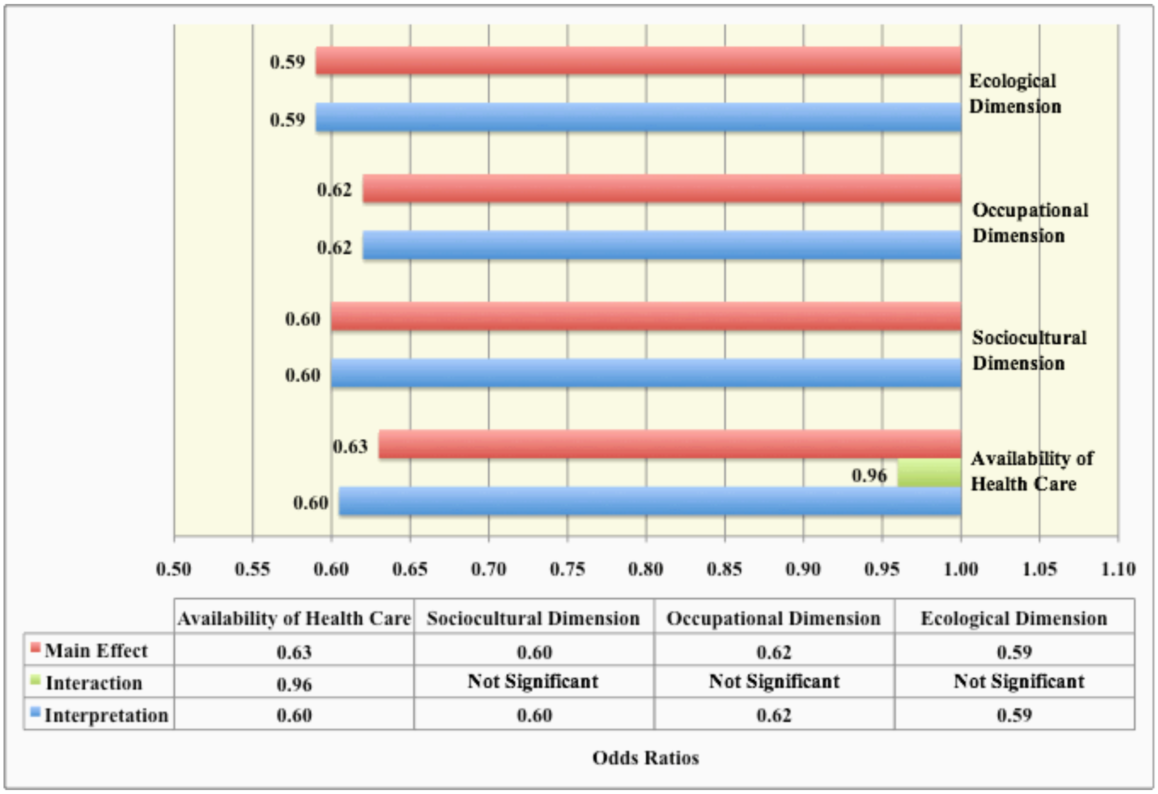
Figure 5-3: Effects of Black Race on Hypertensive Disorders of Pregnancy



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	1.17	1.17	1.18	1.15
Interaction	Not Significant	Not Significant	Not Significant	1.11
Interpretation	1.17	1.17	1.18	1.28

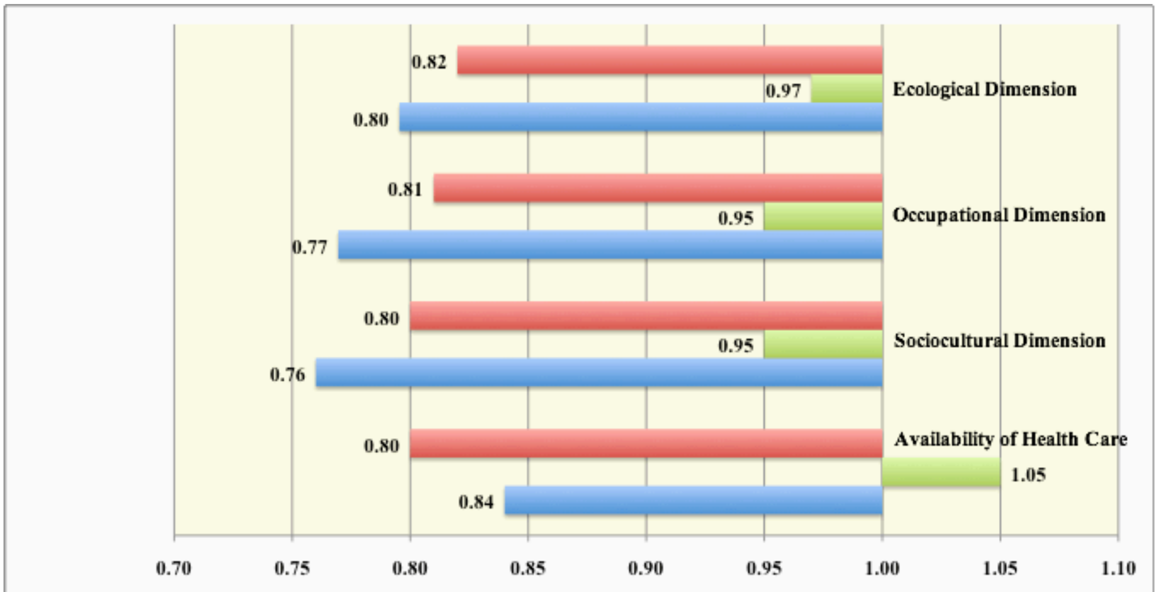
Odds Ratios

Figure 5-4: Effects of American Indian/Alaskan Native Race on Hypertensive Disorders of Pregnancy



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	0.63	0.60	0.62	0.59
Interaction	0.96	Not Significant	Not Significant	Not Significant
Interpretation	0.60	0.60	0.62	0.59

Figure 5-5: Effects of Asian Race on Hypertensive Disorders of Pregnancy



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	0.80	0.80	0.81	0.82
Interaction	1.05	0.95	0.95	0.97
Interpretation	0.84	0.76	0.77	0.80

Figure **5-6**: Effects of Hispanic Ethnicity on Hypertensive Disorders of Pregnancy

Compared to white women, the main effect for black and American Indian/Alaskan Native women show that they are 14 and 15 percent more likely to experience HDP, while Asian women are 41 percent less likely to experience HDP. Hispanic women are 18 percent less likely to experience HDP compared to non-Hispanic women.

However, American Indian/Alaskan Native women who live in counties with a higher ecological dimension of rurality are 28 percent more likely to experience HDP compared to white women (see Figure 5-4; odds ratio: 1.11). In addition, Hispanic women who live in counties with a higher ecological dimension of rurality are 20 percent less likely to experience HDP compared to non-Hispanic women (see Figure 5-6; odds ratio: 0.97). The ecological dimension of rurality has an adverse impact on HDP for American Indian/Alaskan Native women, while it has a protective effect for Hispanic women. The effect of race on HDP for black and Asian women does not significantly vary by the level of the ecological dimension of rurality in the woman's county of residence.

In Model V, the results show that compared to white women, Black women are 11 percent more likely to experience HDP and American Indian/Alaskan Native women are 18 percent more likely to experience HDP, while Asian women are 38 percent less likely to experience HDP. Hispanic women are 19 percent less likely to experience HDP compared to their non-Hispanic counterparts.

The effect of race and ethnicity on HDP varies significantly by the level of the occupational dimension of rurality in the woman's residential county for both black and Hispanic women. For both Black and Hispanic women who live in a county with a higher occupational dimension of rurality, the odds of experiencing HDP are lower than for Black and Hispanic women who live elsewhere. Specifically, Black women who live in counties with a higher occupational dimension of rurality are 4 percent more likely to experience HDP compared to their white counterparts (see Figure 5-3; odds ratio: 0.94). Therefore, black women who live in a county with higher occupational dimension of rurality are less likely to experience HDP compared to those Black women who live elsewhere. In addition, Hispanic women who live in a county with a higher occupational dimension of rurality are 23 percent less likely to experience HDP compared to their non-Hispanic counterparts (odds ratio: 0.95). Just as it did for Black women, the occupational dimension of rurality had a protective effect on HDP for Hispanic women.

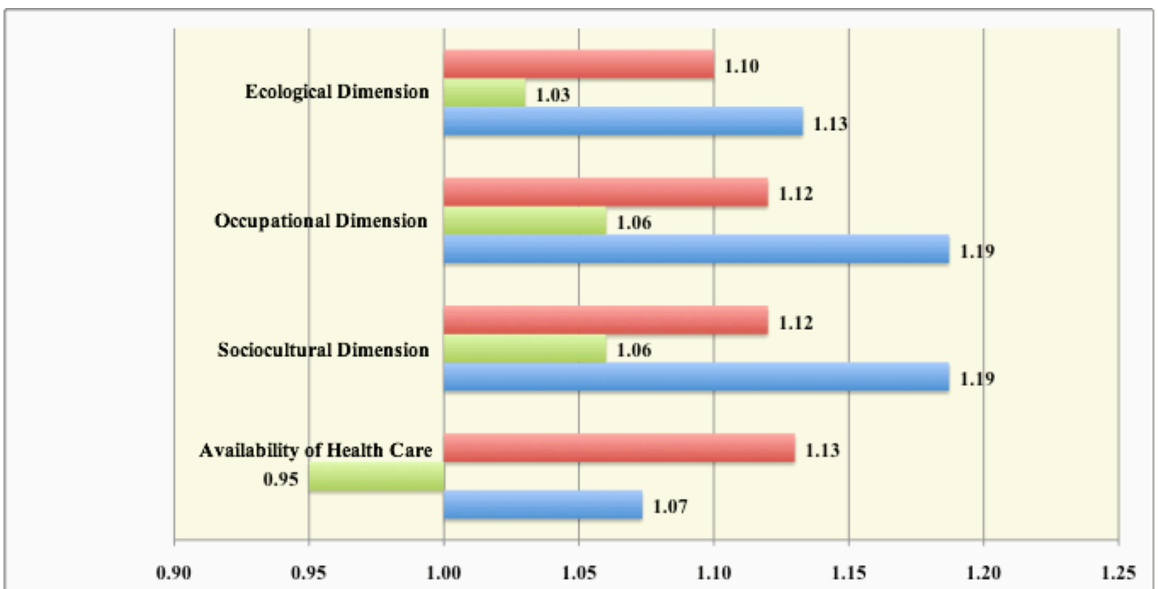
The results of Model VI show that compared to white women, Black women are 12 percent more likely to experience HDP and American Indian/Alaskan Native women are 17 percent more likely to experience HDP, while Asian women are 40 percent less likely to experience HDP. Hispanic women are 20 percent less likely to experience HDP compared to their non-Hispanic counterparts.

Black women who are living in a county with higher sociocultural dimension of rurality are 6 percent more likely to experience HDP compared to their white counterparts (odds ratio: 0.95). The sociocultural dimension of rurality has a protective effect on HDP for Black women. Specifically, Black women are more likely to experience HDP compared to white women; however, Black women who live in a county with high sociocultural dimension of rurality continue to be more likely to experience HDP compared to their white counterparts, but the difference in the odds is not as large as it is for all Black women.

As for Hispanic women, for those who live in a county with a higher sociocultural dimension of rurality, the odds of experiencing HDP are 24 percent lower than they are for their non-Hispanic counterparts (odds ratio: 0.95). As it did for Black women, the sociocultural dimension of rurality has a protective effect on HDP for Hispanic women. In this case, the odds of experiencing HDP for Hispanic women living in a county with a higher sociocultural dimension of rurality are even lower than they are for all Hispanic women.

Effect of Marital Status on Hypertensive Disorders of Pregnancy Across the Levels and Dimensions of Rurality

As reported in Table 5.6, the effect of marital status on HDP varies significantly across the levels and dimensions of rurality in the woman's county of residence. The results of Model I show that married women are 10 percent more likely to experience HDP compared to women who were not married at the time of their infant's birth. However, among those married women who live in a county with a high ecological dimension of rurality, the odds of experiencing HDP are 13 percent greater than they are for their unmarried counterparts (see Figure 5-7; odds ratio: 1.03).



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	1.13	1.12	1.12	1.10
Interaction	0.95	1.06	1.06	1.03
Interpretation	1.07	1.19	1.19	1.13

Figure 5-7: Effects of Marital Status on Hypertensive Disorders of Pregnancy

Table 5.6 Multilevel logistic regression models of how the effect of marital status on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

Variables	Model I	Model II	Model III
Individual-level measures (N=3,451,144)			
Intercept	0.02***	0.02***	0.02***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.85***	0.85***	0.85***
Age 35 and older	1.33***	1.33***	1.33***
Race (White=reference)			
Black	1.19***	1.18***	1.19***
American Indian/Alaskan Native	1.21***	1.21***	1.21***
Asian	0.61***	0.61***	0.61***
Ethnicity			
Hispanic	0.87***	0.86***	0.86***
Marital status			
Married	1.10***	1.12***	1.12***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.04***	1.04***
High school/GED	1.17***	1.17***	1.17***
Some college/Associate's degree	1.22***	1.22***	1.22***
Maternal smoking during pregnancy			
Mother smokes	0.82***	0.82***	0.82***
Mother from California	0.56***	0.56***	0.56***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.14***	1.14***
High weight gain	1.55***	1.55***	1.55***
Parity			
First birth	2.04***	2.04***	2.04***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.74***	0.74***	0.74***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.68***	1.68***	1.68***
County-level measures (N=3,096)			

Direct Associations			
Dimensions of Rurality			
Ecological Dimension†	1.02	1.04**	1.04**
Occupational Dimension†	1.03*	0.99	1.03$^{\psi}$
Sociocultural Dimension†	1.04**	1.04**	1.00
County characteristics			
Availability of health care†	0.97**	0.97**	0.97**
Moderating Associations			
Married*Ecological Dimension†	1.03**		
Married*Occupational Dimension†		1.06***	
Married*Sociocultural Dimension†			1.06***
Variance Components			
Intercept	0.19***	0.19***	0.19***
Married	0.04***	0.04***	0.04***

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

As reported in Model II in Table 5.6, married women are 12 percent more likely to experience HDP compared to their unmarried counterparts. However, for those married women who live in a county with a high occupational dimension of rurality, the odds of experiencing HDP are 19 percent higher than they are for women who were not married at the time of their infant's birth (odds ratio: 1.06). This means that the effect of marriage on HDP varies significantly across the level of the occupational dimension of rurality in the woman's county of residence, with a higher occupational dimension of rurality in a county having an adverse effect on hypertensive disorders of rurality for married women.

The results of Model III show that compared to women who were not married at the time of their infant's birth, the odds of experiencing HDP are 12 percent higher. Then again, among those married women who live in a county with a higher sociocultural dimension of rurality, the odds of experiencing HDP are 19 percent greater than they are for their unmarried counterparts (odds ratio: 1.06).

The results of the models presented in Table 5.6 showed that higher levels of rurality in a woman's residential county make the adverse effect of marriage on HDP even greater. This was the case for each of the dimensions of rurality. Therefore, finding ways to reduce HDP among married women living in rural counties should be a concern and deserves further attention.

Effect of Maternal Education on Hypertensive Disorders of Pregnancy Across the Levels and Dimensions of Rurality

As reported in Model I of Table 5.7, compared to those women with a bachelors degree or higher, the odds of experiencing HDP are 13 percent higher for women who graduated from high school or have their GED, and 18 percent higher for woman with some college education or an Associate's degree. The effect of maternal education on HDP did not vary significantly across the level of the ecological dimension of rurality in the woman's county of residence.

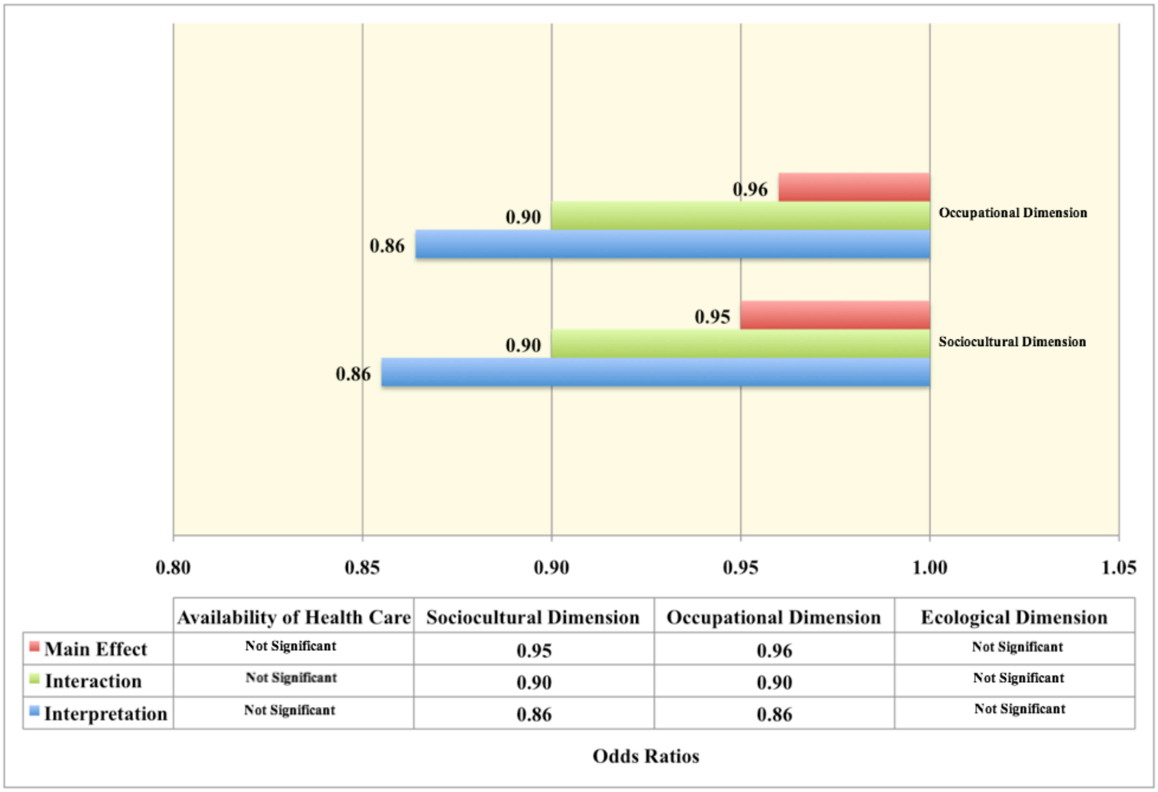
Table 5.7 Multilevel logistic regression models of how the effect of maternal education on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

Variables	Model I	Model II	Model III
Individual-level measures (N=3,451,144)			
Intercept	0.03***	0.03***	0.03***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.85***	0.85***	0.85***
Age 35 and older	1.33***	1.33***	1.33***
Race (White=reference)			
Black	1.18***	1.18***	1.18***
American Indian/Alaskan Native	1.20***	1.20***	1.21***
Asian	0.61***	0.61***	0.61***
Ethnicity			
Hispanic	0.87***	0.87***	0.86***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	0.98	0.96**	0.95***
High school/GED	1.13***	1.10***	1.08***
Some college/Associate's degree	1.18***	1.16***	1.15***
Maternal smoking during pregnancy			
Mother smokes	0.82***	0.82***	0.82***
Mother from California	0.58***	0.57***	0.57***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.14***	1.14***
High weight gain	1.54***	1.54***	1.54***
Parity			
First birth	2.01***	2.01***	2.01***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.74***	0.74***	0.74***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.67***	1.67***	1.67***
County-level measures (N=3,096)			

Direct Associations			
Dimensions of Rurality			
Ecological Dimension†	1.04**	1.03**	1.03*
Occupational Dimension†	1.03*	1.08***	1.03$^{\psi}$
Sociocultural Dimension†	1.04***	1.04***	1.10***
County characteristics			
Availability of health care†	0.97**	0.97**	0.97**
Moderating Associations			
Less than High School*Ecological Dimension†	0.97$^{\psi}$		
High school/GED*Ecological Dimension†	0.99		
Some college*Ecological Dimension†	1.00		
Less than High School*Occupational Dimension†		0.90***	
High school/GED*Occupational Dimension†		0.93***	
Some college*Occupational Dimension†		0.96***	
Less than High School*Sociocultural Dimension†			0.90***
High school/GED*Sociocultural Dimension†			0.92***
Some college*Sociocultural Dimension†			0.95***
Variance Components			
Intercept	0.16***	0.15***	0.15***
Less than High School	0.12***	0.11***	0.11***
High school/GED	0.06***	0.05***	0.05***
Some college/Associate's degree	0.02**	0.02*	0.02*

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

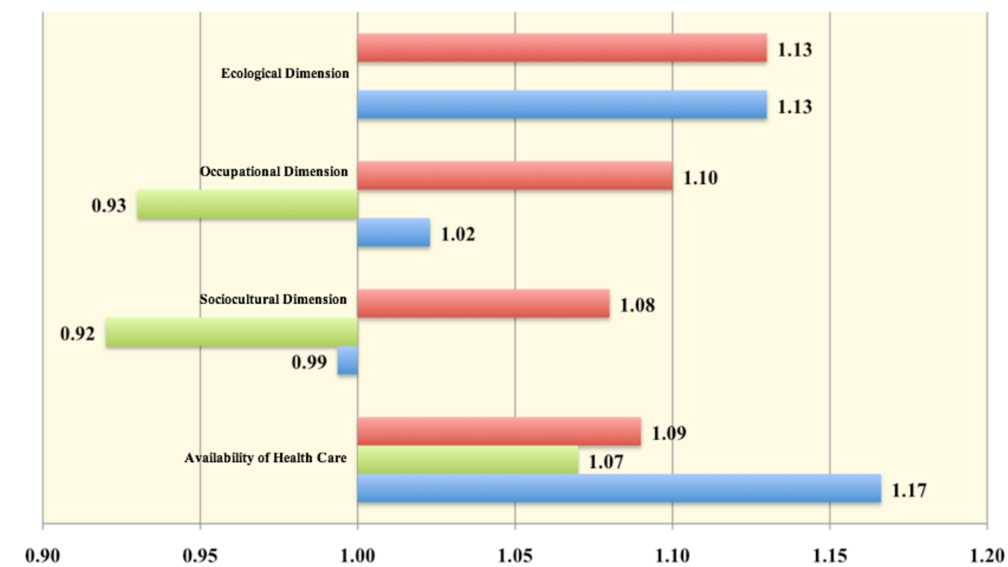
However, the effect of maternal education on HDP did vary significantly across the levels of the occupational dimension of rurality. As shown in Model II, surprisingly, compared to those woman with a bachelors degree or higher, woman with less than a high school degree are 4 percent less likely to experience HDP. Among those women with less than a high school degree who live in a county with high occupational dimension of rurality, the odds of experiencing HDP are 14 percent lower than they are for their counterparts with a bachelors degree or higher (see Figure 5-8; odds ratio: 0.90).



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	Not Significant	0.95	0.96	Not Significant
Interaction	Not Significant	0.90	0.90	Not Significant
Interpretation	Not Significant	0.86	0.86	Not Significant

Figure 5-8: Effects of Less than High School Education on Hypertensive Disorders of Pregnancy

Compared to those women with a bachelor's degree or higher, the odds of experiencing HDP are 10 percent higher for women who graduated from high school or have a GED, and are 16 percent higher for those women with some college education or an Associate's degree. Although, among those women who have graduated from high school or have a GED and live in a county with high occupational dimension of rurality, the odds of experiencing HDP are 2 percent higher than they are for their counterparts with a bachelor's degree or higher (see Figure 5-9; odds ratio: 0.93).

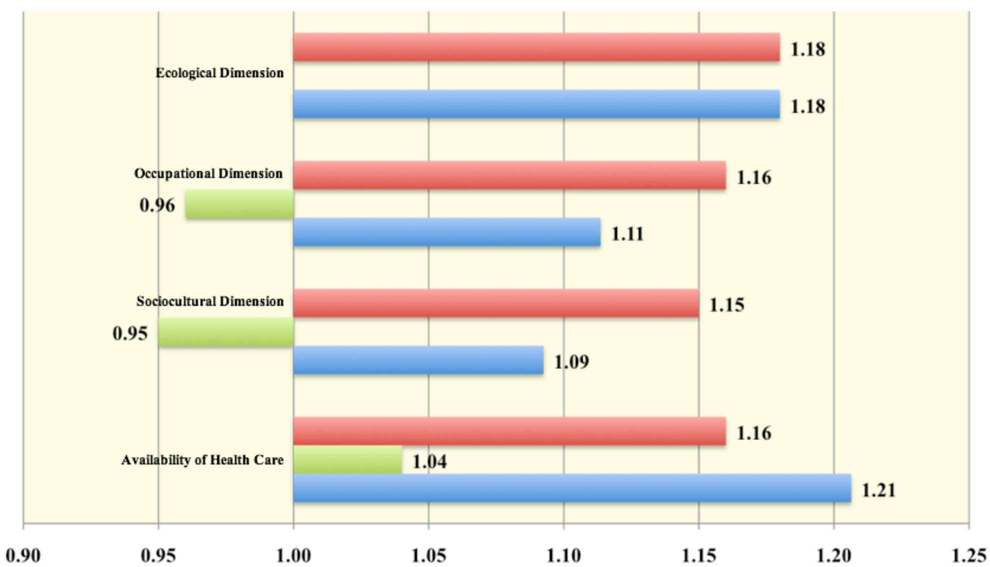


	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	1.09	1.08	1.10	1.13
Interaction	1.07	0.92	0.93	Not Significant
Interpretation	1.17	0.99	1.02	1.13

Odds Ratios

Figure 5-9: Effects of High School Education on Hypertensive Disorders of Pregnancy

In addition, women with some college education or an associate's degree are 16 percent more likely to experience HDP compared to women with a bachelor's degree or higher. However, among those women with some college education or an Associate's degree who live in a county with high occupational dimension of rurality, the odds of experiencing HDP are 11 percent higher than their counterparts with a bachelor's degree or higher (see Figure 5-10; odds ratio: 0.96). Therefore, the occupational dimension of rurality has a protective effect for maternal education on HDP.



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	1.16	1.15	1.16	1.18
Interaction	1.04	0.95	0.96	Not Significant
Interpretation	1.21	1.09	1.11	1.18

Odds Ratios

Figure 5-10: Effects of Some College Education on Hypertensive Disorders of Pregnancy

As shown in Model III, women with less than a high school education are 5 percent less likely to experience HDP compared to women with a bachelor's degree or higher. Although, for those women with less than a high school degree who live in a county with a high sociocultural dimension of rurality, the odds of experiencing HDP are approximately 15 percent lower than they are for their counterparts with a bachelor's degree or higher (odds ratio: 0.90).

While women with a high school degree or GED are 8 percent more likely to have a hypertensive disorder of pregnancy compared to women with a bachelor's degree or higher, women with a high school degree or GED who live in a county with a high sociocultural dimension of rurality are 1 percent less likely to experience HDP compared to their counterparts with a bachelor's degree or higher (odds ratio: 0.92). Also, women with some college education or an associate's degree are 15 percent more likely to experience HDP compared to women with a bachelor's degree or higher; however, among those women who live in a county with a high sociocultural dimension of rurality and have some college education or an associate's degree, the odds of experiencing HDP drop to 9 percent greater than they are for their counterparts with a bachelor's degree or higher (odds ratio: 0.95). Therefore, the sociocultural dimension of rurality has a protective effect on the maternal education and hypertensive disorder of pregnancy relationship.

Effect of Maternal Smoking During Pregnancy on Hypertensive Disorders of Pregnancy Across the Levels and Dimensions of Rurality

As shown in Model I in Table 5.8, the odds of experiencing HDP are 20 percent lower for women who smoke than they are for women who do not smoke. The effect of maternal smoking on HDP does not significantly vary across the level of the ecological dimension of rurality in the woman's residential county.

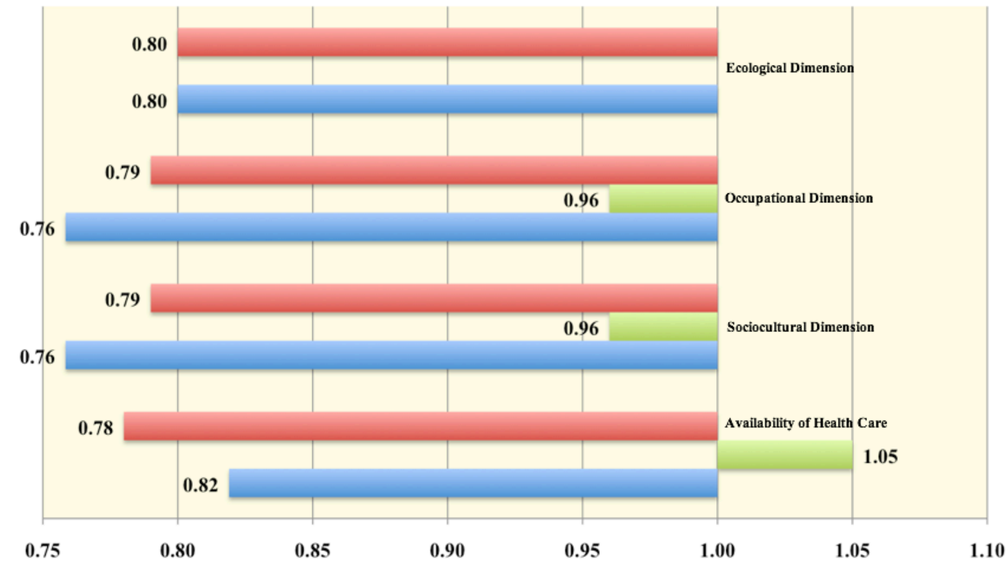
Table 5.8 Multilevel logistic regression models of how the effect of maternal smoking during pregnancy on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

Variables	Model I	Model II	Model III
Individual-level measures (N=3,451,144)			
Intercept	0.03***	0.03***	0.03***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.84***	0.84***	0.84***
Age 35 and older	1.33***	1.33***	1.33***
Race (White=reference)			
Black	1.20***	1.20***	1.20***
American Indian/Alaskan Native	1.21***	1.21***	1.21***
Asian	0.60***	0.61***	0.61***
Ethnicity			
Hispanic	0.87***	0.87***	0.87***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.05***	1.05***
High school/GED	1.17***	1.17***	1.17***
Some college/Associate's degree	1.23***	1.23***	1.23***
Maternal smoking during pregnancy			
Mother smokes	0.80***	0.79***	0.79***
Mother from California	0.56***	0.56***	0.56***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.14***	1.14***
High weight gain	1.56***	1.56***	1.56***
Parity			
First birth	2.04***	2.04***	2.04***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.73***	0.73***	0.73***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.68***	1.68***	1.68***

County-level measures (N=3,096)			
Direct Associations			
Dimensions of Rurality			
Ecological Dimension†	1.04**	1.04**	1.04**
Occupational Dimension†	1.03*	1.03*	1.03*
Sociocultural Dimension†	1.03**	1.03**	1.04**
County characteristics			
Availability of health care†	0.97**	0.97**	0.97**
Moderating Associations			
Smokes*Ecological Dimension†	0.98		
Smokes*Occupational Dimension†		0.96***	
Smokes*Sociocultural Dimension†			0.96***
Variance Components			
Intercept	0.17***	0.17***	0.17***
Smokes	0.03***	0.03***	0.03***

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\Psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

While the effect of maternal smoking on HDP does not vary significantly across the levels of the ecological dimension of rurality, it does vary significantly across both the levels of the occupational dimension of rurality and the sociocultural dimensions of rurality. More specifically, the odds of experiencing HDP are 21 percent lower for those women who smoke compared to those women who do not smoke; however, among those women who smoke who live in a county with a high occupational dimension of rurality, the odds of experiencing HDP are 24 percent lower than they are for their counterparts who do not smoke cigarettes (see Figure 5-11; odds ratio: 0.96).



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	0.78	0.79	0.79	0.80
Interaction	1.05	0.96	0.96	Not Significant
Interpretation	0.82	0.76	0.76	0.80

Odds Ratios

Figure 5-11: Effects of Smoking on Hypertensive Disorders of Pregnancy

Among those women who smoked during pregnancy and lived in a county with a high sociocultural dimension of rurality, the odds of maternal smoking during pregnancy are 24 percent lower than they are for their counterparts who did not smoke during pregnancy (odds ratio: 96). Like the occupational dimension of rurality, the sociocultural dimension of rurality had a protective effect on the maternal smoking during pregnancy and HDP relationship. It may be that who live in the areas with a higher occupational and sociocultural dimension of rurality smoke less, possibly because of the types of occupations they are employed in or higher levels of religious beliefs.

Effect of Maternal Weight Gain on Hypertensive Disorders of Pregnancy Across the Levels and Dimensions of Rurality

The results of the models that tested whether the effect of maternal weight gain on HDP varied across the levels and dimensions of rurality are presented in Tables 5.9a and 5.9b. In Model I through Model III, the variance component for low weight gain was not statistically significant; therefore, these models were re-estimated with the random error term for the interaction between low weight gain and the dimensions of rurality removed. The results of the models that do not include a random error term for the low weight gain and dimensions of rurality interactions are presented in Table 5.9b.

Table **5.9a** Multilevel logistic regression models of how the effect of maternal weight gain on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

Variables	Model I	Model II	Model III
Individual-level measures (N=3,451,144)			
Intercept	0.03***	0.03***	0.03***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.85***	0.85***	0.84***
Age 35 and older	1.32***	1.32***	1.32***
Race (White=reference)			
Black	1.19***	1.19***	1.19***
American Indian/Alaskan Native	1.20***	1.20***	1.20***
Asian	0.61***	0.61***	0.61***
Ethnicity			
Hispanic	0.87***	0.87***	0.87***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.05***	1.05***
High school/GED	1.17***	1.17***	1.17***
Some college/Associate's degree	1.23***	1.23***	1.23***
Maternal smoking during pregnancy			
Mother smokes	0.81***	0.81***	0.81***
Mother from California	0.57***	0.57***	0.57***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.11***	1.10***
High weight gain	1.54***	1.52***	1.52***
Parity			
First birth	2.02***	2.02***	2.02***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.74***	0.74***	0.74***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.67***	1.67***	1.67***

County-level measures (N=3,096)			
Direct Associations			
Dimensions of Rurality			
Ecological Dimension†	1.03**	1.04**	1.04**
Occupational Dimension†	1.03*	1.04**	1.03*
Sociocultural Dimension†	1.03**	1.03**	1.05***
County characteristics			
Availability of health care†	0.97**	0.97**	0.97**
Moderating Associations			
Low weight gain*Ecological Dimension†	1.00		
High weight gain*Ecological Dimension†	1.01		
Low weight gain*Occupational Dimension†		0.96***	
High weight gain*Occupational Dimension†		0.98***	
Low weight gain*Sociocultural Dimension†			0.94***
High weight gain*Sociocultural Dimension†			0.97***
Variance Components			
Intercept	0.17***	0.17***	0.17***
Low weight gain	0.01	0.01	0.01
High weight gain	0.01**	0.01**	0.01**

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\Psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

As shown in Model IV of Table 5.9b, compared to women with average maternal weight gain, women with low maternal weight gain were 14 percent more likely to experience HDP and women with high maternal weight gain were 56 percent more likely to experience HDP. The effect of maternal weight gain on HDP does not significantly vary across the level of the ecological dimension of rurality.

Table 5.9b Multilevel logistic regression models of how the effect of maternal weight gain on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

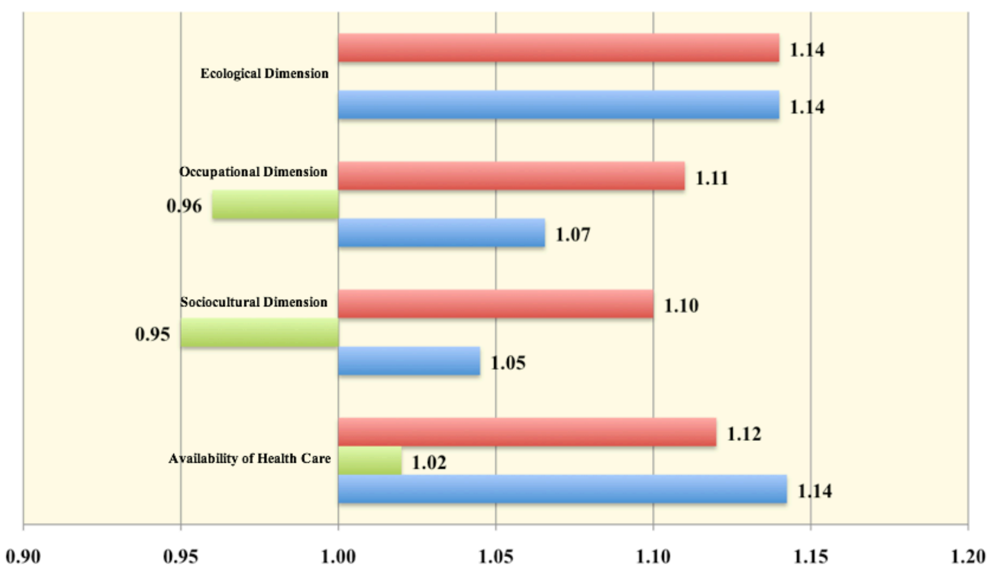
Variables	Model IV	Model V	Model VI
Individual-level measures (N=3,451,144)			
Intercept	0.02***	0.03***	0.03***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.84***	0.84***	0.84***
Age 35 and older	1.33***	1.33***	1.33***
Race (White=reference)			
Black	1.20***	1.20***	1.20***
American Indian/Alaskan Native	1.21***	1.21***	1.21***
Asian	0.60***	0.61***	0.61***
Ethnicity			
Hispanic	0.87***	0.87***	0.87***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.05***	1.05***
High school/GED	1.17***	1.17***	1.17***
Some college/Associate's degree	1.23***	1.23***	1.23***
Maternal smoking during pregnancy			
Mother smokes	0.81***	0.81***	0.81***
Mother from California	0.56***	0.56***	0.56***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.11***	1.10***
High weight gain	1.56***	1.53***	1.53***
Parity			
First birth	2.04***	2.04***	2.04***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.73***	0.73***	0.73***
Adequate care	0.86***	0.86***	0.86***
Adequate plus care	1.68***	1.68***	1.68***

County-level measures (N=3,096)			
Direct Associations			
Dimensions of Rurality			
Ecological Dimension†	1.04**	1.04**	1.04**
Occupational Dimension†	1.03*	1.04**	1.03*
Sociocultural Dimension†	1.03*	1.03**	1.05***
County characteristics			
Availability of health care†	0.97**	0.97**	0.97**
Moderating Associations			
Low weight gain*Ecological Dimension†	1.00		
High weight gain*Ecological Dimension†	1.01		
Low weight gain*Occupational Dimension†		0.96***	
High weight gain*Occupational Dimension†		0.97***	
Low weight gain*Sociocultural Dimension†			0.95***
High weight gain*Sociocultural Dimension†			0.97***
Variance Components			
Intercept	0.17***	0.17***	0.17***
Low weight gain	---	---	---
High weight gain	0.01*	0.01*	0.01*

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\Psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

The results of Model V showed that the odds of experiencing HDP are 11 percent higher for women with low maternal weight gain than they are for women with an average maternal weight gain. On the other hand, among those women with a low maternal weight gain who live in a county with a higher occupational dimension of rurality, the odds of experiencing HDP are 7 percent higher than they are for their counterparts with an average maternal weight gain (see Figure 5-12; odds ratio: 0.96).

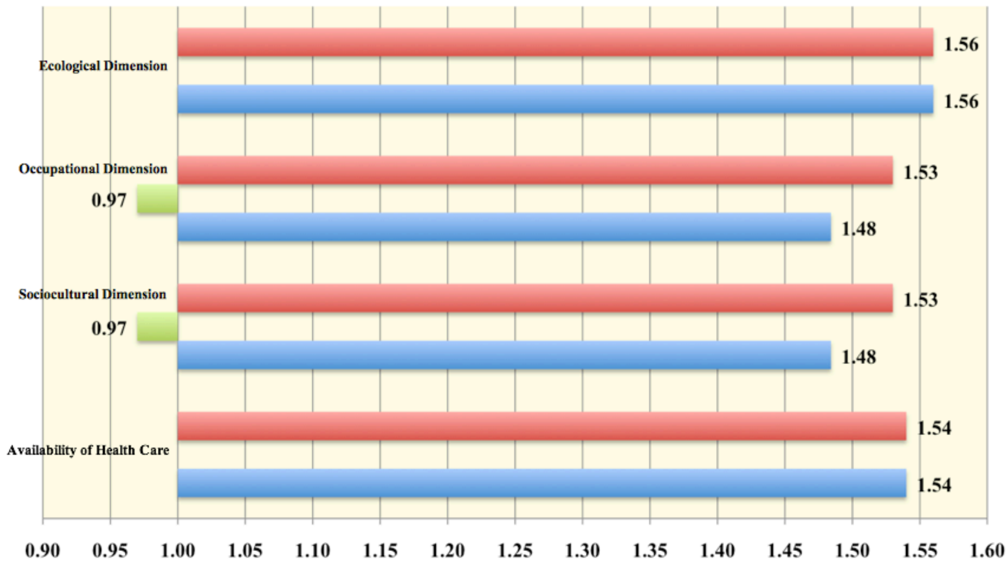
In addition, while the odds of experiencing HDP are 53 percent higher for women with high maternal weight gain than they are for women with an average maternal weight gain, among those women with a high maternal weight gain who live in a county with a high occupational dimension of rurality, the odds of experiencing HDP are 48 percent higher than they are for their counterparts with an average weight gain (see Figure 5-13; odds ratio 0.98).



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	1.12	1.10	1.11	1.14
Interaction	1.02	0.95	0.96	Not Significant
Interpretation	1.14	1.05	1.07	1.14

Odds Ratios

Figure 5-12: Effects of Low Weight Gain on Hypertensive Disorders of Pregnancy



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	1.54	1.53	1.53	1.56
Interaction		0.97	0.97	Not Significant
Interpretation	1.54	1.48	1.48	1.56

Odds Ratios

Figure 5-13: Effects of High Weight Gain on Hypertensive Disorders of Pregnancy

In Model VI, the results show that the odds of experiencing HDP are 10 percent higher for those women with low maternal weight gain than they are for women with an average maternal weight gain. However, among those women with a low maternal weight gain that live in a county with a high sociocultural dimension of rurality, the odds of experiencing HDP are 5 percent higher than they are for their counterparts with an average maternal weight gain (odds ratio: 0.94).

As for those women with a high maternal weight gain, the odds of experiencing HDP are 53 percent higher than they are for women with an average maternal weight gain. Although, among those women with a high maternal weight gain who live in a county with a high sociocultural dimension of rurality, the odds of experiencing HDP are

48 percent higher than they are for their counterparts with an average maternal weight gain (odds ratio: 0.97).

Both the occupational dimension of rurality and the sociocultural dimension of rurality have a protective effect on the relationship between maternal weight gain and HDP. Therefore, while women with low and high maternal weight gain are more likely to experience HDP compared to women with an average maternal weight gain, the differences in the odds are not as large for those women who live in a county with a higher occupational or sociocultural dimension of rurality.

Effect of Prenatal Care Utilization on Hypertensive Disorders of Pregnancy Across the Levels and Dimensions of Rurality

In Table 5.10a and Table 5.10b the results of the cross-level interactions between prenatal care utilization and the dimensions of rurality are presented. In Model I, which includes the cross-level interaction between prenatal care utilization and the ecological dimension of rurality, the variance component for intermediate prenatal care utilization is not statistically significant; therefore, this model was re-estimated without the random error term. The results of this model are discussed later.

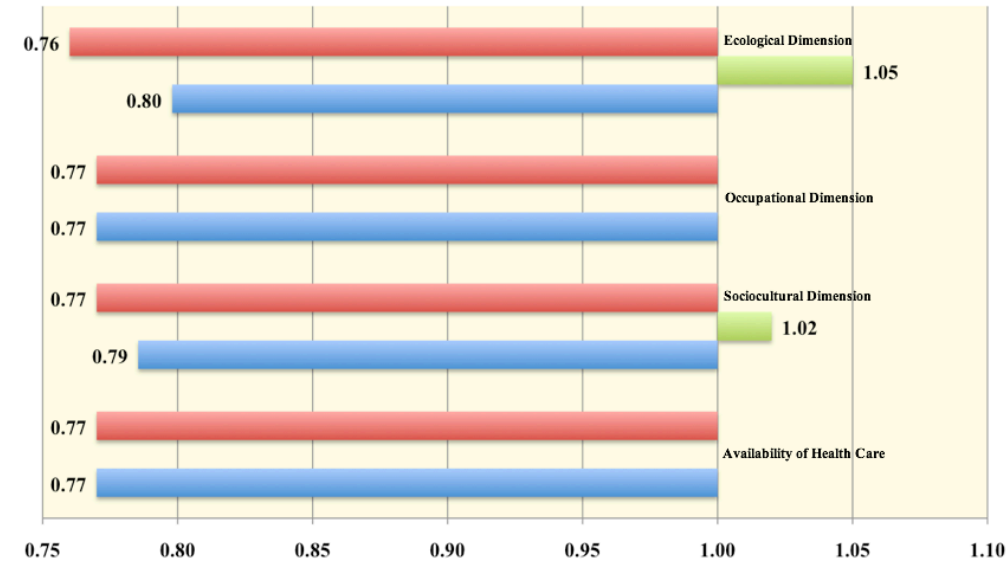
As shown in Model II, the effect of prenatal care utilization on HDP varies significantly across the levels of the occupational dimension of rurality. For example, women who received adequate prenatal care are 13 percent less likely to experience HDP compared to women who received inadequate prenatal. However, among those women who received adequate prenatal care and lived in a county with a high occupational dimension of rurality, the odds of experiencing a hypertensive disorder are 10 percent lower than they are for their counterparts who received inadequate prenatal care (see Figure 5-15; odds ratio: 1.03).

Table 5.10a Multilevel logistic regression models of how the effect of prenatal care utilization on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

Variables	Model I	Model II	Model III
Individual-level measures (N=3,451,144)			
Intercept	0.03***	0.03***	0.03***
Maternal age (Age 20-34=reference)			
Age 19 or younger	0.85***	0.85***	0.85***
Age 35 and older	1.32***	1.32***	1.32***
Race (White=reference)			
Black	1.19***	1.19***	1.19***
American Indian/Alaskan Native	1.20***	1.20***	1.20***
Asian	0.61***	0.61***	0.61***
Ethnicity			
Hispanic	0.88***	0.88***	0.88***
Marital status			
Married	1.05***	1.05***	1.05***
Maternal education (BA or higher=reference)			
Less than High School	1.05***	1.05***	1.05***
High school/GED	1.17***	1.17***	1.17***
Some college/Associate's degree	1.22***	1.22***	1.22***
Maternal smoking during pregnancy			
Mother smokes	0.82***	0.82***	0.82***
Mother from California	0.58***	0.57***	0.58***
Weight gain during pregnancy (Average weight gain=reference)			
Low weight gain	1.14***	1.14***	1.14***
High weight gain	1.54***	1.54***	1.54***
Parity			
First birth	2.00***	2.00***	2.00***
Prenatal Care Utilization (Inadequate=reference)			
Intermediate care	0.76***	0.77***	0.77***
Adequate care	0.87***	0.87***	0.88***
Adequate plus care	1.72***	1.73***	1.73***

County-level measures (N=3,096)			
Direct Associations			
Dimensions of Rurality			
Ecological Dimension†	1.02	1.04**	1.04**
Occupational Dimension†	1.03*	1.00	1.03*
Sociocultural Dimension†	1.03*	1.03*	1.01
County characteristics			
Availability of health care†	0.97**	0.97**	0.97**
Moderating Associations			
Intermediate care*Ecological Dimension†	1.05**		
Adequate care*Ecological Dimension†	1.00		
Adequate plus care*Ecological Dimension†	1.02$^{\psi}$		
Intermediate care*Occupational Dimension†		1.02	
Adequate care*Occupational Dimension†		1.03*	
Adequate plus care*Occupational Dimension†		1.04*	
Intermediate care*Sociocultural Dimension†			1.02*
Adequate care*Sociocultural Dimension†			1.03**
Adequate plus care*Sociocultural Dimension†			1.03**
Variance Components			
Intercept	0.19***	0.19***	0.19***
Intermediate care	0.05	0.05*	0.05*
Adequate care	0.06***	0.06***	0.06***
Adequate plus care	0.06***	0.06***	0.06***

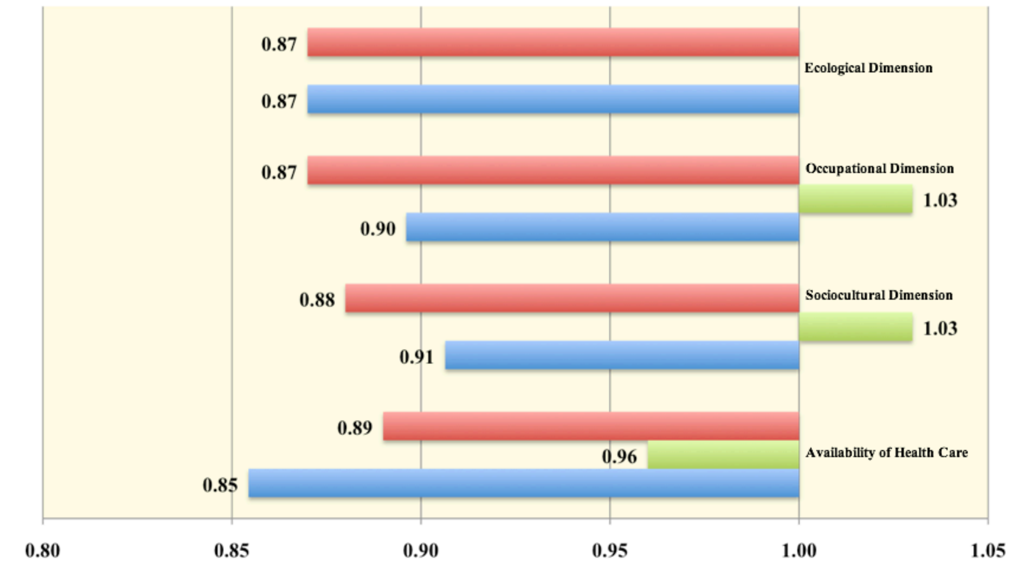
Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	0.77	0.77	0.77	0.76
Interaction	Not Significant	1.02	Not Significant	1.05
Interpretation	0.77	0.79	0.77	0.80

Odds Ratios

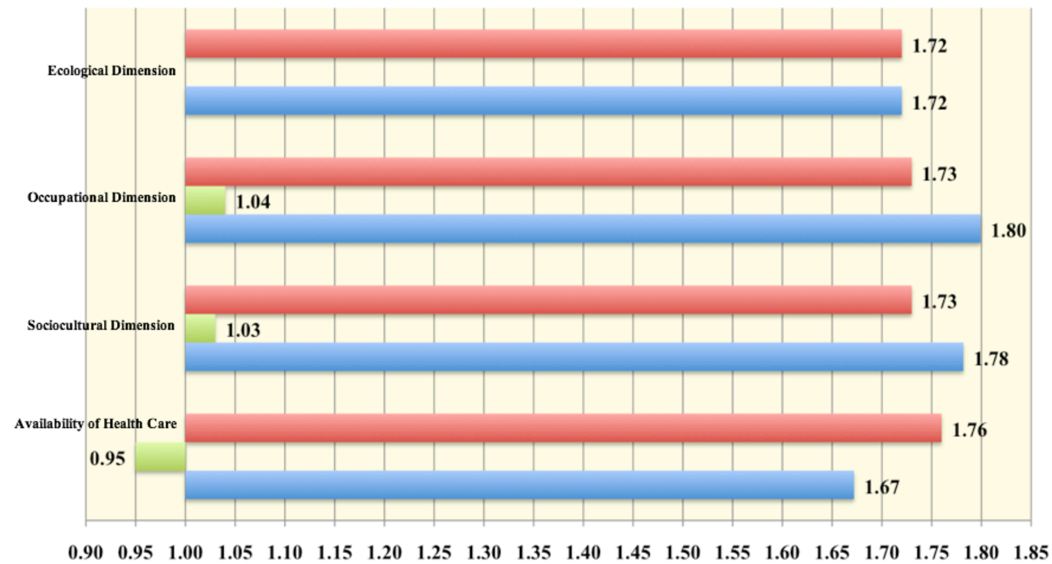
Figure 5-14: Effects of Intermediate Prenatal Care on Hypertensive Disorders of Pregnancy



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	0.89	0.88	0.87	0.87
Interaction	0.96	1.03	1.03	Not Significant
Interpretation	0.85	0.91	0.90	0.87

Odds Ratios

Figure 5-15: Effects of Adequate Prenatal Care on Hypertensive Disorders of Pregnancy



	Availability of Health Care	Sociocultural Dimension	Occupational Dimension	Ecological Dimension
Main Effect	1.76	1.73	1.73	1.72
Interaction	0.95	1.03	1.04	Not Significant
Interpretation	1.67	1.78	1.80	1.72

Odds Ratios

Figure 5-16: Effects of Adequate Plus Prenatal Care on Hypertensive Disorders of Pregnancy

The results of Model II also show that women who received adequate plus prenatal care are 73 percent more likely to experience HDP compared to women who received inadequate prenatal care. Then again, women who received adequate plus prenatal care and live in a county with a high occupational dimension of rurality are 78 percent more likely than their counterparts who received inadequate prenatal care to experience HDP (see Figure 5-16; odds ratio: 1.04).

Model III shows how the effect of prenatal care utilization on HDP varies significantly across the levels of the sociocultural dimension of rurality. Specifically, compared to those women with inadequate prenatal utilization, the odds of experiencing

HDP are 23 percent lower for those women with intermediate prenatal care utilization. However, among those women with intermediate prenatal care utilization who live in a county with high sociocultural dimension of rurality, the odds of experiencing HDP are 21 percent lower than they are for their counterparts with inadequate prenatal care (odds ratio: 1.02).

For those women who had adequate prenatal care utilization, the odds of experiencing HDP were 12 percent lower than they were for women with inadequate prenatal care utilization. Nevertheless, the odds of experiencing HDP were 9 percent lower for women who had adequate prenatal care utilization and lived in a county with high sociocultural dimension of rurality compared to their counterparts with inadequate prenatal care utilization (odds ratio: 1.03).

In addition, compared to those women with inadequate prenatal care, the odds of experiencing HDP are 73 percent greater for women with adequate plus prenatal care. However, for those women with adequate plus prenatal utilization who live in a county with high sociocultural dimension of rurality, the odds of experiencing HDP are 78 percent greater than they are for their counterparts who received inadequate prenatal care (odds ratio: 1.03).

The results of Model IV, which are reported in Table 5.10b, show that those women with intermediate prenatal care utilization are 25 percent less likely to experience HDP compared to women with inadequate prenatal care utilization. Nevertheless, for those women with intermediate prenatal care utilization who live in a county with a high ecological dimension of rurality, the odds of experiencing HDP are 21 percent lower than they are for their counterparts with inadequate prenatal care utilization (see Figure 5-14; odds ratio: 5-14).

Therefore, as shown in Table 5.10a and Table 5.10b, the effect of prenatal care utilization on HDP varies across the levels and dimensions of rurality. Specifically, for those women who live in a county with a strong ecological dimension of rurality, the protective effect of receiving intermediate prenatal care over inadequate prenatal care is not as strong as it is for those women living in a county with a low ecological dimension of rurality. In other words, for those women who live in a county that is less densely populated, the beneficial effect of receiving intermediate prenatal care over inadequate prenatal care is not as large as it is for women living in more densely populated counties.

Table 5.10b Multilevel logistic regression models of how the effect of prenatal care utilization on hypertensive disorders of pregnancy varies across the levels and dimensions of rurality

Variables	Model IV
Individual-level measures (N=3,451,144)	
Intercept	0.03***
Maternal age (Age 20-34=reference)	
Age 19 or younger	0.84***
Age 35 and older	1.32***
Race (White=reference)	
Black	1.19***
American Indian/Alaskan Native	1.21***
Asian	0.61***
Ethnicity	
Hispanic	0.87***
Marital status	
Married	1.05***
Maternal education (BA or higher=reference)	
Less than High School	1.05***
High school/GED	1.17***
Some college/Associate’s degree	1.22***
Maternal smoking during pregnancy	
Mother smokes	0.81***
Mother from California	0.57***
Weight gain during pregnancy (Average weight gain=reference)	
Low weight gain	1.14***
High weight gain	1.55***
Parity	
First birth	2.02***
Prenatal Care Utilization (Inadequate=reference)	
Intermediate care	0.75***
Adequate care	0.86***
Adequate plus care	1.73***

County-level measures (N=3,096)	
Direct Associations	
Dimensions of Rurality	
Ecological Dimension†	1.02
Occupational Dimension†	1.03*
Sociocultural Dimension†	1.03*
County characteristics	
Availability of health care†	0.97**
Moderating Associations	
Intermediate care*Ecological Dimension†	1.05***
Adequate care*Ecological Dimension†	1.00
Adequate plus care*Ecological Dimension†	1.02$^{\Psi}$
Variance Components	
Intercept	0.19***
Intermediate care	---
Adequate care	0.04***
Adequate plus care	0.06***

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\Psi}$ *p*≤ 0.10; **p*≤ 0.05; ***p*≤ 0.01; ****p*≤ 0.001.

These results also show that the benefits of receiving adequate prenatal care over inadequate prenatal care for reducing HDP are not as strong for those women who live in a county with a high occupational dimension of rurality or a high sociocultural dimension of rurality as it is for women who live in a county with a low occupational dimension of rurality or low sociocultural dimension of rurality. In addition, the results of this study show that those women who receive adequate plus prenatal care are more likely to experience HDP compared to mothers with inadequate prenatal care; however, among those women who live in a county with a high occupational dimension of rurality or in a county with a high sociocultural dimension of rurality, this adverse effect is even stronger.

Variation in Individual-level Predictors of Hypertensive Disorders of Pregnancy Across the Levels of Availability of Health Care

This study also tested for possible cross-level interactions between the individual-level predictors and the county-level availability of health care measure. These cross-level interactions were tested in order to determine whether the effect of the individual-level predictors on HDP varied significantly across the level of availability of health care in the residential county. As was the case for the cross-level interactions between the independent variables and the dimensions of rurality, if the variance component was found to not be statistically significant then the model was re-estimated with the random error term associated with that interaction term removed from the model. The results of the models that test for possible cross-level interactions between the individual-level predictors and the level of availability of health care are presented in Table 5.11 through Table 5.17.

Effect of Maternal Age on Hypertensive Disorders of Pregnancy Across the Levels of Availability of Health Care

The models presented in Table 5.11 tested for whether the effect of maternal age on HDP varies across the level of availability of health care in the residential county. As shown in Model I, the variance components for age 19 or younger and age 35 and older were not statistically significant. Therefore, this model was re-estimated by excluding the random error terms (Model II). As reported in Model II, the odds of experiencing HDP are 19 percent lower for women 19 years of age or younger than they are for women 20 through 34 years of age. However, among those women 19 years of age or younger who live in a county with higher availability of health care, the odds of experiencing HDP are 15 percent lower than they are for their counterparts who are 20 through 34 years of age (see Figure 5-1; odds ratio: 1.05). Therefore, while women who live in a county with higher availability of health care have a lower odds of experiencing HDP, higher availability of health care does not have as protective effect for those women who are 19 years of age or younger.

The results of this model also show that women 35 years of age or older are 40 percent more likely to experience HDP than are women 20 through 34 years of age. However, women 35 years of age or older who live in a county with high availability of health care are 33 percent more likely to experience HDP compared to their counterparts who are 20 through 34 years of age (see Figure 5-2; odds ratio: 0.95). In other words, availability of health care in the woman's county of residence has a protective effect for women 35 years of age or older. Better availability of health care may be more beneficial for women who are older than it is for women who are in their teenage years, because even when better availability of health care is available in a county this does not mean that it is easily attainable for all women. Women in their teenage years may not have adequate means of transportation, funds or knowledge to access health care, or insurance through her work or parental work.

Table 5.11 Multilevel logistic regression models of how the effect of maternal age on hypertensive disorders of pregnancy varies across the levels of availability of health care

Variables	Model I	Model II
Individual-level measures (N=3,451,144)		
Intercept	0.03***	0.02***
Maternal age (Age 20-34=reference)		
Age 19 or younger	0.82***	0.81***
Age 35 and older	1.36***	1.40***
Race (White=reference)		
Black	1.19***	1.19***
American Indian/Alaskan Native	1.20***	1.21***
Asian	0.61***	0.60***
Ethnicity		
Hispanic	0.87***	0.87***
Marital status		
Married	1.05***	1.05***
Maternal education (BA or higher=reference)		
Less than High School	1.05***	1.05***
High school/GED	1.17***	1.17***
Some college/Associate's degree	1.22***	1.23***
Maternal smoking during pregnancy		
Mother smokes	0.81***	0.81***
Mother from California	0.56***	0.56***
Weight gain during pregnancy (Average weight gain=reference)		
Low weight gain	1.14***	1.14***
High weight gain	1.55***	1.56***
Parity		
First birth	2.02***	2.05***
Prenatal Care Utilization (Inadequate=reference)		
Intermediate care	0.74***	0.73***
Adequate care	0.86***	0.86***
Adequate plus care	1.67***	1.69***
County-level measures (N=3,096)		

Direct Associations		
Dimensions of Rurality		
Ecological Dimension†	1.04**	1.04**
Occupational Dimension†	1.03*	1.03$^{\psi}$
Sociocultural Dimension†	1.04**	1.04**
County characteristics		
Availability of health care†	0.98*	0.97*
Moderating Associations		
Age 19 or younger*Availability of health care†	1.05***	1.05***
Age 35 and older*Availability of health care†	0.96***	0.95***
Variance Components		
Intercept	0.17***	0.17***
Age 19 or younger	0.02	---
Age 35 and older	0.02	---

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Effect of Maternal Race and Ethnicity on Hypertensive Disorders of Pregnancy Across the Levels of Availability of Health Care

The results of the models that tested whether the effect of race and ethnicity on HDP varies across the levels of availability of health care are presented in Table 5.12. In Model I, the variance component for American Indian/Alaskan Native is not statistically significant; therefore, the model was re-estimated without including the random error term. The results of this model (Model II) show that the effect of race and ethnicity on HDP varies significantly across the levels of availability of health care for Black, Asian, and Hispanic women.

Table 5.12 Multilevel logistic regression models of how the effect of maternal race and ethnicity on hypertensive disorders of pregnancy varies across the levels of availability of health care

Variables	Model I	Model II
Individual-level measures (N=3,451,144)		
Intercept	0.03***	0.03***
Maternal age (Age 20-34=reference)		
Age 19 or younger	0.85***	0.84***
Age 35 and older	1.32***	1.33***
Race (White=reference)		
Black	1.08***	1.08***
American Indian/Alaskan Native	1.15***	1.17***
Asian	0.63***	0.63***
Ethnicity		
Hispanic	0.82***	0.80***
Marital status		
Married	1.05***	1.05***
Maternal education (BA or higher=reference)		
Less than High School	1.05***	1.05***
High school/GED	1.16***	1.16***
Some college/Associate's degree	1.21***	1.21***
Maternal smoking during pregnancy		
Mother smokes	0.81***	0.81***
Mother from California	0.59***	0.58***
Weight gain during pregnancy (Average weight gain=reference)		
Low weight gain	1.14***	1.14***
High weight gain	1.53***	1.54***
Parity		
First birth	1.98***	2.01***
Prenatal Care Utilization (Inadequate=reference)		
Intermediate care	0.74***	0.74***
Adequate care	0.86***	0.86***
Adequate plus care	1.65***	1.66***

County-level measures (N=3,096)		
Direct Associations		
Dimensions of Rurality		
Ecological Dimension†	1.04**	1.04***
Occupational Dimension†	1.03*	1.03*
Sociocultural Dimension†	1.04**	1.04**
County characteristics		
Availability of health care†	0.96***	0.96***
Moderating Associations		
Black*Availability of health care†	1.08***	1.08***
AIAN*Availability of health care†	1.01	1.02
Asian*Availability of health care†	0.96**	0.96*
Hispanic*Availability of health care†	1.05***	1.05***
Variance Components		
Intercept	0.16***	0.16***
Black	0.04***	0.04***
American Indian/Alaskan Native	0.12	---
Asian	0.03***	0.04***
Hispanic	0.08***	0.08***

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\Psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

As reported in Model II, black women are 8 percent more likely to experience HDP compared to white women. However, among those black women who live in a county with better availability of health care, the odds of experiencing HDP are 17 percent higher than they are for their white counterparts (see Figure 5-3; odds ratio: 1.08). While availability of health care has a protective effect on the odds of experiencing HDP overall, this is not the case for black women.

The results of Model II also show that the odds of experiencing HDP are 37 percent lower for Asian women than they are for white women. Nevertheless, Asian women who live in a county with better availability of health care are 40 percent less likely than their white counterparts to experience HDP (see Figure 5-5; odds ratio: 0.96). Unlike the situation for black women, living in a county with better availability of health care is beneficial for reducing the odds of HDP for Asian women.

The effect of ethnicity on HDP also varied significantly across the levels of availability of health care. Specifically, Hispanic women are 20 percent less likely to experience HDP than non-Hispanic women; however, among those Hispanic women who live in a county with better availability of health care, the odds of experiencing HDP are 16 percent lower than they are for their non-Hispanic counterparts (see Figure 5-6; odds ratio: 1.05). As was the case for Black women, better availability of health care increases the odds of HDP for Hispanic women.

Effect of Marital Status on Hypertensive Disorders of Pregnancy Across the Levels of Availability of Health Care

As reported in Table 5.13, the effect of marital status on HDP varies across the levels of availability of health care in the woman's county of residence. The odds of experiencing HDP are 13 percent greater for married women than they are for women who are not married. However, the odds of experiencing HDP are 7 percent greater for married women who live in a county with better availability of health care compared to their unmarried counterparts (see Figure 5-7; odds ratio: 0.95).

Table **5.13** Multilevel logistic regression models of how the effect of marital status on hypertensive disorders of pregnancy varies across the levels of availability of health care

Variables	Model I
Individual-level measures (N=3,451,144)	
Intercept	0.02***
Maternal age (Age 20-34=reference)	
Age 19 or younger	0.85***
Age 35 and older	1.33***
Race (White=reference)	
Black	1.18***
American Indian/Alaskan Native	1.21***
Asian	0.61***
Ethnicity	
Hispanic	0.86***
Marital status	
Married	1.13***
Maternal education (BA or higher=reference)	
Less than High School	1.04***
High school/GED	1.17***
Some college/Associate's degree	1.22***
Maternal smoking during pregnancy	
Mother smokes	0.82***
Mother from California	0.56***
Weight gain during pregnancy (Average weight gain=reference)	
Low weight gain	1.14***
High weight gain	1.55***
Parity	
First birth	2.04***
Prenatal Care Utilization (Inadequate=reference)	
Intermediate care	0.74***
Adequate care	0.86***
Adequate plus care	1.68***
County-level measures (N=3,096)	

Direct Associations	
Dimensions of Rurality	
Ecological Dimension†	1.04**
Occupational Dimension†	1.03*
Sociocultural Dimension†	1.04**
County characteristics	
Availability of health care†	1.01
Moderating Associations	
Married*Availability of health care†	0.95***
Variance Components	
Intercept	0.19***
Married	0.04***

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\Psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Effect of Maternal Education on Hypertensive Disorders of Pregnancy Across the Levels of Availability of Health Care

The effect of maternal education on HDP varies across the levels of availability of health care that is available in the residential county. As reported in Table 5.14, the odds of experiencing HDP are 9 percent higher for women with a high school degree or GED than they are for women with a bachelors degree or higher. However, the odds of experiencing HDP are 17 percent higher for women with a high school degree or GED that live in a county with better availability of health care than they are for their counterparts with a bachelor's degree or higher (see Figure 5-9; odds ratio: 1.07).

Table 5.14 Multilevel logistic regression models of how the effect of maternal education on hypertensive disorders of pregnancy varies across the levels of availability of health care

Variables	Model I
Individual-level measures (N=3,451,144)	
Intercept	0.03***
Maternal age (Age 20-34=reference)	
Age 19 or younger	0.85***
Age 35 and older	1.33***
Race (White=reference)	
Black	1.18***
American Indian/Alaskan Native	1.21***
Asian	0.61***
Ethnicity	
Hispanic	0.87***
Marital status	
Married	1.05***
Maternal education (BA or higher=reference)	
Less than High School	0.94
High school/GED	1.09***
Some college/Associate’s degree	1.16***
Maternal smoking during pregnancy	
Mother smokes	0.82***
Mother from California	0.57***
Weight gain during pregnancy (Average weight gain=reference)	
Low weight gain	1.14***
High weight gain	1.54***
Parity	
First birth	2.01***
Prenatal Care Utilization (Inadequate=reference)	
Intermediate care	0.74***
Adequate care	0.86***
Adequate plus care	1.67***

County-level measures (N=3,096)	
Direct Associations	
Dimensions of Rurality	
Ecological Dimension†	1.03**
Occupational Dimension†	1.03*
Sociocultural Dimension†	1.05***
County characteristics	
Availability of health care†	0.93***
Moderating Associations	
Less than High School*Availability of health care†	1.10***
High school/GED*Availability of health care†	1.07***
Some college*Availability of health care†	1.04***
Variance Components	
Intercept	0.16***
Less than High School	0.10***
High school/GED	0.05***
Some college/Associate's degree	0.02*

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\Psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

As for women with some college education or an associate's degree, the odds of experiencing HDP are 16 percent greater than they are for women with a bachelor's or higher degree. Although, for those women with some college education or an associate's degree who live in a county with better availability of health care, the odds of experiencing HDP are 21 percent larger than they are their counterparts with a bachelor's or higher degree (see Figure 5-10; odds ratio: 1.04).

While those women who live in a county with better availability of health care are 7 percent less likely to experience HDP compared to those women who live in a county with poor availability of health care, these models show that better availability of health care has an adverse effect on the relationship between maternal education and HDP. In other words, women with lower levels of education are more likely to experience HDP, but the magnitude of these maternal education differentials are even greater for women who live in a county with better availability of health care.

Effect of Maternal Smoking During Pregnancy on Hypertensive Disorders of Pregnancy Across the Levels of Availability of Health Care

As reported in Table 5.15, the effect of maternal smoking during pregnancy on HDP varies significantly across the level of availability of health care in the woman's residential county. Specifically, women who smoke during pregnancy are 21 percent less likely to experience HDP compared to those women who did not smoke during their pregnancy. However, women who smoke during their pregnancy who live in a county with better availability of health care are 18 percent less likely to experience HDP compared to their non-smoking counterparts (see Figure 5-11; odds ratio: 1.05).

Table 5.15 Multilevel logistic regression models of how the effect of maternal smoking during pregnancy on hypertensive disorders of pregnancy varies across the levels of availability of health care

Variables	Model I
Individual-level measures (N=3,451,144)	
Intercept	0.03***
Maternal age (Age 20-34=reference)	
Age 19 or younger	0.84***
Age 35 and older	1.33***
Race (White=reference)	
Black	1.20***
American Indian/Alaskan Native	1.21***
Asian	0.61***
Ethnicity	
Hispanic	0.87***
Marital status	
Married	1.05***
Maternal education (BA or higher=reference)	
Less than High School	1.05***
High school/GED	1.17***
Some college/Associate’s degree	1.23***
Maternal smoking during pregnancy	
Mother smokes	0.78***
Mother from California	0.56***
Weight gain during pregnancy (Average weight gain=reference)	
Low weight gain	1.14***
High weight gain	1.56***
Parity	
First birth	2.04***
Prenatal Care Utilization (Inadequate=reference)	
Intermediate care	0.73***
Adequate care	0.86***
Adequate plus care	1.68***

County-level measures (N=3,096)	
Direct Associations	
Dimensions of Rurality	
Ecological Dimension†	1.04**
Occupational Dimension†	1.03*
Sociocultural Dimension†	1.04**
County characteristics	
Availability of health care†	0.97**
Moderating Associations	
Smokes*Availability of health care†	1.05***
Variance Components	
Intercept	0.17***
Smokes	0.03***

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\Psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Effect of Maternal Weight Gain on Hypertensive Disorders of Pregnancy Across the Levels of Availability of Health Care

As shown in Table 5.16, the variance component for low maternal weight gain was not statistically significant; therefore, this model was re-estimated without the random error term. These results are reported in Model II. Women with low maternal weight gain are 12 percent more likely to experience HDP compared to women with an average maternal weight gain. Nevertheless, women with low maternal weight gain who live in a county with better availability of health care are 14 percent more likely to experience HDP compared to their counterparts with an average maternal weight gain (see Figure 5-12; odds ratio: 1.02). Women with high maternal weight gain are 55 percent more likely than women with an average maternal weight gain to experience

HDP, and living in a county with greater availability of health care has no effect on this relationship.

Table 5.16 Multilevel logistic regression models of how the effect of maternal weight gain on hypertensive disorders of pregnancy varies across the levels of availability of health care

Variables	Model I	Model II
Individual-level measures (N=3,451,144)		
Intercept	0.03***	0.03***
Maternal age (Age 20-34=reference)		
Age 19 or younger	0.85***	0.84***
Age 35 and older	1.32***	1.33***
Race (White=reference)		
Black	1.19***	1.20***
American Indian/Alaskan Native	1.20***	1.21***
Asian	0.61***	0.60***
Ethnicity		
Hispanic	0.87***	0.87***
Marital status		
Married	1.05***	1.05***
Maternal education (BA or higher=reference)		
Less than High School	1.05***	1.05***
High school/GED	1.17***	1.17***
Some college/Associate's degree	1.23***	1.23***
Maternal smoking during pregnancy		
Mother smokes	0.81***	0.81***
Mother from California	0.57***	0.56***
Weight gain during pregnancy (Average weight gain=reference)		
Low weight gain	1.12***	1.12***
High weight gain	1.54***	1.55***
Parity		
First birth	2.02***	2.04***
Prenatal Care Utilization (Inadequate=reference)		
Intermediate care	0.74***	0.73***
Adequate care	0.86***	0.86***
Adequate plus care	1.67***	1.68***

County-level measures (N=3,096)		
Direct Associations		
Dimensions of Rurality		
Ecological Dimension†	1.04**	1.04**
Occupational Dimension†	1.03*	1.03
Sociocultural Dimension†	1.03**	1.03**
County characteristics		
Availability of health care†	0.97**	0.97**
Moderating Associations		
Low weight gain*Availability of health care†	1.02**	1.02**
High weight gain*Availability of health care†	1.00	1.00
Variance Components		
Intercept	0.17***	0.17***
Low weight gain	0.01	---
High weight gain	0.01**	0.01*

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\Psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Effect of Prenatal Care Utilization on Hypertensive Disorders of Pregnancy Across the Levels of Availability of Health Care

As reported in Table 5.17, the effect of prenatal care utilization on HDP varies significantly across the levels of availability of health care in the residential county. Women with intermediate prenatal care utilization were 23 percent less likely to experience HDP compared to women with inadequate prenatal care utilization. However, women with intermediate prenatal care utilization who live in a county with better availability of health care are 25 percent less likely to experience HDP compared to their counterparts with inadequate prenatal care utilization (see Figure 5-14; odds ratio: 0.98). It should be noted that this relationship is only marginally significant.

Table 5.17 Multilevel logistic regression models of how the effect of prenatal care utilization on hypertensive disorders of pregnancy varies across the levels of availability of health care

Variables	Model I
Individual-level measures (N=3,451,144)	
Intercept	0.03***
Maternal age (Age 20-34=reference)	
Age 19 or younger	0.85***
Age 35 and older	1.32***
Race (White=reference)	
Black	1.19***
American Indian/Alaskan Native	1.20***
Asian	0.61***
Ethnicity	
Hispanic	0.88***
Marital status	
Married	1.05***
Maternal education (BA or higher=reference)	
Less than High School	1.05***
High school/GED	1.17***
Some college/Associate's degree	1.22***
Maternal smoking during pregnancy	
Mother smokes	0.82***
Mother from California	0.57***
Weight gain during pregnancy (Average weight gain=reference)	
Low weight gain	1.14***
High weight gain	1.54***
Parity	
First birth	2.00***
Prenatal Care Utilization (Inadequate=reference)	
Intermediate care	0.77***
Adequate care	0.89***
Adequate plus care	1.76***

County-level measures (N=3,096)	
Direct Associations	
Dimensions of Rurality	
Ecological Dimension†	1.04**
Occupational Dimension†	1.03*
Sociocultural Dimension†	1.03*
County characteristics	
Availability of health care†	1.01
Moderating Associations	
Intermediate care*Availability of health care†	0.98^{ψ}
Adequate care*Availability of health care†	0.96***
Adequate plus care*Availability of health care†	0.95***
Variance Components	
Intercept	0.19***
Intermediate care	0.05*
Adequate care	0.06***
Adequate plus care	0.05***

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

The results reported in Table 5.17 also show that the odds of experiencing HDP are 11 percent lower for women with adequate prenatal care utilization than they are for women with inadequate prenatal care utilization. Even so, women with adequate prenatal care utilization who live in a county with better availability of health care are 15 percent less likely to experience HDP compared to their counterparts with inadequate prenatal care utilization (see Figure 5-15; odds ratio: 0.96).

In addition, women with adequate plus prenatal care utilization are 76 percent more likely to experience HDP compared to women with inadequate prenatal care utilization. Though, women with adequate plus prenatal care utilization who live in a county with better availability of health care are 67 percent more likely to experience HDP compared to their counterparts with inadequate prenatal care utilization (see Figure 5-16; odds ratio: 0.95).

Summary of the Results

The results of the multilevel logistic regression models are discussed in this section. The individual-level predictors and their relationship with HDP are discussed first. This is followed by a discussion of the relationship between the county-level predictors and HDP. This section concludes with a discussion of the cross-level interaction effects.

Individual-level Predictors of HDP Summary

The results of the models of maternal demographic characteristics and their relationship with HDP are summarized. This section concludes with a discussion of the association between maternal behavioral characteristics and HDP. These are the measures typically included in the models examining variations in HDP. Table 5.18 shows the minimum and maximum odds ratios across all of the models. The important message from this table is the stability of the estimated main effects. The only individual-level characteristics that have odds ratios that differ by 0.04 or more across the models include: mother from California, first birth, and adequate plus prenatal care.

Maternal Demographic Characteristics Summary

A statistically significant relationship was identified in this study between each of the maternal demographic characteristics and HDP. Among women who are 19 years of age or younger, the odds of experiencing HDP were lower than they were for women 20 to 34 years of age. Women who are 35 years of age or older are more likely to experience HDP compared to women who are 20 to 34 years of age and so these older women are most likely to experience HDP. These findings are consistent with prior studies of HDP.

Consistent across the models, the odds of experiencing HDP vary by the race and ethnicity of the woman; thus, the null hypotheses of no relationship are rejected. Specifically, both Black and American Indian/Alaskan Native women were more likely to experience HDP compared to white women (H1). Asian women were less likely to experience HDP compared to white women (H1a). In addition, Hispanic women were less likely to experience HDP compared to their non-Hispanic counterparts (H1b). These findings are consistent with those reported by Wolf et al. (2004) who reported lower rates of gestational hypertension among Hispanic women compared to non-Hispanic women. This finding is also consistent with the Hispanic Paradox.

Table 6.1 shows the minimum and maximum odds ratios across all of the models. The important message from this table is the stability of the estimated main effects. The only individual-level characteristics that have odds ratios that differ by 0.04 or more include: mother from California, first birth, adequate plus prenatal care.

Table 5.18 Minimum and maximum odds ratios of the effect of individual maternal characteristics on hypertensive disorders of pregnancy across all models

Variables	Minimum Odds Ratio	Maximum Odds Ratio
Individual-level measures (N=3,451,144)		
Intercept	0.02***	0.03***
Maternal age (Age 20-34=reference)		
Age 19 or younger	0.84***	0.85***
Age 35 and older	1.32***	1.33***
Race (White=reference)		
Black	1.18***	1.20***
American Indian/Alaskan Native	1.20***	1.22***
Asian	0.60***	0.61***
Ethnicity		
Hispanic	0.86***	0.88***
Marital status		
Married	1.05***	1.05***
Maternal education (BA or higher=reference)		
Less than High School	1.04***	1.05***
High school/GED	1.16***	1.18***
Some college/Associate's degree	1.21***	1.23***
Maternal smoking during pregnancy		
Mother smokes	0.81***	0.82***
Mother from California	0.54***	0.60***
Weight gain during pregnancy (Average weight gain=reference)		
Low weight gain	1.13***	1.14***
High weight gain	1.53***	1.56***
Parity		
First birth	1.98***	2.05***
Prenatal Care Utilization (Inadequate=reference)		
Intermediate care	0.73***	0.75***
Adequate care	0.86***	0.86***
Adequate plus care	1.65***	1.69***

Note: Results are reported in Odds Ratios; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Married women were more likely to experience HDP compared to women who were not married at the time their infant was born. Compared to those women with a bachelor's degree or higher, the odds of experiencing HDP were greater among those women with less than a high school education, high school degree or GED, or some college or Associate's degree (H2). The null hypothesis of no relationship between educational attainment and hypertensive disorders is rejected. The alternative hypothesis that less education increases the risk of HDP is supported and holds across the educational attainment levels. In addition, the finding that women with less education are more likely to experience HDP compared to those women with a bachelor's degree or higher holds, even after accounting for individual health risk behaviors, including maternal smoking during pregnancy and not having adequate prenatal care utilization (H2a). These results are similar to those identified by Fortner and colleagues (2011) that showed that those women who have not completed their high school education are the most likely to develop HDP.

Maternal Behavioral Characteristics Summary

The relationship between maternal behavioral characteristics and HDP are discussed in this section. The null hypothesis that smoking is not associated with HDP was rejected. This study found a protective effect of smoking on HDP. While this finding may seem surprising, it is consistent with results reported in previous research that have shown smoking during pregnancy to have a protective effect on HDP

(Hammoud et al. 2005; Zhang et al. 1999). It is important to note that this does not mean that this effect outweighs the risks of smoking during pregnancy (Janakiraman, Gantz, Maynard, and El-Mohandes 2009).

The null hypothesis that prenatal care utilization is not associated with HDP was rejected. In addition, the results of this study found some support for the hypothesis that women with adequate prenatal care utilization are less likely to experience HDP compared to women with inadequate prenatal care utilization (H3). Specifically, the odds of experiencing HDP were lower for those women with intermediate prenatal care utilization and adequate prenatal care utilization than they were for women with inadequate prenatal care utilization. However, the odds of experiencing HDP were greater for women with adequate plus prenatal care utilization than they were for women with inadequate prenatal care utilization. This result is similar to findings reported in another study that found that women who received adequate prenatal care are more likely to experience HDP compared to women with inadequate prenatal care (Bryson, Ioannou, Rulyak, and Critchlow 2003). It could be that women who had experienced an elevated blood pressure attended more frequent prenatal care visits.

Although this finding may seem counterintuitive, it does not suggest that prenatal care utilization causes women to experience HDP. An explanation for this finding is that women who experience complications during pregnancy may be attending more prenatal care appointments because of their condition, and the number of prenatal care appointments attended is captured in the measurement of the adequacy of prenatal care index. Overall, each of the individual-level predictors was significantly associated with the odds of a woman experiencing HDP.

County-level Predictor Results Summary

The results of the multiple dimensions of rurality and their relationship with HDP are summarized. Table 5.19 shows the minimum and maximum odds ratios of the effect of the county-level characteristics (dimensions of rurality, income inequality, and availability of health care) on HDP. The county-level effects varied more than the individual-level effects across the models. The reason behind the greater variation could be because there are fewer county-level observations, and because there is more variation in how place interacts with different individual-level characteristics.

Dimensions of Rurality

Overall, the model results show that there are differences in the odds of women experiencing HDP across the levels and dimensions of rurality. The null hypothesis that rurality is not associated with HDP was rejected. Women who live in more rural counties are more likely to experience HDP (H4), even after controlling for individual demographic characteristics (e.g., marital status and maternal education) (H4a), and individual health risk behaviors (e.g., maternal smoking during pregnancy and inadequate prenatal care utilization) (H4b). This finding was identified for each of the dimensions of rurality (e.g., ecological, occupational, and sociocultural). Even though the effect of rurality on HDP was reduced (occupational dimension of rurality) after including the other county-level characteristics (e.g., income inequality and the availability of health care) in the model, the association was not eliminated (H4c), and this relationship held across all of the models estimated.

Income Inequality

Hypotheses 5 (H5) suggests that the expected relationship of income inequality and HDP is that the odds of experiencing HDP would be higher for those women who live in a county with greater income inequality. However, the results of this study showed no statistically significant relationship between county income inequality and HDP. The null hypothesis that county-level income inequality is not associated with HDP was accepted.

Availability of Health Care

This study did find support for the hypothesis that women living in counties with greater availability of health care are less likely to experience HDP (H6). The null hypothesis that availability of health care is not associated with HDP was rejected.

Summary

This section included a summary of the county-level predictors and how they were associated with the odds of a woman experiencing HDP. As discussed, higher levels of rurality in a county are associated with an increase in the odds of a woman experiencing HDP. This finding was true for each of the dimensions of rurality (ecological, occupational, and sociocultural). No significant association between county income inequality and individual women's HDP was identified. Evidence of a significant relationship between county health care availability and individual women's HDP was found. How the effects of individual maternal characteristics on HDP vary across the levels and dimensions of rurality and across the levels of county health care availability are discussed in the following section.

Table 5.19 Minimum and maximum odds ratios of the effect of county-level characteristics on hypertensive disorders of pregnancy across all models

Variables	Minimum Odds Ratio	Maximum Odds Ratio
County-level measures (N=3,096)		
Dimensions of Rurality		
Ecological Dimension†	1.03***	1.04***
Occupational Dimension†	1.03***	1.08***
Sociocultural Dimension†	1.03***	1.10***
County characteristics		
Availability of health care†	0.93***	0.98*

Note: Results are reported in Odds Ratios; † indicates the variable is a composite measure that was created from principal components analysis; $^{\Psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Cross-level Interactions

The cross-level interaction effects are discussed in this section. How the effects of individual maternal characteristics on HDP vary across the levels and dimensions of rurality are summarized first, followed by an explanation of how the effect of individual maternal characteristics on HDP vary across the level of availability of health care in the residential county.

Variation across the Level of Rurality

The results of this study showed that the effect of individual-level characteristics of women on HDP risks vary by the level and dimension of rurality in the residential county. It was hypothesized that African American women who live in counties with a higher level of rurality are more likely to experience HDP when compared to African American women who live in less rural areas (H7). The results of this study did not support this hypothesis.

Hypothesis 8 states that the protective effect of prenatal care utilization on HDP would not be as strong for those women who live in counties with a higher level of rurality than they are for all women (H8). Table 5.20 shows how the effect of prenatal care utilization (as well as the other individual maternal characteristics) on HDP varied by the level of the ecological, occupational, and sociocultural dimensions of rurality in the county (as well as by the availability of health care in the county).

The results also show that for those women who live in a county with a strong ecological dimension of rurality, the protective effect of receiving intermediate prenatal care utilization over inadequate prenatal care utilization is not as strong as it is for those women living in a county with a low ecological dimension of rurality, confirming H9. Therefore, for those women who live in a county that is less densely populated, the beneficial effect of receiving intermediate prenatal care utilization over inadequate prenatal care utilization is not as large as it is for women living in more densely populated counties.

Additionally, the full model shows that the benefits of receiving adequate prenatal care utilization over inadequate prenatal care utilization for reducing HDP are not as strong for those women who live in a county with a high occupational dimension of rurality or a high sociocultural dimension of rurality as it is for women who live in a county with a low occupational dimension of rurality or low sociocultural dimension of rurality, again confirming H9.

Table 5.20 Comparison of how the effect of individual maternal characteristics on hypertensive disorders of pregnancy varied by the level of the ecological, occupational, and sociocultural dimensions of rurality in the county and by the availability of health care in the county

Variables	Ecological Dimension	Occupational Dimension	Sociocultural Dimension	Availability of Health Care
Cross-level interactions (N=3,451,144)				
Maternal age (Age 20-34=reference)				
Age 19 or younger	0.98^{ψ}	0.95***	0.96***	1.05***
Age 35 and older	1.04**	1.07***	1.08***	0.95***
Race (White=reference)				
Black	0.98^{ψ}	0.94***	0.95***	1.08***
American Indian/Alaskan Native	1.11**	NS	NS	NS
Asian	NS	1.03^{ψ}	NS	0.96*
Ethnicity				
Hispanic	0.97*	0.95***	0.95***	1.05***
Marital status				
Married	1.03***	1.06***	1.06***	0.95***
Maternal education (BA or higher=reference)				
Less than High School	0.97^{ψ}	0.90***	0.90***	1.10***
High school/GED	NS	0.93***	0.92***	1.07***
Some college/Associate's degree	NS	0.96***	0.95***	1.04***
Maternal smoking during pregnancy				

Mother smokes	NS	0.96***	0.96***	1.05***
Mother from California	Not Tested	Not Tested	Not Tested	Not Tested
Weight gain during pregnancy (Average weight gain=reference)				
Low weight gain	NS	0.97***	0.95***	1.02**
High weight gain	NS	0.97***	0.97***	NS
Parity				
First birth	Not Tested	Not Tested	Not Tested	Not Tested
Prenatal Care Utilization (Inadequate=reference)				
Intermediate care	1.05***	NS	1.02*	0.98^{ψ}
Adequate care	NS	1.03*	1.03**	0.96***
Adequate plus care	1.02^{ψ}	1.04*	1.03**	0.95***

Note: Results are reported in Odds Ratios; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Table 5.21 compares the variance components for the cross-level interactions across each of the models. When the variance component is statistically significant this allows the effect of an individual maternal demographic or behavioral characteristic on HDP to vary across and within counties. When the variance component for the cross-level interaction is not statistically significant, this means that the effect does not significantly vary within counties. The effect can vary *across* counties, but can no longer vary *within* counties. As shown in Table 5.21, the affect of maternal age on HDP did not vary within counties with the exception of age 35 and older by the ecological dimension of rurality. In addition, low maternal weight gain and its relationship with HDP did not vary within counties.

Table 5.21 Comparison of the variance components for the cross-level interactions

Variables	Ecological Dimension	Occupational Dimension	Sociocultural Dimension	Availability of Health Care
Cross-level interactions (N=3,451,144)				
Maternal age (Age 20-34=reference)				
Age 19 or younger	---	---	---	---
Age 35 and older	0.03**	---	---	---
Race (White=reference)				
Black	0.05***	0.04***	0.04***	0.04***
American Indian/Alaskan Native	---	---	---	---
Asian	0.04***	0.04***	0.04***	0.04***
Ethnicity				
Hispanic	0.08***	0.08***	0.08***	0.08***
Marital status				
Married	0.04***	0.04***	0.04***	0.04***
Maternal education (BA or higher=reference)				
Less than High School	0.12***	0.11***	0.11***	0.10***
High school/GED	0.06***	0.05***	0.05***	0.05***
Some college/Associate's degree	0.02**	0.02*	0.02*	0.02*
Maternal smoking during pregnancy				
Mother smokes	0.03***	0.03***	0.03***	0.03***
Mother from California	Not Tested	Not Tested	Not Tested	Not Tested

Weight gain during pregnancy (Average weight gain=reference)				
Low weight gain	---	---	---	---
High weight gain	0.01*	0.01*	0.01*	0.01*
Parity				
First birth	Not Tested	Not Tested	Not Tested	Not Tested
Prenatal Care Utilization (Inadequate=reference)				
Intermediate care	---	0.05*	0.05*	0.05*
Adequate care	0.04***	0.06***	0.06***	0.06***
Adequate plus care	0.06***	0.06***	0.06***	0.05***

Note: Results are reported in Odds Ratios; --- Random slope not included in the model; $^{\psi}$ $p \leq 0.10$; *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

Variation across the Level of Availability of Health Care

Availability of health care is another important characteristic of counties that may affect risk of hypertensive disorders. The results showed that the effect of individual-level characteristics on HDP varied by the level of availability of health care in the residential county (H9). For example, women with lower levels of education are more likely to experience HDP, but the magnitude of these maternal education differentials are even greater for women who live in a county with better availability of health care. This finding does not support H9a, which was that greater availability of health care in a county would reduce the maternal education differentials.

Summary

This section included a discussion of how the effect of the individual maternal demographic and behavioral characteristics on HDP varied across the levels and dimensions of rurality and across the level of availability of health care in the county.

Conclusions

This chapter described the descriptive statistics for each of the county-level measures included in the analyses. It also reported the results of the multilevel logistic regression models that include the individual-level and county-level predictors, as well as the cross-level interactions. The chapter concluded with a summary of the study results.

The results of this study are discussed in the following chapter. The following chapter also includes of the study contributions, limitations, and policy implications.

Chapter 6

Discussion and Conclusion

Introduction

Previous research that has focused on rural/urban health disparities has not examined pregnancy outcomes and research on disparities in pregnancy outcomes has not considered various dimensions of rurality. This dissertation built upon previous rural/urban health disparities research by considering how multiple indicators of rurality are associated with HDP. It also considered how individual maternal characteristics of women may contribute to the odds of a woman experiencing HDP differently across these multiple levels and dimensions of rurality. In order to fully understand the disparities in HDP across the levels and dimensions of rurality, additional residential characteristics such as income inequality and the availability of health care also were considered. This study went beyond prior research on HDP by demonstrating how the attributes of rural areas such as low population density, isolation, and a high proportion of people working in the primary industries can affect the likelihood of a pregnant woman experiencing HDP.

The purpose of this dissertation was to address three broad research questions about the relationships between HDP and individual characteristics and local residential conditions. The purpose of answering these research questions was to gain a better understanding of the characteristics of women and the places that they live that may be most amenable to intervention or policy. This information could be used for designing interventions or implementing policies aimed at reducing the rates of hypertensive disorders in pregnancy. The three research questions examined in this dissertation are as follows:

(1) Do the odds of experiencing HDP vary by the race/ethnicity, education, and prenatal care utilization of the woman?

(2) Do the odds of experiencing HDP vary by the level and dimension of rurality? If yes, can these observed effects of rurality be accounted for by health care service availability and income inequality?

(3) Does the effect of individual-level characteristics such as maternal race, ethnicity, and education on HDP vary by the characteristics of the residential context in which the woman lives?

In light of these research questions, a theoretical framework that incorporated multiple dimensions of rurality, income inequality, and local health care availability with HDP was developed to help guide the analytical approach. The analytical approach included multilevel logistic regression models of HDP for women who live in the continental United States and had a live birth at any time during the 2007 calendar year. Natality data from the National Center for Health Statistics was merged with county-level measures of rurality, income inequality, and availability of health care in a woman's county of residence. These data were used to estimate multilevel logistic regression models of HDP.

Discussion of the Results

As previously discussed, a conceptual framework was developed to guide this study that includes both individual- and county-level characteristics (see Figure 2-1). This model was used to assess the relative importance of the predictors of HDP. Previous studies have shown that individual maternal characteristics are directly associated with HDP. What these studies did not do, however, is to investigate how characteristics of the place a woman lives and how a woman's individual characteristics can interact with characteristics of the place she lives to affect her likelihood of experiencing HDP.

As shown in the conceptual model (Figure 2-1), characteristics of the place a woman lives (e.g., dimensions of rurality, income inequality, and health care availability) were expected to be associated with variation in the odds of a woman experiencing HDP across counties (as shown by the solid arrow). The results of this study showed just that. Each of the dimensions of rurality (e.g., ecological, occupational, and sociocultural) was found to be significantly associated with HDP. It was no surprise to find that with an increase in rurality in the place a woman lived increased the odds that she would experience HDP. Prior research has shown that rural residents are in poorer health compared to those living in urban areas (Ricketts 2000; Ziller, Coburn, Anderson, and Loux 2008). What was interesting to find was that each of the dimensions of rurality was positively associated with HDP. In other words, an increase in the ecological, occupational, and sociocultural dimensions of rurality all contributed to an increase in the odds of a woman experiencing HDP. This was the case when the dimensions were included in the model independently and jointly. This means that when a woman lives in an area with high rurality (on any dimension or a combination of dimensions) this increases her risk of experiencing HDP.

The ecological dimension of rurality, the dimension that involves the spatial distribution of the population across geographical areas, was associated with an increase in an individual woman's odds of experiencing HDP for a number of possible reasons. When areas have low population densities and the area is not in close proximity to more urban places, there may not be a sufficient population base to support quality healthcare (Glasgow, Johnson, and Morton 2004a). The social isolation that is inherent in areas with a higher ecological dimension of rurality is associated with limited or no public transportation to travel to health care services and less formal health insurance coverage (Snyder and McLaughlin 2004). All of these problems may contribute to the increase in the odds of experiencing HDP that was found for those women who live in a county with a high ecological dimension of rurality.

The results of this study also showed that increases in the occupational dimension of rurality in a county are associated with an increase in the odds that a woman will experience HDP. As discussed in Chapter 2, the occupational dimension of rurality consists of whether the occupations that are dominant in the area are based in the primary industries (e.g., agriculture, mining, fishing, and forestry. Areas that are characterized by occupations that are based in the primary industries have health risks that are not apparent in more urbanized areas (Hendryx, O'Donnell, and Horn 2008; Villarejo 2003). Women who live in these areas may have been exposed to environmental contamination at their job or even through the water, air, soil, or from their diet, which may have contribute to HDP. These types of occupations also have lower salaries and do not have health insurance benefits, which can contribute to women not being able to afford the health care that they need to take preventative measures to avoid experiencing HDP. When the majority of the population is working in the primary industries, this also means that fewer people are working in managerial and professional occupations. Without a strong economy, areas will not be able to support the infrastructure needed to promote healthy lifestyles and ensure adequate health care facilities. These risks may all have contributed to the increased risk of HDP identified for those women who are living in areas with a high occupational dimension of rurality.

This study found that women living in areas with a high sociocultural dimension of rurality were more likely to experience HDP than their counterparts who did not live in this type of area. Several characteristics of areas with high a sociocultural dimension may have contributed to this finding. Areas that are high on the sociocultural dimension of rurality tend to have poor housing, higher poverty rates, lower family incomes, and less access to resources compared to more urban areas (Krout 2004). Living in these types of areas can have detrimental effects on health and could have contributed to the increased risk of HDP, which women whom lived in areas with higher sociocultural dimension of rurality experienced. Areas with higher sociocultural dimension of rurality also tend to have lower rates of educational attainment. Women with lower levels of educational attainment may have less ability to effectively utilize health care services

(Sparks, McLaughlin, and Stokes 2009), which may have contributed to the increased risk of women experiencing HDP.

It was hypothesized that county income inequality would have a direct effect on HDP; however, the findings of this study showed that this was not the case. Income inequality is a measure of relative disadvantage that has been found to be associated with differentials in a variety of health outcomes. In areas with higher income inequality, individuals who are disadvantage may feel left behind the rest of society (Wilkinson 2006). For the case of HDP, it may not be the relative deprivation that is important, but rather the actual deprivation of the area that was captured in the sociocultural dimension of rurality measure.

The availability of health care in a county was found to have a direct effect on HDP. In other words, when a woman lived in a county with a greater availability of health care, this reduced her odds of experiencing HDP. A number of characteristics of these places contributed to the decreased risk of a woman experiencing HDP including higher rates of health insurance coverage, more doctors including medical doctors and OB/GYN physicians, and more health care providers.

The conceptual model also showed how the characteristics of the place a woman lives are expected to interact with her individual maternal characteristics to affect the likelihood that she will experience HDP. The results of this study showed that the effect of individual maternal characteristics on HDP varied by the level of rurality (for each the ecological, occupational, and sociocultural dimensions) and by the level of availability of health care in the county. For example, the beneficial effect of receiving additional prenatal care is not as strong for those women who live in rural areas.

The results show that for those women who live in a county with a strong ecological dimension of rurality, the protective effect of receiving intermediate prenatal care utilization over inadequate prenatal care utilization is not as strong as it is for those women living in a county with a low ecological dimension of rurality. In other words, for those women who live in a county that is less densely populated, the beneficial effect of receiving intermediate prenatal care utilization over inadequate prenatal care utilization is not as large as it is for women living in more densely populated counties. Receiving more prenatal care reduces the odds that a woman will experience HDP; however, there is something about areas with low population densities and far proximity to urban areas that causes the beneficial effect of receiving more prenatal care to be not as strong. As previously discussed, areas with a high ecological dimension of rurality may not have a large enough population base to support a strong health care system. It may be that when women who live in an area with a high ecological dimension of rurality, the additional prenatal care they are receiving may not be of as high quality as it would be in an areas that can support a strong health care system.

The results also show that the benefits of receiving adequate prenatal care utilization over inadequate prenatal care utilization for reducing HDP are not as strong for those women who live in a county with a high occupational dimension of rurality compared to those who live in other areas. Areas that are dominated by occupations in the primary industries tend to have residents who earn lower salaries and are uninsured. Women with lower salaries or no health care insurance may not have the means to receive high quality prenatal care, so the care they are receiving does not have as strong of an effect on HDP.

The additional benefit of greater prenatal care utilization on HDP was not as strong for those women who live in an area with a high sociocultural dimension of rurality as it is for women who live in a county with low sociocultural dimension of rurality. Areas with a high sociocultural dimension of rurality tend to have lower educational attainment. When women live in an area with a high proportion of individuals with low levels of education, they may not have the opportunity to interact with individuals who know the importance of receiving prenatal care from quality providers or understand the importance of following the recommendations provided by the prenatal care provider. This may explain why women who live in areas with a high sociocultural dimension of rurality do not have as strong of a benefit when receiving more prenatal care.

Not only did the effect of individual maternal characteristics on HDP vary by the level and dimension of rurality in the woman's residential county, but the results also showed that the effect of individual-level characteristics on HDP varied by the level of availability of health care in the residential county. For example, women with lower levels of education are more likely to experience HDP, but the magnitude of these maternal education differentials are even greater for women who live in a county with better availability of health care. Women with higher levels of education may better understand the importance of receiving adequate health care for reducing their odds of experiencing HDP. In areas with greater availability of health care, more educated women have the option of receiving the quality of care they know they need, which in turn may reduce their risk of experiencing HDP.

Contributions

Individual-level risk factors for HDP, such as demographic and behavioral characteristics, have been well documented in the literature. Until now, the impact of the residential context has not been considered. There is a growing recognition that good health is associated with opportunities and resources that are available in the places in which we live. Having a thorough understanding of the characteristics of places and how they differ is important for shaping health policy, because the underlying differences in the opportunities and resources that people have available contribute to the uneven distribution of health in the United States (Williams 2011).

This dissertation increased our understanding of the variation in the odds of a woman experiencing HDP related to individual characteristics and behaviors, but also through the local conditions in which women live. For example, this study moves beyond prior research on HDP by considering the importance of health care availability and income inequality by estimating multilevel logistic regression models of HDP that include both individual-level predictors and measures of residential county conditions. Multilevel modeling provides the ability to examine whether pregnancy-related risks of HDP vary across the conditions of the residential context (e.g., income inequality and health care availability) and across the levels and dimensions of rurality. The capability to test for these cross-level interaction effects provides for the opportunity to pay special attention to the most vulnerable populations of women, because characteristics of places may worsen (or lessen) the health risks for women with individual-level characteristics that place them most at risk of HDP.

This study also increased our understanding of how differences in the levels and dimensions of rurality contribute to differences in women experiencing HDP. The results showed that when women live in a county with a higher ecological, occupational, or sociocultural dimension of rurality, this increases her odds of experiencing HDP. These findings contribute to both the Rural Sociology and Demography literatures.

Specifically, rural sociologists are increasingly interested in investigating geographical health disparities across rural and urban areas. In order to improve the health of rural Americans it is necessary to understand the differences in health outcomes among rural and urban residents. By identifying rural and urban differences in health outcomes, we can begin to investigate the causes of these geographical health disparities. Once the causes of the geographical health disparities are identified, policies can be implemented that are intended to address these causes. Addressing these underlying causes of health disparities should help reduce the geographical disparities in health outcomes.

This study contributed to geographical disparities research by identifying that when women live in more rural areas they are more likely to experience HDP. After establishing this geographical disparity in HDP, further analyses were completed to identify how women of a particular age, race, ethnicity, and education level have different odds of experiencing HDP depending upon the level of rurality in the county in which the woman lives. By identifying these differences, more appropriate strategies for reducing the odds of HDP can be established through health policy and other initiatives.

Recently, demographers are interested in identifying social determinants of health. This study contributed to the demographic literature by identifying how maternal education is associated with the odds of experiencing HDP. Maternal education is not often considered in previous studies on HDP. The results of this study not only revealed that there are significant differences in the odds of a woman experiencing HDP by the highest level of education she completed, but the results also showed that the effect of maternal education on HDP varies significantly across the levels and dimensions of rurality and by the availability of health care in the woman's county of residence. These findings can be used to reduce rates of HDP among women of varying levels of education and who live in different types of areas (i.e., more rural areas or areas with less health care availability).

Policy Implications

Despite the fact that rural and urban populations vary on a number of demographic, social, and cultural characteristics, policies are not always designed with these differences in mind. The level of rurality in an area has long been recognized as an important element that affects availability of health services (Eberhardt et al. 2001). For example, rural health policy has traditionally focused on the limited availability of health services caused by the scarcity of health care providers in nonmetropolitan areas (Eberhardt et al. 2001). In rural areas, there have been efforts made to increase physician supply. These efforts include medical student financial incentives, changes in Medicare and Medicaid reimbursements, and direct provision of care through community health care centers (Eberhardt et al. 2001).

The results of this study show that availability of health services is not the only element that should be taken into account when examining geographical disparities in health. As previously discussed, the effects of individual maternal characteristics on HDP varied by the levels and dimensions of rurality. This finding provides evidence that policies focused on reducing HDP may not work the same for women with different demographic or behavioral characteristics or for women who live in different types of areas. In other words, strategies aimed at reducing HDP for women with lower levels of education may need to be specific for type of area in which the woman lives.

Study Limitations

This study made significant contributions to the maternal health literature by using a nationwide dataset to investigate whether and how the levels and dimensions of rurality are associated with HDP. The study does have a few limitations. First, there may be issues related to the validity and reliability of the information included on the birth certificates, which could potentially bias the results of this study. While these data are maintained by federal agencies and are of high quality, there are inconsistencies in who fills out the information on the birth certificate (Woolbright and Harshbarger 1995). Prior studies have shown that there can be issues with validity when using data on maternal smoking during pregnancy and prenatal care utilization that was derived from a birth certificate (Northam and Knapp 2006).

Second, since the data used in this study were derived from birth records, these data exclude women whose infants die. This is unfortunate, because these are probably some of the women who are more likely to experience HDP. This may partially explain why the rates of HDP reported in this study are slightly lower than has been reported previously (i.e. 4 percent vs. 5 to 10 percent of woman that has been reported elsewhere (Bryson, Ioannou, Rulyak, and Critchlow 2003; Sibai et al. 1997)).

Third, several individual-level characteristics that may be associated with HDP, such as income, employment status, and health insurance coverage, were not included in the models as these data are not available in the detailed natality files. In addition, these data did not include a true measure of maternal nutrition. As a result, a proxy measure of maternal nutrition (maternal weight gain) was used in the analyses. The data file used in this study is limited in scope in terms of the amount of information that is gathered about the woman; however, it is unique in that it is a 100 percent sample of women who gave birth in the United States and that it contains identifiers for where the women live. Unfortunately, due to the amount of missing data on birth certificates, the 100 percent sample of women could not be fully utilized and those women with missing information were excluded from the analyses.

Fourth, the National Center for Health Statistics non-public use detailed natality files only include information on the mother's weight gain during pregnancy, but does not provide information on the mother's height (National Center for Health Statistics 2007a). This does not allow for the calculation of the mother's Body Mass Index (BMI) prior to pregnancy and during pregnancy, which is a more reliable measure of maternal weight gain.

Finally, the data included on the birth certificate is limited in terms of the amount of medical information included about the mother. As this study was concentrated on gaining a better understanding of HDP, a condition that occurs during pregnancy, more detailed medical information about the woman and her pregnancy would have strengthened the results of this study, by eliminating alternative explanations for incidence of HDP. The data included information on whether or not the woman experienced HDP, but did not include information for when HDP occurred or the severity of the woman's condition.

Future Research

Future research on variation in HDP in the United States is needed in order to gain a better understanding of how the levels and dimensions of rurality of the place a woman lives affects the odds of experiencing HDP differently for women depending upon their race or ethnicity. The cross-level interactions effects tested in this study indicated that the effect of race and ethnicity on HDP varied across the levels and dimensions of rurality in the residential county. Further research is needed to understand these differences. Specifically, the results showed that the relationship between race and ethnicity on HDP significantly varied across the levels and dimensions of rurality for black and Hispanic women.

In the future, multilevel logistic models can be estimated separately for women according to their race or ethnicity. These race-specific multilevel logistic regression models will allow for a more thorough understanding of how the individual and county-level predictors of HDP vary for women of different racial and ethnic backgrounds. These race-specific findings can be used to establish racial and ethnic specific strategies that are aimed at reducing HDP for these women. The racial/ethnic composition of counties should also be considered in order to understand whether a larger composition of certain racial or ethnic groups poses an adverse effect on the odds of a woman experiencing HDP. These further analyses may help explain the protective effect of African American race on HDP in the most rural counties, as most rural African Americans live in areas with higher concentrations of African Americans. These are the same areas with poor health care services and low wage jobs.

More research needs to be done to investigate disparities in HDP across the rural-urban continuum. The knowledge gained from this research can be used to find ways to improve the quality of healthcare that rural women receive. For example, rural hospitals, which often serve as the basis for healthcare delivery in rural areas, need to provide a more diversified set of services. Policies need to be established to allow rural hospitals to stay open or adequate health care providers need to put in these rural areas. In addition, we need to establish ways to provide the most cost-effective care that is appropriate for rural environments with struggling economies and shortages of healthcare professionals. One way to help improve healthcare in rural areas is to discover new ways to recruit physicians to practice in rural areas (Moscovice and Stensland 2002). The downside to this approach is that there needs to be a large enough population base to support doctors and specialists. In areas that do not have a large enough population to support specialists, it may be helpful to provide the general practitioners with more training on poor pregnancy outcomes such as hypertensive disorders of pregnancy. This would allow for earlier diagnosis and better treatment options.

While research has shown that the risk of preeclampsia is decreased for women who smoke during pregnancy, the biological linkage between smoking and preeclampsia is not well understood (Castles, Adams, Melvin, Kelsch, and Boulton 1999; Miller et al. 2010). Further researcher is needed in order to better understand this finding. It may be that there is an underlying mechanism that is driving this finding that has not been previously identified.

Conclusion

Prior to this dissertation, research has not addressed geographical differentials in HDP resulting from individual and residential characteristics. This dissertation focused on examining variation in the odds of a woman experiencing HDP by examining how individual and residential/county-level characteristics contribute to these differences. In addition, this dissertation built upon previous research that has focused on rural/urban health disparities and disparities in pregnancy outcomes by considering how multiple indicators of rurality are associated with HDP. The results from this study have documented these differences and can be used to offer insight into how the risks of experiencing HDP can be reduced for women with various individual maternal characteristics and for women living in both rural and urban areas across the continental United States.

References

Abraido-Lanza, A.F., B.P. Dohrenwend, D.S. Ng-Mak, and J.B. Turner. 1999. "The Latino mortality paradox: a test of the "salmon bias" and healthy migrant hypotheses." *American Journal of Public Health* 89(10):1543-1548.

Adams, E.K. and G.E. Wright. 1991. "Hospital choice of Medicare beneficiaries in a rural market: why not the closest?" *The Journal of Rural Health* 7(2):134-152.

Adler, N.E., T. Boyce, M.A. Chesney, S. Cohen, S. Folkman, R.L. Kahn, and S.L. Syme. 1994. "Socioeconomic status and health: The challenge of the gradient." *American Psychologist* 49(1):15-24.

Adler, N.E., W.T. Boyce, M.A. Chesney, S. Folkman, and S.L. Syme. 1993. "Socioeconomic inequalities in health." *JAMA: The Journal of the American Medical Association* 269(24):3140-3145.

Adler, N.E. and K. Newman. 2002. "Socioeconomic disparities in health: pathways and policies." *Health Affairs* 21(2):60-76.

Adler, N.E. and J.M. Ostrove. 1999. "Socioeconomic status and health: What we know and what we don't." *Annals of the New York Academy of Sciences* 896(1):3-15.

Adler, N.E. and D.H. Rehkopf. 2008. "US disparities in health: descriptions, causes, and mechanisms." *Annual Review of Public Health* 29(1):235-252.

Agency for Healthcare Research Quality. 2004. "National Healthcare Disparities Report." Rockville, MD.

Ahern, M., M. Mullett, K. MacKay, and C. Hamilton. 2011. "Residence in Coal-Mining Areas and Low-Birth-Weight Outcomes." *Maternal and Child Health Journal* 15(7):974-979.

Albrecht, S.L., M.K. Miller, and L.L. Clarke. 1994. "Assessing the importance of family structure in understanding birth outcomes." *Journal of Marriage and Family* 56(4):987-1003.

Alexander, G.R. and D.A. Cornely. 1987. "Racial disparities in pregnancy outcomes: The role of prenatal care utilization and maternal risk status." *American Journal of Preventive Medicine* 3(5):254.

Alexy, B., B. Nichols, M.A. Heverly, and L. Garzon. 1997. "Prenatal factors and birth outcomes in the public health service: a rural/urban comparison." *Research in Nursing & Health* 20(1):61-70.

American Pregnancy Association. 2012. "Gestational hypertension: pregnancy induced hypertension." in *Promoting Pregnancy Wellness*. Irving, Texas.

Area Resource File. 2008. US Department of Health and Human Services, Health Resources and Services Administration, Bureau of Health Professions, Rockville, MD.

Association of Religious Data Archives. 2000. "Religious Congregations and Membership Study, 2000."

Ayoola, A.B., M.D. Nettleman, M. Stommel, and R.B. Canady. 2010. "Time of pregnancy recognition and prenatal care use: A population based study in the United States." *Birth Issues in Perinatal Care* 37(1):37-43.

Bailey, B.A. and L.K.J. Cole. 2009. "Rurality and birth outcomes: findings from Southern Appalachia and the potential role of pregnancy smoking." *The Journal of Rural Health* 25(2):141-149.

Barton, J.R., J.M. O'Brien, N.K. Bergauer, D.L. Jacques, and B.M. Sibai. 2001. "Mild gestational hypertension remote from term: progression and outcome." *American Journal of Obstetrics and Gynecology* 184(5):979-983.

Batstra, L., M. Hadders-Algra, and J. Neeleman. 2003. "Effect of antenatal exposure to maternal smoking on behavioural problems and academic achievement in childhood: prospective evidence from a Dutch birth cohort." *Early Human Development* 75(1-2):21-33.

Bealer, R.C., F.K. Willits, and W.P. Kuvlesky. 1965. "The meaning of rurality in American society: Some implications of alternative definitions." *Rural Sociology* 30(3):255-266.

Blakely, T.A. and A.J. Woodward. 2000. "Ecological effects in multi-level studies." *Journal of Epidemiology and Community Health* 54(5):367-374.

Blumenthal, S. and J. Kagen. 2002. "The Effects of Socioeconomic Status on Health in Rural and Urban America." *JAMA: The Journal of the American Medical Association* 287(1):109.

Brame, R., R. Paternoster, P. Mazerolle, and A. Piquero. 1998. "Testing for the equality of maximum-likelihood regression coefficients between two independent equations." *Journal of Quantitative Criminology* 14(3):245-261.

Brasure, M., J. Stensland, and A. Wellever. 2000. "Quality oversight: why are rural hospitals less likely to be JCAHO accredited?" *The Journal of Rural Health* 16(4):324-336.

Braunstein, S. and R. Lavizzo-Mourey. 2011. "How the health and community development sectors are combining forces to improve health and well-being." *Health Affairs* 30(11):2042-2051.

Braveman, P., K. Marchi, S. Egerter, M. Pearl, and J. Neuhaus. 2000. "Barriers to timely prenatal care among women with insurance: the importance of prepregnancy factors." *Obstetrics & Gynecology* 95874-880.

Brewster, L.M., Z. Taherzadeh, S. Volger, J.F. Clark, T. Rolf, H. Wolf, E. VanBavel, and G.A. van Montfrans. 2010. "Ethnic differences in resistance artery contractility of normotensive pregnant women." *American Journal of Physiology-Heart and Circulatory Physiology* 299(2):H431.

Bronstein, J.M., V.A. Johnson, and A.F. Crayton Jr. 1997. "How rural physicians compare on cost and quality measures for Medicaid ambulatory care episodes." *The Journal of Rural Health* 13(2):126-135.

Bronstein, J.M. and M.A. Morrisey. 1991. "Bypassing rural hospitals for obstetrics care." *Journal of Health Politics Policy Law* 1687-118.

Bryant, A.S., E.W. Seely, A. Cohen, and E. Lieberman. 2005. "Patterns of pregnancy-related hypertension in black and white women." *Hypertension in Pregnancy* 24(3):281-290.

Bryant, A.S., A. Worjoloh, A.B. Caughey, and A.E. Washington. 2010. "Racial/ethnic disparities in obstetric outcomes and care: prevalence and determinants." *American Journal of Obstetrics and Gynecology* 202(4):335-343.

Bryson, C.L., G.N. Ioannou, S.J. Rulyak, and C. Critchlow. 2003. "Association between gestational diabetes and pregnancy-induced hypertension." *American Journal of Epidemiology* 158(12):1148.

Bullock, L.F.C., J.L.C. Mears, C. Woodcock, and R. Record. 2001. "Retrospective study of the association of stress and smoking during pregnancy in rural women." *Addictive Behaviors* 26(3):405-413.

Castles, A., E.K. Adams, C.L. Melvin, C. Kelsch, and M.L. Boulton. 1999. "Effects of smoking during pregnancy: Five meta-analyses." *American Journal of Preventive Medicine* 16(3):208-215.

Chang, J., L.D. Elam-Evans, C.J. Berg, J. Herndon, L. Flowers, K.A. Seed, and C.J. Syverson. 2003. "Pregnancy-related mortality surveillance: United States, 1991-1999." *MMWR Surveill Summ* 52(2):1-8.

Chang, J.J., L.J. Muglia, and G.A. Macones. 2010. "Association of early onset pre eclampsia in first pregnancy with normotensive second pregnancy outcomes: a population based study." *BJOG: An International Journal of Obstetrics & Gynaecology* 117(8):946-953.

Clogg, C.C., E. Petkova, and A. Haritou. 1995. "Statistical methods for comparing regression coefficients between models." *American Journal of Sociology* 1261-1293.

Coburn, A.F., M. Wakefield, M. Casey, I. Moscovice, S. Payne, and S. Loux. 2004. "Assuring rural hospital patient safety: what should be the priorities?" *The Journal of Rural Health* 20(4):314-326.

Cohen, D. and A. Coco. 2009. "Declining trends in the provision of prenatal care visits by family physicians." *Annals of Family Medicine* 7(2):128.

Conde-Agudelo, A., F. Althabe, J.M. Belizan, and A.C. Kafury-Goeta. 1999. "Cigarette smoking during pregnancy and risk of preeclampsia: a systematic review." *American Journal of Obstetrics and Gynecology* 181(4):1026-1035.

Cordes, S.M. 1989. "The changing rural environment and the relationship between health services and rural development." *Health services research* 23(6):757.

Coronado, G.D., B. Thompson, T.D. Koepsell, S.M. Schwartz, and D. McLerran. 2004. "Use of Pap test among Hispanics and non-Hispanic whites in a rural setting." *Preventive Medicine* 38(6):713-722.

Culler, S.D., A. Atherly, S. Walczak, A. Davis, J.N. Hawley, K.J. Rask, V. Naylor, and K.E. Thorpe. 2006. "Urban rural differences in the availability of hospital information technology applications: a survey of Georgia hospitals." *The Journal of Rural Health* 22(3):242-247.

Curwin, B., W. Sanderson, S. Reynolds, M. Hein, and M. Alavanja. 2002. "Pesticide use and practices in an Iowa farm family pesticide exposure study." *Journal of agricultural Safety and Health* 8(4):423-433.

Cutler, D. and G. Miller. 2005. "The role of public health improvements in health advances: the twentieth-century United States." *Demography* 42(1):1-22.

Davis, K., L. Baksh, L. Bloebaum, N. Streeter, and B. Rolfs. 2004. "Barriers to adequate prenatal care in Utah." *PRAMS Perspectives* 1(1):1-8.

DeLind, L.B. 1995. "The state, hog hotels, and the" right to farm": A curious relationship." *Agriculture and Human Values* 12(3):34-44.

DeLind, L.B. 1998. "Parma, a story of hog hotels and local resistance." Pp. 23-38 in *Pigs, profits, and rural communities*, edited by K. M. Thu and E. P. Durrenberger. Albany: State University of New York.

Duncan, G.J., M.C. Daly, P. McDonough, and D.R. Williams. 2002. "Optimal indicators of socioeconomic status for health research." *American Journal of Public Health* 92(7):1151.

Durkheim, E. and G. Simpson. 1951. *Suicide, A Study in Sociology*. New York, NY: Free Press.

Eberhardt, M.S., D.D. Ingram, D.M. Makuc, E.R. Pamuk, V.M. Freid, S.B. Harper, C. Schoenborn, and H. Xia. 2001. "Urban and Rural Health Chartbook. Health, United States, 2001." Hyattsville, MD.

Epstein, B., T. Grant, M. Schiff, and L. Kasehagen. 2009. "Does rural residence affect access to prenatal care in Oregon?" *The Journal of Rural Health* 25(2):150-157.

Ettner, S.L. 1996. "The timing of preventive services for women and children: the effect of having a usual source of care." *American Journal of Public Health* 86(12):1748.

Finch, B.K. 2003. "Socioeconomic gradients and low birth weight: empirical and policy considerations." *HSR: Health Services Research* 38(6p2):1819-1842.

Fingerhut, L.A., J.C. Kleinman, and J.S. Kendrick. 1990. "Smoking before, during, and after pregnancy." *American Journal of Public Health* 80(5):541.

Fortner, R.T., P.S. Pekow, B.W. Whitcomb, L.L. Sievert, G. Markenson, and L. Chasan-Taber. 2011. "Physical activity and hypertensive disorders of pregnancy among Hispanic women." *Medicine & Science in Sports & Exercise* 43(4):639.

Frank, A.L., R. McKnight, S.R. Kirkhorn, and P. Gunderson. 2004. "Agricultural safety and health." *Annual Review of Public Health* 25(1):225-245.

Garovic, V. D., K. R. Bailey, E. Boerwinkle, S. C. Hunt, A. B. Weder, D. Curb, T. H. Mosley, H. J. Wiste, and S. T. Turner. 2010. "Hypertension in pregnancy as a risk factor for cardiovascular disease later in life." *Journal of Hypertension* 28(4):826-833.

Gibbs, R.M., P.L. Swaim, and R. Teixeira. 1998. *Rural Education and Training in the New Economy: The Myth of the Rural Skills Gap*: Iowa State University Press.

Glasgow, N., N.E. Johnson, and L.W. Morton. 2004a. "Introduction." Pp. 3-11 in *Critical Issues in Rural Health*, edited by N. Glasgow, N. E. Johnson, and L. W. Morton. Ames, Iowa: Blackwell Publishing.

Glasgow, N., N.E. Johnson, and L.W. Morton. 2004b. "Preface." Pp. ix-x in *Critical Issues in Rural Health*, edited by N. Glasgow, N. E. Johnson, and L. W. Morton. Ames, Iowa: Blackwell Publishing.

Goldman, L.E. and R.A. Dudley. 2008. "United States rural hospital quality in the Hospital Compare database--Accounting for hospital characteristics." *Health Policy* 87(1):112-127.

Guirguis-Blake, J., G.E. Fryer, M. Deutchman, L.A. Green, S.M. Dovey, and R.L. Phillips. 2002. "Family physicians' declining contribution to prenatal care in the United States." *American Family Physician* 66(12):2192.

Hammoud, A. O., E. Bujold, Y. Sorokin, C. Schild, M. Krapp, and P. Baumann. 2005. "Smoking in pregnancy revisited: Findings from a large population-based study." *American Journal of Obstetrics and Gynecology* 192(6):1856-1862.

Harper, M.A., M.A. Espeland, E. Dugan, R. Meyer, K. Lane, and S. Williams. 2004. "Racial disparity in pregnancy-related mortality following a live birth outcome." *Annals of Epidemiology* 14(4):274-279.

Hawthorne, G. and P. Elliot. 2005. "Imputing Cross-Sectional Missing Data: Comparison of Common Techniques." *Australian and New Zealand Journal of Psychiatry* 39583-590.

Hendryx, M., K. O'Donnell, and K. Horn. 2008. "Lung cancer mortality is elevated in coal-mining areas of Appalachia." *Lung Cancer* 62(1):1-7.

Herd, P., B. Goesling, and J.S. House. 2007. "Socioeconomic position and health: the differential effects of education versus income on the onset versus progression of health problems." *Journal of Health and Social Behavior* 48(3):223.

Hillemeier, M.M., C.S. Weisman, G.A. Chase, and A.M. Dyer. 2007. "Individual and community predictors of preterm birth and low birthweight along the rural urban continuum in central Pennsylvania." *The Journal of Rural Health* 23(1):42-48.

HLM. 2008. "Hierarchical linear and nonlinear modeling." edited by Scientific Software Incorporation. Lincolnwood, IL.

Hodne, C.J. 2004. "Rural Environmental Health and Industrial Agriculture: A Case Example of Concentrated Animal Feeding Operations." Pp. 61-73 in *Critical Issues in Rural Health*, edited by N. Glasgow, L. W. Morton, and N. E. Johnson. Ames, Iowa: Blackwell Publishing.

House, J.S. 1992. "Social Stratification, Age, and Health." in *Aging, Health Behaviors, and Health Outcomes*, edited by K. W. Schaie, D. Blazer, and J. S. House. Mahway, N.J.: Erlbaum.

House, J.S. 2008. "Social psychology, social science, and economics: twentieth century progress and problems, twenty-first century prospects." *Social Psychology Quarterly* 71(3):232-256.

House, J.S., R.C. Kessler, and A.R. Herzog. 1990. "Age, socioeconomic status, and health." *The Milbank Quarterly* 383-411.

House, JS. 2002. "Understanding social factors and inequalities in health: 20th century progress and 21st century prospects." *Journal of Health and Social Behavior* 43(2):125-142.

Hueston, W.J. 1991. "Impact of a family physician-staffed maternity center on obstetric services in a rural region." *The Journal of Family Practice* 32(1):76.

Hughes, S., J.A. Zweifler, A. Garza, and M.A. Stanich. 2008. "Trends in rural and urban deliveries and vaginal births: California 1998-2002." *The Journal of Rural Health* 24(4):416-422.

Hulme, P.A. and M.A. Blegen. 1999. "Residential status and birth outcomes: Is the rural/urban distinction adequate?" *Public Health Nursing* 16(3):176-181.

Institute of Medicine of the National Academies. 2005. "Quality through collaboration: The future of rural health." The National Academies Press, Washington, DC.

Janakiraman, V., M. Gantz, S. Maynard, and A. El-Mohandes. 2009. "Association of cotinine levels and preeclampsia among African-American women." *Nicotine & Tobacco Research* 11(6):679-684.

Kaplan, G.A., E.R. Pamuk, J.W. Lynch, R.D. Cohen, and J.L. Balfour. 1996. "Inequality in income and mortality in the United States: analysis of mortality and potential pathways." *BMJ: British Medical Journal* 312(7037):999-1003.

Kawachi, I., B.P. Kennedy, K. Lochner, and D. Prothrow-Stith. 1997. "Social capital, income inequality, and mortality." *American Journal of Public Health* 87(9):1491-1498.

Kawachi, I., S. Levine, M. Miller, K. Lasch, and B. Amick III. 1994. "Income inequality and life expectancy: theory, research, and policy." in *Society and Health Working Paper Series*. Boston: Joint Program in Society & Health, Health Institute, New England Medical Center and Harvard School of Public Health.

Kennedy, B.P., I. Kawachi, R. Glass, and D. Prothrow-Stith. 1998. "Income distribution, socioeconomic status, and self rated health in the United States: multilevel analysis." *BMJ: British Medical Journal* 317(7163):917-921.

Kennedy, B.P., I. Kawachi, and D. Prothrow-Stith. 1996. "Income distribution and mortality: cross sectional ecological study of the Robin Hood index in the United States." *BMJ: British Medical Journal* 312(7037):1004-1007.

Kotelchuck, M. 1994a. "The Adequacy of Prenatal Care Utilization Index: its US distribution and association with low birthweight." *American Journal of Public Health* 84(9):1486-1489.

Kotelchuck, M. 1994b. "An evaluation of the Kessner Adequacy of Prenatal Care Index and a proposed Adequacy of Prenatal Care Utilization Index." *American Journal of Public Health* 84(9):1414-1420.

Krieger, N., J.T. Chen, P.D. Waterman, D.H. Rehkopf, and SV Subramanian. 2005. "Painting a truer picture of US socioeconomic and racial/ethnic health inequalities: the Public Health Disparities Geocoding Project." *American Journal of Public Health* 95(2):312.

Krout, J.A. 2004. "Forward." Pp. vii-viii in *Critical Issues in Rural Health*, edited by N. Glasgow, L. W. Morton, and N. E. Johnson. Ames, Iowa: Blackwell Publishing.

Kuklina, E. V., C. Ayala, and W. M. Callaghan. 2009. "Hypertensive disorders and severe obstetric morbidity in the United States." *Obstetrics & Gynecology* 113(6):1299-1306.

Laditka, J.N., S.B. Laditka, and J.C. Probst. 2005. "More may be better: evidence of a negative relationship between physician supply and hospitalization for ambulatory care sensitive conditions." *HSR: Health Services Research* 40(4):1148-1166.

Laditka, S.B., J.N. Laditka, K.J. Bennett, and J.C. Probst. 2005. "Delivery complications associated with prenatal care access for Medicaid insured mothers in rural and urban hospitals." *The Journal of Rural Health* 21(2):158-166.

Laditka, S.B., J.N. Laditka, M.P. Mastanduno, M.R. Lauria, and T.C. Foster. 2005. "Potentially avoidable maternity complications: an indicator of access to prenatal and primary care during pregnancy." *Women & Health* 41(3):1-26.

Lantz, P.M., J.S. House, J.M. Lepkowski, D.R. Williams, R.P. Mero, and J. Chen. 1998. "Socioeconomic factors, health behaviors, and mortality." *JAMA: The Journal of the American Medical Association* 279(21):1703-1708.

Lantz, P.M., J.W. Lynch, J.S. House, J.M. Lepkowski, R.P. Mero, M.A. Musick, and D.R. Williams. 2001. "Socioeconomic disparities in health change in a longitudinal study of US adults: the role of health-risk behaviors." *Social Science & Medicine* 53(1):29-40.

Larson, S. and R. Correa-de-Araujo. 2006. "Preventative health examinations: A comparison along the rural-urban continuum." *Women's Health Issues* 16(2):80-88.

Lauderdale, D.S., T.J. VanderWeele, J. Siddique, and J.D. Lantos. 2010. "Prenatal care utilization in excess of recommended levels: Trends from 1985 to 2004." *Medical Care Research and Review* 67(5):609-622.

Leeman, L. and P. Fontaine. 2008. "Hypertensive disorders of pregnancy." *American Family Physician* 78(1):93-100.

Lichter, D.T. and D.L. Brown. 2011. "Rural America in an urban society: Changing spatial and social boundaries." *Annual Review of Sociology* 37(1):565-592.

Lieberson, S. 1985. *Making it count: The improvement of social research and theory*: University of California Press.

Link, B.G. and J. Phelan. 1995. "Social conditions as fundamental causes of disease." *Journal of Health and Social Behavior* 35(Extra Issue):80-94.

Lishner, D.M., E.H. Larson, R.A. Rosenblatt, and S.J. Clark. 1999. "Rural maternal and perinatal health." Pp. 134-149 in *Rural Health in the United States*, edited by T. C. Ricketts. New York, NY: Oxford University Press.

Litaker, D., S.M. Koroukian, and T.E. Love. 2005. "Context and healthcare access: looking beyond the individual." *Medical Care* 43(6):531.

Litaker, D. and T.E. Love. 2005. "Health care resource allocation and individuals' health care needs: examining the degree of fit." *Health Policy* 73(2):183-193.

Liu, J.J., G.R. Bellamy, and M. McCormick. 2007. "Patient bypass behavior and critical access hospitals: implications for patient retention." *The Journal of Rural Health* 23(1):17-24.

Lobao, L. and D.S. Kraybill. 2005. "The emerging roles of county governments in metropolitan and nonmetropolitan areas: Findings from a national survey." *Economic Development Quarterly* 19(3):245-259.

Luo, Z.C., N. An, H.R. Xu, A. Larante, F. Audibert, and W.D. Fraser. 2007. "The effects and mechanisms of primiparity on the risk of preeclampsia: a systematic review." *Pediatric and Perinatal Epidemiology* 2136-45.

Luo, Z.C. and R. Wilkins. 2008. "Degree of rural isolation and birth outcomes." *Pediatric and Perinatal Epidemiology* 22(4):341-349.

Lynch, J.W. and G.A. Kaplan. 1997. "Understanding how inequality in the distribution of income affects health." *Journal of Health Psychology* 2(3):297-314.

Lynch, J.W., G.A. Kaplan, E.R. Pamuk, R.D. Cohen, K.E. Heck, J.L. Balfour, and I.H. Yen. 1998. "Income inequality and mortality in metropolitan areas of the United States." *American Journal of Public Health* 88(7):1074-1080.

Lynch, J.W., G.A. Kaplan, and J.T. Salonen. 1997. "Why do poor people behave poorly? Variation in adult health behaviours and psychosocial characteristics by stages of the socioeconomic lifecourse." *Social Science & Medicine* 44(6):809-819.

Lynch, J.W., G.D. Smith, G.A. Kaplan, and J.S. House. 2000. "Income inequality and mortality: importance to health of individual income, psychosocial environment, or material conditions." *BMJ: British Medical Journal* 320(7243):1200.

Mainous, A.G. and F.P. Kohrs. 1995. "A comparison of health status between rural and urban adults." *Journal of Community Health* 20(5):423-431.

Markides, K.S. and K. Eschbach. 2005. "Aging, migration, and mortality: current status of research on the Hispanic paradox." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 60(Special Issue 2):S68-S75.

Marmot, M. 2004. *The Status Syndrome: How Social Standing Affects Our Health and Longevity*. New York: Henry Holt and Company.

McDaniel, C., R. Gates, and C.W. Lamb Jr. 1992. "Who leaves the service area? Profiling the hospital outshopper." *Journal of Health Care Marketing* 12(3):2.

McEwen, B.S. 1998. "Stress, adaptation, and disease: Allostasis and allostatic load." *Annals of the New York Academy of Sciences* 840(1):33-44.

McIntosh, W.A. and J. Sobal. 2004. "Rural Eating, Diet, Nutrition, and Body Weight." Pp. 113-124 in *Critical Issues in Rural Health*, edited by N. Glasgow, L. W. Morton, and N. E. Johnson. Ames, Iowa: Blackwell Publishing.

McLaughlin, D.K. and S.C. Stokes. 2002. "Income inequality and mortality in US counties: Does minority racial concentration matter?" *American Journal of Public Health* 92(1):99-104.

McLaughlin, D.K., S.C. Stokes, and A. Nonoyama. 2001. "Residence and Income Inequality: Effects on Mortality Among U.S. Counties." *Rural Sociology* 66(4):579-598.

Miller, E. C., H. L. Cao, S. W. Wen, Q. Y. Yang, J. Lafleche, and M. Walker. 2010. "The risk of adverse pregnancy outcomes is increased in preeclamptic women who smoke compared with nonpreeclamptic women who do not smoke." *American Journal of Obstetrics and Gynecology* 203(4).

Miller, M.K., L.L. Clarke, S.L. Albrecht, and F.L. Farmer. 1996. "The interactive effects of race and ethnicity and mother's residence on the adequacy of prenatal care." *The Journal of Rural Health* 126-8.

Miller, M.K. and A.E. Luloff. 1981. ""Who is rural?" A typological approach to the examination of rurality." *Rural Sociology* 46608-625.

Morris, C.D., S.L. Jacobson, R. Anand, M.G. Ewell, J.C. Hauth, L.B. Curet, P.M. Catalano, B.M. Sibai, and R.J. Levine. 2001. "Nutrient intake and hypertensive disorders of pregnancy: evidence from a large prospective cohort." *American Journal of Obstetrics and Gynecology* 184(4):643-651.

Morton, L.W. 2004. "Spatial patterns of rural mortality." Pp. 37-45 in *Critical Issues in Rural Health*, edited by N. Glasgow, N. E. Johnson, and L. W. Morton. Ames, Iowa: Blackwell Publishing.

Morton, L.W., D.I. Worthen, and L.J. Weatherspoon. 2004. "Rural Food Insecurity and Health." Pp. 101-112 in *Critical Issues in Rural Health*, edited by N. Glasgow, L. W. Morton, and N. E. Johnson. Ames, Iowa: Blackwell Publishing.

Moscovice, I. and J. Stensland. 2002. "Rural hospitals: trends, challenges, and a future research and policy analysis agenda." *The Journal of Rural Health* 18(5):197-210.

Mueller, K.J., S.T. Ortega, K. Parker, K. Patil, and A. Askenazi. 1999. "Health status and access to care among rural minorities." *Journal of Health Care for the Poor and Underserved* 10(2):230-249.

National Center for Health Statistics. 2007a. "Machine readable data file and documentation, CD-ROM." edited by National Vital Statistics System Detail Natality Files. Hyattsville, MD: U.S. Department of Health and Human Services.

National Center for Health Statistics. 2007b. "National Vital Statistics System Detail Natality Files." edited by U.S. Department of Health and Human Services. Washington, D.C.: The Office On Women's Health Quick Health Data Online.

Nayga Jr, R.M. and O. Capps Jr. 1994. "Analysis of away-from-home and at-home intake of saturated fat and cholesterol." *Review of agricultural economics* 16(3):387-398.

Nesbitt, T.S. and L.M. Baldwin. 1993. "Access to obstetric care." *Primary Care* 20(3):509.

Nesbitt, T.S., F.A. Connell, L.G. Hart, and R.A. Rosenblatt. 1990. "Access to obstetric care in rural areas: effect on birth outcomes." *American Journal of Public Health* 80(7):814.

Nesbitt, T.S., E.H. Larson, R.A. Rosenblatt, and L.G. Hart. 1997. "Access to maternity care in rural Washington: its effect on neonatal outcomes and resource use." *American Journal of Public Health* 87(1):85.

Northam, S. and T.R. Knapp. 2006. "The reliability and validity of birth certificates." *Journal of Obstetric, Gynecologic, & Neonatal Nursing* 35(1):3-12.

Paternoster, R., R. Brame, P. Mazerolle, and A. Piquero. 1998. "Using the correct statistical test for the equality of regression coefficients." *Criminology* 36(4):859-866.

Peck, L. and K. Alexander. 2003. "Rural healthy people 2010: a companion document to healthy people 2010." Texas A & M University System Health Science Center, School of Rural Public Health, Southwest Rural Health Research Center, College Station, TX.

Phelan, Jo C., Bruce G. Link, and Parisa Tehranifar. 2010. "Social Conditions as Fundamental Causes of Health Inequalities: Theory, Evidence, and Policy Implications." *Journal of Health and Social Behavior* 51(s):s28-s40.

Phillippi, J.C. 2009. "Women's perceptions of access to prenatal care in the United States: A literature review." *Journal of Midwifery & Women's Health* 54(3):219-223.

Pol, L.G. and R.K. Thomas. 2001. *The demography of health and health care*. New York: Springer.

Polzin, S.E., X. Chu, and J.R. Rey. 1999. *Mobility and mode choice of people of color for non-work travel*: Center for Urban Transportation Research.

Probst, J.C., S.B. Laditka, J.Y. Wang, and A.O. Johnson. 2007. "Effects of residence and race on burden of travel for care: cross sectional analysis of the 2001 US National Household Travel Survey." *BMC health services research* 7(1):40.

Pucher, J. and J.L. Renne. 2004. "Urban-Rural differences in mobility and mode choice: Evidence from the 2001 NHTS." *Bloustein School of Planning and Public Policy, Rutgers University*.

Radcliff, T.A., M. Brasure, I. Moscovice, and T. Stensland. 2003. "Understanding rural hospital bypass behavior." *The Journal of Rural Health* 19(3):252-259.

Rask, K.J., M.V. Williams, R.M. Parker, and S.E. McNagny. 1994. "Obstacles predicting lack of a regular provider and delays in seeking care for patients at an urban public hospital." *JAMA: The Journal of the American Medical Association* 271(24):1931.

Raudenbush, S.W. and A.S. Bryk. 2002. *Hierarchical linear models: Applications and data analysis methods*, vol. 1: Sage Publications, Inc.

Reschovsky, J.D. and A.B. Staiti. 2005. "Access and quality: does rural America lag behind?" *Health Affairs* 24(4):1128.

Ricketts, T.C. 2000. "The changing nature of rural health care." *Annual Review of Public Health* 21(1):639-657.

Roh, C.Y. and K.H. Lee. 2006. "Hospital choice by rural medicare beneficiaries: does hospital ownership matter? A Colorado case." *Journal of Health and Human Services Administration* 28(3):306-319.

Rosenblatt, R.A. 2002. "Quality of care in the rural context: a proposed research agenda." *The Journal of Rural Health* 18(5):176-185.

Rubin, H.R., B. Gandek, W.H. Rogers, M. Kosinski, C.A. McHorney, and J.E. Ware. 1993. "Patients' ratings of outpatient visits in different practice settings." *JAMA: The Journal of the American Medical Association* 270(7):835.

Sahyoun, N. and P. Basiotis. 2001. "Food insufficiency and the nutritional status of the elderly population." *Family Economics and Nutrition Review* 13(2):58.

Samadi, A.R., R.M. Mayberry, A.A. Zaidi, J.C. Pleasant, N. McGhee Jr, and R.J. Rice. 1996. "Maternal hypertension and associated pregnancy complications among African-American and other women in the United States." *Obstetrics & Gynecology* 87(4):557.

Satel, S. 1996. "The politicization of public health." *Wall Street Journal* 12144-149.

Schafer, J.L. and J.W. Graham. 2002. "Missing data: our view of the state of the art." *Psychological Methods* 7(2):147-177.

Schneider, E.C., A.M. Zaslavsky, and A.M. Epstein. 2002. "Racial disparities in the quality of care for enrollees in Medicare managed care." *JAMA: The Journal of the American Medical Association* 287(10):1288-1294.

Schoenbaum, M. and T. Waidmann. 1997. "Race, socioeconomic status, and health: Accounting for race differences in health." *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 52(Special Issue):61-73.

Schulman, M.D. and D.P. Slesinger. 2004. "Health Hazards of Rural Extractive Industries and Occupations." Pp. 49-60 in *Critical Issues in Rural Health*, edited by N. Glasgow, L. W. Morton, and N. E. Johnson. Ames, Iowa: Blackwell Publishing.

Seeman, T.E. and E. Crimmins. 2001. "Social environment effects on health and aging." *Annals of the New York Academy of Sciences* 954(1):88-117.

Senat, M.V., P.Y. Ancel, M.H. Bouvier-Colle, and G. Breart. 1998. "How does multiple pregnancy affect maternal mortality and morbidity?" *Clinical Obstetrics and Gynecology* 41(1):79.

Shoff, C., T.C. Yang, and S.A. Matthews. 2012. "What has geography got to do with it? Using GWR to explore place-specific associations with prenatal care utilization." *GeoJournal* 77(3):331-341.

Sibai, B.M., M. Ewell, R.J. Levine, M.A. Klebanoff, J. Esterlitz, P.M. Catalano, R.L. Goldenberg, and G. Joffe. 1997. "Risk factors associated with preeclampsia in healthy nulliparous women." *American Journal of Obstetrics and Gynecology* 177(5):1003-1010.

Silva, L.M., M. Coolman, E.A.P. Steegers, V.W.V. Jaddoe, HA Moll, A. Hofman, J.P. Mackenbach, and H. Raat. 2008. "Maternal educational level and risk of gestational hypertension: the Generation R Study." *Journal of Human Hypertension* 22(7):483-492.

Simpson, K., S. DesHarnais, A. Jacobs, and A. Menapace. 1994. "Methods for defining medical service areas." *Geographic Methods for Health Services Research* 207-33.

Singer, B. and C.D. Ryff. 2001. *New horizons in health: An integrative approach*: National Academies Press.

Snyder, A.R. and D.K. McLaughlin. 2004. "Risky Behaviors Affecting Rural Adolescents' Health." *Critical Issues in Rural Health* (2):89-100.

Sorokin, P.A. and C.C. Zimmerman. 1929. *Principles of rural-urban sociology*: H. Holt.

Sparks, P.J., D.K. McLaughlin, and C.S. Stokes. 2009. "Differential neonatal and postneonatal infant mortality rates across US counties: the role of socioeconomic conditions and rurality." *The Journal of Rural Health* 25(4):332-341.

Sternthal, M.J., N. Slopen, and D.R. Williams. 2011. "Racial disparities in health." *Du Bois Review: Social Science Research on Race* 8(01):95-113.

Stevens, S., B. Colwell, and L. Hutchison. 2010. "Tobacco use in rural areas: a literature review."

Stokes, C.S. and K.D. Brace. 1988. "Agricultural chemical use and cancer mortality in selected rural counties in the U.S.A." *Journal of Rural Studies* 4(3):239-247.

Subramanian, S.V., C. Duncan, and K. Jones. 2001. "Multilevel perspectives on modeling census data." *Environment and Planning A* 33(3):399-418.

Sunil, T.S., W.D. Spears, L. Hook, J. Castillo, and C. Torres. 2010. "Initiation of and barriers to prenatal care use among low-income women in San Antonio, Texas." *Maternal and Child Health Journal* 14(1):133-140.

Tanaka, M., G. Jaamaa, M. Kaiser, E. Hills, A. Soim, M. Zhu, I.Y. Shcherbatykh, R. Samelson, E. Bell, and M. Zdeb. 2007. "Racial disparity in hypertensive disorders of pregnancy in New York State: a 10-year longitudinal population-based study." *American Journal of Public Health* 97(1):163.

Taylor, S.E., R.L. Repetti, and T. Seeman. 1997. "Health psychology: what is an unhealthy environment and how does it get under the skin?" *Annual Review of Psychology* 48411-447.

The Henry J. Kaiser Family Foundation. 2008. "Health coverage and access to care among Asian Americans, Native Hawaiians, and Pacific Islanders." Washington, D.C.

Thiemann, D.R., J. Coresh, W.J. Oetgen, and N.R. Powe. 1999. "The association between hospital volume and survival after acute myocardial infarction in elderly patients." *New England Journal of Medicine* 340(21):1640-1648.

Turner, R.J. and D.A. Lloyd. 1995. "Lifetime traumas and mental health: The significance of cumulative adversity." *Journal of Health and Social Behavior* 360-376.

Turner, R.J. and F. Marino. 1994. "Social support and social structure: A descriptive epidemiology." *Journal of Health and Social Behavior* 193-212.

U.S. Census Bureau. 2005-2009. "American Community Survey 5-Year County Estimates." U.S. Census Bureau.

U.S. Department of Health and Human Services. 2000. "Healthy People 2010: Understanding and Improving Health." Department of Health and Human Services, Washington, DC: U.S. Government Printing Office.

U.S. Department of Health and Human Services. 2001a. "Surgeon General's Report-Women and Smoking." Atlanta, GA.

U.S. Department of Health and Human Services. 2001b. "Women and smoking: A report of the Surgeon General." Public Health Service, Office of the Surgeon General.

U.S. Department of Health and Human Services. 2011. "Healthy People 2020: Maternal, Infant, and Child Health Objectives." vol. 2011. Washington, D.C.

Ulmer, J.T. and B. Johnson. 2004. "Sentencing in context: a multilevel analysis." *Criminology* 42(1):137-177.

Ver Ploeg, M. and E. Perrin. 2004. *Eliminating health disparities: measurement and data needs*. Washinton, D.C.: National Academy Press.

Verheij, R.A. 1996. "Explaining urban-rural variations in health: a review of interactions between individual and environment." *Social Science & Medicine* 42(6):923-935.

Villar, J., G. Carroli, D. Wojdyla, E. Abalos, D. Giordano, H. Ba'aqeel, U. Farnot, P. Bergsj, L. Bakketeig, and P. Lumbiganon. 2006. "Preeclampsia, gestational hypertension and intrauterine growth restriction, related or independent conditions?" *American Journal of Obstetrics and Gynecology* 194(4):921-931.

Villarejo, D. 2003. "The health of US hired farm workers." *Annual Review of Public Health* 24(1):175-193.

Vistnes, J.P., S. Zuvekas, United States Agency for Health Care Policy Research, and Medical Expenditure Panel Survey. 1999. *Health insurance status of the civilian noninstitutionalized population: 1997*: US Dept. of Health and Human Services, Public Health Service, Agency for Health Care Policy and Research.

Walker, J.J. 2000. "Pre-eclampsia." *The Lancet* 356(9237):1260-1265.

Wallace, R.B., L.A. Grindeanu, and D.J. Cirillo. 2004. "Rural/Urban Contrasts in Population Morbidity Status." in *Critical Issues in Rural Health*, vol. 15-26, edited by N. Glasgow, L. W. Morton, and N. E. Johnson. Ames, Iowa: Blackwell Publishing.

Waterstone, M., S. Bewley, C. Wolfe, and J.D. Murphy. 2001. "Incidence and predictors of severe obstetric morbidity: case-control study commentary: Obstetric morbidity data and the need to evaluate thromboembolic disease." *BMJ: British Medical Journal* 322(7294):1089-1094.

Weinick, R.M., S. Zuvekas, S.K. Drilea, and United States Agency for Health Care Policy Research. 1997. *Access to health care: Sources and barriers, 1996*: US Dept. of Health and Human Services, Public Health Service, Agency for Health Care Policy and Research.

Weinstein, M.C., E.L. Toy, E.A. Sandberg, P.J. Neumann, J.S. Evans, K.M. Kuntz, J.D. Graham, and J.K. Hammitt. 2001. "Modeling for health care and other policy decisions: uses, roles, and validity." *Value in Health* 4(5):348-361.

Weisman, C.S., M.M. Hillemeier, G.A. Chase, A.M. Dyer, S.A. Baker, M. Feinberg, D. Symons Downs, R.L. Parrott, H.K. Cecil, and J.J. Botti. 2006. "Preconceptional health: risks of adverse pregnancy outcomes by reproductive life stage in the Central Pennsylvania Women's Health Study (CePAWHS)." *Women's Health Issues* 16(4):216-224.

Wilkinson, R.G. 1997. "Socioeconomic determinants of health: Health inequalities: relative or absolute material standards?" *BMJ: British Medical Journal* 314(7080):591.

Wilkinson, R.G. 2006. "Ourselves and others-for better or worse: Social vulnerability and inequality." Pp. 341-357 in *Social Determinants of Health*, edited by M. G. Marmot and R. G. Wilkinson. New York: Oxford University Press.

Williams, D.R., S.A. Mohammed, J. Leavell, and C. Collins. 2010. "Race, socioeconomic status, and health: complexities, ongoing challenges, and research opportunities." *Annals of the New York Academy of Sciences* 1186(1):69-101.

Williams, R. 2011. "Multicollinearity." vol. 2011: University of Notre Dame.

Willits, F.K. and R.C. Bealer. 1967. "An evaluation of a composite definition of 'rurality'." *Rural Sociology* 32165-177.

Willits, F.K., R.C. Bealer, and V.L. Timbers. 1990. "Popular images of 'rurality': Data from a Pennsylvania survey." *Rural Sociology* 55(4):559-578.

Windham, CT, BW Wyse, and RG Hansen. 1983. "Nutrient density of diets in the USDA Nationwide Food Consumption Survey, 1977-1978: II. Adequacy of nutrient density consumption practices." *Journal of the American Dietetic Association* 82.

Wolf, M., A. Shah, R. Jimenez-Kimble, J. Sauk, J. L. Ecker, and R. Thadhani. 2004. "Differential risk of hypertensive disorders of pregnancy among Hispanic women." *Journal of the American Society of Nephrology* 15(5):1330-1338.

Woolbright, L.A. and D.S. Harshbarger. 1995. "The revised standard certificate of live birth: analysis of medical risk factor data from birth certificates in Alabama, 1988-92." *Public Health Reports* 110(1):59-63.

Yang, Q., S.W. Wen, G.N. Smith, Y. Chen, D. Krewski, X.K. Chen, and M.C. Walker. 2006. "Maternal cigarette smoking and the risk of pregnancy-induced hypertension and eclampsia." *International Journal of Epidemiology* 35(2):288.

Yang, T.C., V.Y.J. Chen, C. Shoff, and S.A. Matthews. 2012. "Tales from the tales: Examining the effect of inequality at the extremes of the mortality distribution." *Social Science & Medicine* 74(12):1900-1910.

Zhang, J., M.A. Klebanoff, R.J. Levine, M. Puri, and P. Moyer. 1999. "The puzzling association between smoking and hypertension during pregnancy." *American Journal of Obstetrics and Gynecology* 181(6):1407-1413.

Ziller, E.C., A.F. Coburn, N.J. Anderson, and S.L. Loux. 2008. "Uninsured rural families." *The Journal of Rural Health* 24(1):1-11.

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Yang, Tse-Chuan, **Carla Shoff**, and Stephen A. Matthews. "Examining the spatially non-stationary associations between the second demographic transition and infant mortality: A Poisson GWR approach." *Spatial Demography*, Forthcoming.

Yang, Tse-Chuan, Vivian Yi-Ju Chen, **Carla Shoff**, and Stephen A. Matthews. (2012). "Using quantile regression to examine the effects of inequality across the mortality distribution in the US counties." *Social Science and Medicine*, 74(12): 1900-1910, DOI: 10.1016/j.socscimed.2012.02.029.

Shoff, Carla and Tse-Chuan Yang. (2012). "Untangling the associations among distrust, race, and neighborhood social environment: A social disorganization perspective." *Social Science and Medicine*, 74(9): 1342-1352, DOI:10.1016/j.socscimed.2012.01.012.

Shoff, Carla, Tse-Chuan Yang, and Stephen A. Matthews. (2012). "What has geography got to do with it? Using GWR to explore place-specific associations with prenatal care utilization." *GeoJournal*, 77(3): 331-341, DOI: 10.1007/s10708-010-9405-3.

Yang, Tse-Chuan, Stephen A. Matthews, and **Carla Shoff**. (2011). "Individual health care system distrust and neighborhood social environment: How are they jointly associated with self-rated health?" *Journal of Urban Health*, 88(5): 945-958, DOI: 10.1007/s11524-011-9561-x.