Effect of Neighborhood Socioeconomic Indicators and Violent Crime on Prenatal Care Utilization

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THESIS

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This thesis is dedicated to my loving wife, Iyabode Oladunni Adejumo, and my beautiful daughters, Oluwatunmise Ademilola Adejumo and Oluwafikayomi Bonita Adejumo.

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LIST OF ABBREVIATIONS

ACS	American Community Survey
APNCU	Adequacy of Prenatal Care Utilization
CCA	Chicago community area
CDC	Centers for Disease Control and Prevention
GIS	Geographical Information Systems
GWR	Geographically weighted regression
HBM	Health Belief Model
IBM	Integrated Behavior Model
PNC	Prenatal Care
PNCU	Prenatal Care Utilization
USDHHS	United States Department of Health and Human Services

SUMMARY

Prenatal care is a preventive health care service during pregnancy that has the potential to improve health outcomes for women and their infants. For many decades, it has been regarded as a major way of preventing adverse pregnancy outcomes because early initiation of prenatal care provides the opportunity for timely detection of maternal and fetal risks and prevention of their complications. It also provides the opportunity to counsel women on healthy behavioral practices during pregnancy and the postpartum period. However, some groups of women do not have an adequate number of prenatal care visits. Women who have the greatest risk of experiencing adverse pregnancy outcomes are often those that do not receive adequate prenatal care during pregnancy.

The reasons why some women do not have adequate prenatal care utilization are not clear. This is partly because most studies have focused more on maternal sociodemographic factors with less attention to detrimental neighborhood characteristics that may also influence adequate utilization of prenatal care services. While there is a substantial evidence of racial/ethnic disparities in prenatal care utilization, the reasons for the disparities are not completely well understood. Moreover, studies that have critically examined the role of individual-level characteristics, or factors beyond the individual level to explain racial/ethnic disparities in prenatal care utilization are quite sparse.

To this end, the three studies in this dissertation explored factors associated with prenatal care utilization by analyzing data collected at both the individual and neighborhood levels. The studies examine the interrelationships between individual-level characteristics and neighborhood social contexts (i.e., neighborhood socioeconomic indicators, community violent crime rate, racial residential segregation and community racial/ethnic composition) with respect to utilization of prenatal care by Chicago residents. In the first study, Geographical Information Systems (GIS) were used to map the prevalence and spatial pattern of inadequate prenatal care utilization across Chicago community areas

and examine the relationships between neighborhood social contexts and prenatal care utilization using spatial cluster and geographical weighted regression (GWR) analyses. In the second study, multilevel logistic regression analysis was used to examine the effects of neighborhood socioeconomic indicators and community violent crime rate on prenatal care utilization above the compositional influence of residents, given the complex and dynamic relationships between individual- and neighborhood-level characteristics. Finally, in the third study, racial/ethnic disparities in prenatal care utilization at the individual level were examined to identify important maternal characteristics, including their relative roles, that may explain the disparities, and to determine if the disparities vary by community racial/ethnic composition. The effect of living in a community area where one's race/ethnic group is the majority on prenatal care utilization was also examined.

The findings in the dissertation show evidence of spatial disparities in prenatal care utilization in the city of Chicago. The spatial pattern of inadequate prenatal care utilization closely follows the spatial distributions of neighborhood hardship, community violent crime rate, and Non-Hispanic Black isolation across Chicago community areas. The relationships between the community-level variables with respect to prenatal care utilization are inextricably complex. However, for all racial/ethnic groups combined, neighborhood hardship is ubiquitously associated with inadequate prenatal care utilization. Racial/ethnic disparities in prenatal care utilization in Chicago appear to be due to factors that can be measured, assessed, and addressed at both the individual and neighborhood levels. Finally, there is indication that in Chicago, a racially/ethnically segregated city, living in Non-Hispanic white communities may confer an advantage with respect to receiving adequate prenatal care services.

1. INTRODUCTION

1.1 Background

Prenatal care is a preventive health care service during pregnancy that has the potential to improve health outcomes for women and their infants. For many decades, it has been regarded as a major way of preventing adverse pregnancy outcomes because early initiation of prenatal care provides the opportunity for timely detection of maternal and fetal risks and prevention of their complications (Institute of Medicine 1985; United States Public Health Service, 1989). In addition, prenatal care provides the opportunity to counsel women on healthy behavioral practices such as quitting smoking, breastfeeding, and the importance of well-child visits (Cogan, Josberger, Gesten, & Roohan, 2012; Kogan, Alexander, Jack, & Allen, 1998; Reichman, Corman, Noonan, & Schwartz-Soicher, 2010).

Despite the emphasis placed on the value of prenatal care, studies have shown that some groups of women do not have an adequate number of prenatal care visits. Women who have the greatest risk of experiencing adverse pregnancy outcomes, based on their socio-demographic characteristics, are often those that do not receive adequate prenatal care during pregnancy (Alexander, Kogan, & Nabukera, 2002; Kogan, Alexander, Jack, & Allen, 1998). A major limitation of the studies on prenatal care utilization in the literature is that most studies focus more on maternal sociodemographic factors with less attention to structural barriers to prenatal care utilization and detrimental neighborhood characteristics that may affect adequate utilization of prenatal care services.

The two major forms of structural barriers that have been studied in research related to prenatal care utilization are financial barriers (health insurance) and physical barriers, which include availability of and access to prenatal care services, and experience with navigating the healthcare system. At present, the provision of health insurance coverage for women during pregnancy is not

universal in the United States. Research has shown that women with no health insurance are more likely to receive inadequate prenatal care when pregnant than those with any form of health insurance (Ayoola, Nettleman, Stommel, & Canady, 2010; Oberg, Lia-Hoagberg, Skovholt, Hodkinson, & Vanman, 1991; Perloff & Jaffee, 1999). Other common structural factors that have been related to prenatal care utilization include geographical proximity and transportation to prenatal clinics, long waiting time for an appointment for a prenatal care visit, limited clinic hours, long waiting time at the clinic, and poor patient-provider interactions (Braveman, Marchi, Egerter, Pearl, & Neuhaus, 2000; Nepal, Banerjee, & Perry, 2011; Salm-Ward, Mazul, Ngui, Bridgewater, & Harley, 2013; Sunil, Spears, Hook, Castillo, & Torres, 2010).

There is increasing evidence that the neighborhood characteristics where women live may influence their use of prenatal care services. However, the literature on the role of neighborhood characteristics in prenatal care utilization is very sparse. It has been shown that poverty (Braveman, Egerter, Cubbin, & Marchi, 2004; Daoud et al., 2015), health insurance status (Shoff, Yang, & Matthews, 2012), and physician density (Perloff & Jaffee, 1999; Shoff, Chen, & Yang, 2014) measured at the neighborhood level influence prenatal care utilization. Other neighborhood characteristics include percent of residents who are uneducated or unemployed, racial/ethnic minority composition, number of households with single parent, and number of crowded housing units (Charreire & Combier, 2009; Cubbin et al., 2008; Kieffer, Alexander & Mor, 1992; Shoff, Yang, & Matthews, 2014). A related neighborhood characteristic that may also affect prenatal care utilization is the rate of violent crime. However, no published study has directly assessed its influence on prenatal care utilization.

A major limitation of most of the few studies that examined the effect of neighborhood characteristics on prenatal care utilization is that they do not account for *within-group* correlation among individual observations within a neighborhood (Braveman, Egerter, Cubbin, & Marchi, 2004;

Cubbin et al., 2008; Daoud et al., 2015; Perloff & Jaffee, 1999). While traditional regression methods, such as ordinary least squares (OLS) regression, are appropriate for data collected at only one level of observation (e.g., individual or neighborhood level), their use for multilevel data is inappropriate and may lead to incorrect statistical inferences. This is because methods that ignore *within-group* correlation in multilevel data underestimate the standard errors of regression coefficients, and thus increase the likelihood of Type-I error (Raudenbush & Bryk, 2002). Multilevel regression techniques account for *within-group* correlation; thus, they provide unbiased standard errors of regression coefficients when estimating the effects of exposure variables measured at both the individual and neighborhood levels (Diez-Roux, 2000; Raudenbush & Bryk, 2002).

Another methodological approach that is becoming more popular in research related to utilization of health care services is the use of geographical information systems (GIS). Although, there are many studies that have used geographic tools to analyze spatial inequalities in adverse pregnancy outcomes (Anthopolos, James, Gelfand & Miranda, 2011; Byrnes, 2015; South, 2012), only a few studies have applied GIS to prenatal care utilization (Charreire & Combier, 2009; McLafferty & Grady, 2004; Shoff, Chen, & Yang, 2014; Shoff, Yang, & Matthews, 2012). Beyond the use of GIS for mapping the prevalence and the spatial patterns of a health attribute, the technology can also be used to identify factors that are spatially related to it. Geographically weighted regression (GWR) is an emerging statistical technique that allows for spatial variations in the relationships between variables to be measured within a single modeling framework (Brunsdon, Fotheringham, & Charlton, 1996; Fotheringham, Brunsdon, & Charlton, 2002). However, its use in research related to prenatal care utilization is limited to a few studies (Shoff, Chen, & Yang, 2014; Shoff, Yang, & Matthews, 2012).

Evidence of racial disparities in prenatal care utilization has been documented for many decades (Ingram, Makuk, & Keinman, 1986; Kotelchuck; 1994; Cox, Zhang, Zotti, & Graham, 2011). However, the

reasons for these disparities are not completely well understood. In the literature, most of the researchers who document racial disparities in prenatal care utilization do not adequately explore maternal characteristics or factors beyond the individual level that might explain the study findings. Moreover, the few studies that specifically examine the role of maternal characteristics in racial disparities focus only on health insurance status (Bengiamin, Capitman, & Ruwe, 2010), or examined a limited number of individual-level characteristics (Bromley, Nunes, & Phipps, 2012).

Given the complex, inextricable relationships between individual-level characteristics, and the intricate and dynamic interplays between individual-level characteristics and neighborhood contexts, simply adjusting for confounding variables to identify the role of maternal characteristics, including health insurance status, is far from sufficient to understand racial disparities in prenatal care utilization. For example, the effect of having health insurance on prenatal care utilization may not be the same for different racial/ethnic groups. The effect may differ by maternal age, marital status, maternal level of education, and the characteristics of place of primary residence for a racial/ethnic group and between different racial/ethnic groups. Therefore, understanding the intertwined relationships between individual-level characteristics, neighborhood contexts, and the healthcare system- including health insurance policy, distribution of healthcare resources and healthcare organization, is essential to addressing racial disparities in use of healthcare services (Andersen, Davidson, & Baumeister, 2013).

A recent focus of research related to place effect on health is racial residential segregation, which has been regarded as a fundamental cause of racial disparities in health (White, Haas, & Williams, 2012; Williams, & Collins, 2001). Studies have shown that the socioeconomic, physical, and environmental contexts of neighborhoods may be determined by racial residential segregation (White, Haas, & Williams, 2012). Therefore, the causes of racial disparities in health and in health care utilization, especially between African-Americans and white Americans, may be rooted in racial

residential segregation. Thus, the effects of neighborhood social contexts on health outcomes and behaviors in highly segregated communities may be explained by racial residential segregation, especially with respect to racial/ethnic disparities. Consequently, valuable information may be obtained when the distal effects of racial residential segregation, or its proxy, neighborhood racial/ethnic composition, are considered when evaluating the effects of neighborhood socioeconomic, physical, and environmental contexts on a health outcome or behavior (Acevedo-Garcia, & Lochner, 2003; White, Haas, & Williams, 2012).

To this end, the studies in this dissertation approached the research on prenatal care utilization by analyzing data collected at multiple levels to examine the interrelationships between individual-level characteristics and neighborhood social contexts (neighborhood socioeconomic indicators, violent crime, community racial/ethnic composition, and racial residential segregation) with respect to utilization of prenatal care by Chicago residents. Given the intricate relationships between neighborhood social contexts and racial residential segregation, the causal pathways linking neighborhood social contexts to prenatal care utilization were carefully specified and guided by appropriate theoretical frameworks (Acevedo-Garcia, & Lochner, 2003; Andersen, Davidson, & Baumeister, 2013; White, Haas, & Williams, 2012).

First, at the community level, Geographical Information Systems were used to map the prevalence and spatial pattern of inadequate prenatal care utilization across Chicago community areas. The relationships between neighborhood social context and prenatal care utilization was also examined using both ordinary least squares (OLS) and geographical weighted regression (GWR) models. Second, racial/ethnic disparities in prenatal care utilization at the individual level were examined to identify important maternal characteristics, including their relative roles, that may explain these disparities and to determine if the disparities vary by community racial/ethnic composition. The effect of living in a

community area where one's race/ethnic group is the majority on prenatal care utilization was also examined. Third, multilevel logistic regression that accounts for within neighborhood correlation was used to examine the effects of neighborhood socioeconomic indicators and violent crime on prenatal care utilization above the compositional influence of residents.

Consequently, the studies reported in this dissertation contribute to the body of literature on prenatal care utilization in multiple ways. The findings from these studies have important implications for planning with respect to the prenatal care delivery system and the public efforts aimed at improving the health of women, infants and children.

1.2 Magnitude of the Problem

One of the three major objectives related to pregnancy health and behavior is to increase the proportion of pregnant women who receive early and adequate prenatal care by 10%, over the baseline of 70.5% in 2007 (United States Department of Health and Human Services [USDHHS], Healthy People 2020, 2017). The objectives are directed towards reducing adverse pregnancy outcomes, especially preterm birth, low birth weight and infant mortality. Although the relationship between prenatal care and adverse pregnancy outcomes is equivocal due to many methodological issues, it is generally agreed that ensuring women have adequate prenatal care utilization to prevent preterm birth and low birth weight, the two leading causes of infant mortality, is more efficient than taking care of infants born with these adverse pregnancy outcomes.

Recent data show that improving maternal and infant health in the city of Chicago is crucial. Rates of preterm birth and low birth-weight, and infant mortality in both Illinois and Chicago have been consistently higher than the national average for many years. In 2016, Illinois ranked 26th in infant mortality (6.3 vs. 5.9 infant deaths per 1,000 live births), 36th in preterm birth (10.1% vs. 9.6%), and

28th in low birth-weight (8.2% vs. 8.0%) among the 50 states in the United States (United Health Foundation, 2017). The city of Chicago is one of the urban areas in Illinois that contribute to Illinois' high infant mortality. In 2014, infant mortality in Chicago and Illinois was 7.1 and 6.6 infant deaths per 1,000 live births, respectively (Illinois Department of Public Health [IDPH], 2017), and the percentage of births to women who received at least adequate prenatal care was lowest in the city of Chicago compared to all other cities in Illinois (IDPH, 2015).

In 2005, the care of preterm infants cost the United States healthcare system more than $26 billion, about $51,600 per infant born preterm (Behrman & Butler, 2007). Using the same national rate of $51,600 per infant born preterm, the Perinatal Advisory Committee of IDPH estimated that the cost of care for the 21,168 infants born premature in Illinois in 2009 was more than $1.09 billion for the first year of life (IDPH, Perinatal Advisory Committee, 2012).

In addition to the high cost of taking care of preterm infants, preterm birth has been shown to be associated with higher morbidity from neurocognitive problems, respiratory distress syndrome, intra-ventricular hemorrhage, retinopathy, and broncho-pulmonary dysplasia (Vohr, 2014; Lekic et al., 2015; Neubauer, Junker, Griesmaier, Schocke, & Kiechl-Kohlendorfer 2015; Herbst, Mercer, Beazley, Meyer, & Carr, 2003). Importantly, the effects of preterm birth and/or low birth-weight may persist beyond the neonatal period through childhood into adolescence (Chan & Quigley, 2014; Damgaard et al., 2015; Huddy, Johnson, & Hope, 2001; Johnson et al., 2009; Marlow, Wolke, Bracewell, & Samara, 2005). Furthermore, the care of preterm birth and low birth weight infants brings considerable emotional and economic burdens to their families (Taylor, Klein, Minich, & Hack, 2001).

Another important benefit of adequate utilization of prenatal care is a reduction in maternal complications. Although this outcome has not been well studied as preterm birth and low birthweight, some studies have shown that inadequate prenatal care utilization may increase maternal complications

such as excessive or insufficient weight gain during and after pregnancy, and lengthy hospitalization after birth (Conway & Kutinova, 2006; Yan, 2017). In addition, the opportunity to counsel and educate women on healthy behavioral practices such as quitting smoking and breastfeeding may be missed among those who receive no prenatal care, and those who have inadequate care (Reichman, Corman, Noonan, & Schwartz-Soicher, 2010; Yan, 2017). Furthermore, studies have found that children of mothers who receive inadequate prenatal care have fewer well-child visits and are more likely to receive inadequate immunizations than the children of mothers who receive adequate prenatal care (Cogan, Josberger, Gesten, & Roohan, 2012; Kogan, Alexander, Jack, & Allen, 1998; Reichman, Corman, Noonan, & Schwartz-Soicher, 2010).

Despite the potentials of adequate prenatal care utilization to improve maternal, infant and child health, the percentage of pregnant women in the US who initiated prenatal care in the first trimester decreased between 2003 and 2007 (Martin et al., 2005-2009). Recent national statistics from the United States Department of Health and Human Services (USDHHS), Centers for Disease Control and Prevention (CDC) showed a nonremarkable percentage increase (70.8% vs. 71.7%) in the number of women who started prenatal care in the first trimester between 2014 and 2015 (USDHHS, CDC, 2017). Data for the year 2013 and earlier are not comparable with those for 2015 because of the change in the method for measuring prenatal care utilization and estimating gestational age between those periods.

Given the pivotal role of prenatal care in multiple aspects of the reproductive, perinatal and child health continuum (Handler & Johnson, 2016), research related to prenatal care should be broadened to embrace both individual and contextual neighborhood factors that influence its adequate utilization. In addition, valid and reliable instruments to measure prenatal care utilization and appropriate statistical techniques are essential to our comprehensive understanding of why some pregnant women underutilize prenatal care, even when they have financial access.

1.3 Purpose of the Study

Most of the currently available studies in the literature related to prenatal care have considered only individual-level factors such as socio-demographics, maternal health status, and health insurance coverage as determinants of adequate utilization (Hueston, Geesey, & Diaz, 2008; D'Ascoli, Alexander, Petersen, & Kogan, 1997; Frisbie, Echevarria, & Humme, 2001; Funai, White, Lee, Allen, & Kuczynski, 2003; Park, Vincent, & Hastings-Tolsma, 2007; Wu et al., 2013; Sunil et al., 2010). A major effort by the United States government to address the problem of inadequate prenatal care utilization has been to improve financial access to prenatal care at the individual level. While there are federal and state policies to achieve this (D'Angelo et al., 2016; USDHHS, 2015), there is a functional gap between having financial access to prenatal care, as defined at the policy level, and its adequate utilization by pregnant women (Handler & Johnson, 2016). Having health insurance does not guarantee that a pregnant woman will start prenatal care early in pregnancy, attend the required number of visits, and receive the optimum level of quality care based on expert recommendations.

There are five important dimensions to health service utilization: availability, accessibility, accommodation, affordability, and acceptability (Penchansky & Thomas, 1981). With respect to prenatal care services, availability defines the supply of prenatal care services in relation to those who need them; accessibility is a measure of geographical barriers to the services; accommodation is related to the degree to which the services are organized to meet the needs of all pregnant women; affordability is having the financial means to receive all the necessary services, which has to date been the major focus of legislators and policy makers; and acceptability describes the attitudes of pregnant women towards prenatal care, which are shaped by their knowledge and beliefs, cultural and social norms, and social interactions at the family, neighborhood, and health system level, including their interpersonal relationships with prenatal care service providers (Fishbein & Cappella, 2006; Kasprzyk, Montaño, &

Fishbein, 1998; Penchansky & Thomas, 1981). Therefore, understanding why some pregnant women do not receive adequate prenatal care requires a broader scope beyond individual-level factors.

The importance of area of residence or neighborhood as a major contributor to health outcomes, health behaviors, and healthcare utilization has been well emphasized (Macintyre, Ellaway & Cummins, 2002; Diez-Roux & Mair, 2010). Many studies have examined the relationship between neighborhood factors and health outcomes such as obesity (Feng, Glass, Curriero, Stewart, & Schwartz, 2010; Papas et al., 2007), mental health (Kim, 2008; Mair, Roux & Galea, 2008; Truong & Ma 2006), and adverse pregnancy outcomes (Vos, Posthumus, Bonsel, Steegers, & Denktaş, 2014), and also health behaviors such as physical activity and dietary habits (Bancroft et al., 2015; Casagrande et al., 2009). However, the literature on the influence of neighborhood characteristics on utilization of healthcare services is sparse (Hussein, Roux, & Field, 2016; Kirby & Kaneda, 2005; Prentice, 2006) with only a few studies on neighborhood factors and prenatal care utilization (Braveman, Egerter, Cubbin, & Marchi, 2004; Charreire & Combier, 2009; Cubbin et al., 2008; Daoud et al., 2015; Kieffer, Alexander & Mor, 1992; Perloff & Jaffee, 1999; Shoff, Chen, & Yang, 2014; Shoff, Yang, & Matthews, 2012).

There are many limitations of the existing studies which focus on the effect of neighborhood factors on prenatal care utilization. First, most of the studies do not use the appropriate statistical techniques to account for multiple levels of influence (i.e., individual and neighborhood level) (Braveman, Egerter, Cubbin, & Marchi, 2004; Cubbin et al., 2008; Daoud et al., 2015; Perloff & Jaffee, 1999). This is critical in the interpretation of study findings because ordinary regression analysis may underestimate the standard errors of regression coefficients and result in Type-I error (Raudenbush & Bryk, 2002). Multilevel analyses allow researchers to simultaneously examine the independent contributions of individual- and neighborhood-level factors on a health outcome or behavior (Diez-Roux, 2000). Multilevel analyses answer the question: What other factors influence a health behavior or

health outcome above and beyond individual-level factors (Oakes, Andrade, Biyoow, & Cowan, 2015)? In addition, multi-level analysis can be used to understand how neighborhood-level factors interact with individual-level factors to influence a health outcome or behavior (Diez-Roux, 2000; Raudenbush & Bryk, 2002).

Second, many of the studies that examined the effects of neighborhood on prenatal care utilization have been limited to one measure of neighborhood context, usually a measure of neighborhood poverty (Braveman, Egerter, Cubbin, & Marchi, 2004; Daoud et al., 2015). Neighborhood can be broadly viewed in two dimensions with respect to providing an explanation for geographical variations in health: compositional and contextual (Macintyre, Ellaway, & Cummins, 2002). Compositional dimensions are related to the characteristics of individuals concentrated in the neighborhood while contextual dimensions are related to the socially constructed and socially patterned features of the neighborhood's physical and social environment, including the collective social functioning and practices inherent to that neighborhood (Macintyre, 2002). Due to the complex interrelation of the compositional and contextual dimensions of place, it is important that researchers explore multiple neighborhood contexts before any conclusion that there is no place effect on a health outcome or behavior.

Third, because most of the existing studies on the contextual effect of neighborhood on prenatal care utilization rely on census data, there is often a large gap between the time the neighborhood-level factors and prenatal care utilization are measured (Braveman, Egerter, Cubbin, & Marchi, 2004; Cubbin et al., 2008; Kieffer, Alexander & Mor, 1992). Some studies even measure exposure variables years after the occurrence of the outcome (Cubbin et al., 2008; Kieffer, Alexander & Mor, 1992). Lastly, while neighborhood violent crime has been found to be associated with some health outcomes including adverse pregnancy outcomes (Collins & David, 1996; Messer, Kaufman, Dole, Savitz, & Laraia, 2006,

Morenoff, 2003; O'campo, Xue, Wang, & Caughy, 1997), to date, there is no published study that has assessed the relationship between neighborhood violent crime rate and prenatal care utilization.

An innovative approach to the relationship between place and health that has gained ground in the last two decades is the use of geographical information systems (GIS). They can be used for visualization and mapping, and for spatial analysis of health-related data (Cromley & McLafferty, 2012). While there are many studies that have used GIS tools to examine the spatial distribution of health outcomes, including adverse pregnancy outcomes (Anthopolos, James, Gelfand, & Miranda, 2011; Byrnes, 2015; South, 2012), only a few studies have used these tools to map prenatal care utilization and analyze its determinants at the neighborhood level (Charreire & Combier, 2009; McLafferty & Grady, 2004; Shoff, Chen, & Yang, 2014; Shoff Yang, & Matthews, 2012).

Racial disparities in prenatal care utilization have been documented in the literature for many decades (Ingram, Makuk & Keinman, 1986; Kotelchuck, 1994; Alexander, Kogan & Nabukera, 2002; Cox, Zhang, Zotti, & Graham, 2011); however, studies that critically examine the role of maternal characteristics including health insurance status in explaining the disparities are sparse (Bengiamin, Capitman, & Ruwe, 2010; Bromley, Nunes, & Phipps, 2012; LaVeist, Keith, & Gutierrez, 1995). In addition, some of the few studies that specifically examine the relationships focused only on health insurance status (Bengiamin, Capitman, & Ruwe, 2010), or examined a limited number of individual-level characteristics (Bromley, Nunes, & Phipps, 2012). Also, there is no published study that has explicitly examined racial disparities in prenatal care utilization with respect to the racial/ethnic composition of place of residence.

To this end, the studies in this dissertation contribute to the body of literature on prenatal care utilization in multiple ways. First, geographic tools are used to map the prevalence and spatial patterns of prenatal care utilization, and to examine the spatial associations between neighborhood contextual

factors and prenatal care utilization. Second, the association of both individual and neighborhood-level factors with prenatal care utilization were simultaneously examined to distinguish between associations that are compositional from those that are contextual using the appropriate statistical techniques for analyzing multi-level data. Third, racial disparities in prenatal care utilization are critically examined to identify important maternal characteristics, including their relative roles, that may explain the disparities and to determine if the disparities vary by community racial/ethnic composition. The effect of living in a community area where one's race/ethnic group is the majority on prenatal care utilization is also examined. Given the complex, inextricably linked compositional and contextual dimensions of neighborhood, this study examined multiple neighborhood social contexts: neighborhood socioeconomic indicators, violent crime, community racial/ethnic composition, and racial residential segregation. Also, the interactions between the neighborhood contextual factors and the individual-level risk factors for prenatal care utilization were examined.

The studies in this dissertation utilized community-level data that reflect the neighborhood experience of Chicago residents to minimize measurement (misspecification) errors. The 77 community areas in the city of Chicago in Illinois were used to examine the association between the contextual effects of neighborhood and prenatal care utilization. The city of Chicago contributes more than 40% of the total number of births in Illinois every year. While there are some studies on the contextual effects of neighborhood on adverse pregnancy outcomes in the city of Chicago (Buka, Brennan, Rich-Edwards, Raudenbush, & Earls, 2003; Collins, Simon, Tara, Jackson, & Drolet, 2006; Collins, David, Rankin, & Desireddi, 2009; Giurgescu et al., 2016; Morenoff, 2003), to date no study has examined the contextual effects of neighborhood on prenatal care utilization among Chicago residents.

1.4 Study Objectives

In this dissertation, three separate studies were conducted. The first study examined the associations between three neighborhood characteristics (neighborhood socioeconomic indicators, violent crime, and racial residential segregation) and prenatal care utilization at the community level using Geographical Information Systems (GIS). The spatial pattern of inadequate prenatal care utilization in Chicago community areas was compared with the patterns of the three neighborhood characteristics. In addition, the effects of neighborhood socioeconomic indicators and violent crime on prenatal care utilization were examined. Given the intricate relationships among the three neighborhood characteristics, the effects of neighborhood socioeconomic indicators and violent crime on prenatal care utilization independent of racial residential segregation were also examined.

In the second study, multilevel regression analysis was used to examine the associations between neighborhood social contexts (neighborhood socioeconomic indicators, violent crime and racial residential segregation) and inadequate prenatal care utilization using data obtained at both the individual and neighborhood levels. Similar to the first study conducted at the community level using GIS, the effects of neighborhood socioeconomic indicators and violent crime on prenatal care utilization were examined, including their independent effects adjusted for racial residential segregation. In addition, their effects on prenatal care utilization were also examined by race/ethnicity with and without adjusting for racial residential segregation.

The third study critically examined racial disparities in prenatal care utilization to identify important individual-level characteristics, including their relative roles, that may explain the disparities, and to determine if the disparities vary by community racial/ethnic composition. The effect of living in a community area where one's race/ethnic group is the majority on both late/no prenatal care and inadequate prenatal care were also examined.

Though discussed in detail in the method section, for clarity of the study objective, prenatal care utilization was measured as late/no prenatal care, and inadequate prenatal care utilization. Late/no prenatal care was defined as starting prenatal care after the first trimester or having no prenatal care, and inadequate prenatal care utilization (PNCU) was defined as having inadequate or intermediate prenatal care utilization versus adequate or adequate plus prenatal care based on Kotelchuck's Adequacy of Prenatal Care Utilization (APNCU) Index (Kotelchuck, 1994).

For each study, the specific objectives are outlined below:

Study 1. Effect of Neighborhood Socioeconomic Indicators and Violent Crime on Prenatal Care Utilization: a GIS Analysis

1) To estimate and map the prevalence of inadequate prenatal care utilization between 2010 and 2014 by Chicago Community Area.
2) To describe and relate the spatial patterns of inadequate prenatal care utilization, neighborhood socioeconomic indicators, violent crime, and racial residential segregation in Chicago community areas.
3) To examine the spatial associations of neighborhood socioeconomic indicators, violent crime, and racial residential segregation with inadequate prenatal care utilization across Chicago Community Areas between 2010 and 2014.

Study 2. Effect of Neighborhood Socioeconomic Indicators and Violent Crime on Prenatal Care Utilization: a Multilevel Regression Analysis

4) To estimate the effects of neighborhood socioeconomic indicators and violent crime on prenatal care utilization over and above the influence of individual-level characteristics among Chicago residents.

5) To estimate the effects of neighborhood socioeconomic indicators and violent crime on prenatal care utilization over and above the influence of individual-level characteristics, independent of racial residential segregation among Chicago residents.
6) To determine if the effects of neighborhood socioeconomic indicators and violent crime on prenatal care utilization adjusted for individual-level characteristics differ by race/ethnicity among Chicago residents.

Study 3. Racial Disparities in Prenatal Care utilization: Individual-level Characteristics and Place of Residence

7) To identify maternal characteristics, including health insurance status, that may explain the racial disparities in prenatal care utilization among Chicago residents.
8) To determine if racial disparities in prenatal care utilization vary by Chicago community racial/ethnic composition.
9) To assess the effect of living in a community area where one's race/ethnic group is the majority on prenatal care utilization among Chicago residents.

The studies were conducted using the 2010–2014 birth files obtained from the Chicago Department of Public Health linked with the neighborhood socioeconomic indicators, racial/ethnic composition, and racial residential segregation data obtained from the American Community Survey, and the community-area violent crime rate data obtained from the Chicago Police Department.

1.5 Significance of the Studies: Public Health Implications

Understanding the determinants of prenatal care utilization requires not only understanding individual-level risk factors but also the social and the environmental contexts in which individuals live. A good start to addressing the problem of inadequate prenatal care utilization is identifying and mapping the spatial distribution of community areas that are most in need of interventions. Spatial pattern

analysis is a valuable statistically-based technique for identifying clusters of community areas with high rates of inadequate prenatal care utilization. It provides spatial information that is more realistic than can be obtained from the traditional descriptive approach by correcting for spatial correlation between adjacent neighborhoods (Cromley & McLafferty, 2012). In addition, identifying local variation in the strength of the association between community-level characteristics and prenatal care utilization using geographically weighted regression (GWR) can provide useful information for the focus of future research to facilitate the identification of community areas that are most in need of public health interventions.

Eliminating racial disparities in prenatal care utilization requires a comprehensive understanding of their causes. Although some factors, especially maternal level of education and health insurance status, have been implicated in the literature, understanding the relative role of individual-level factors in racial disparities is essential to effective and efficient planning, and the prioritization of public health efforts aimed at reducing them. In addition, given the intricate relationships between race/ethnicity and cultural beliefs, values and norms, racial/ethnic-specific public health interventions may be necessary since the direction of influence of individual-level factors responsible for racial disparities may not be the same for all minority racial/ethnic minority. Furthermore, establishing that racial disparities vary by racial/ethnic composition of area of residence will provide evidence for broadening the scope of research on racial disparities beyond the individual to the neighborhood level.

Given the complex, dynamic interplays between individual-level risk factors and neighborhood context, a useful approach to examining the determinants of prenatal utilization at more than one level is multilevel regression analysis. The technique can be used to examine the contextual effects of neighborhood on prenatal care utilization above and beyond individual-level factors (Oakes, Andrade, Biyoow, & Cowan, 2015). Consequently, it is valuable in obtaining information for understanding factors

beyond individual control that may influence prenatal care utilization. This information is essential to public health policy that focuses on the relevant community-level social and environmental characteristics that generally influence individual decisions to adequately utilize health services, including prenatal care.

Although the role of prenatal care in reducing adverse pregnancy outcomes is somewhat equivocal (Alexander & Kotelchuck, 2001; Lu, Tache, Alexander, Kotelchuck, & Halfon, 2003), prenatal care still plays a pivotal role in multiple aspects of the reproductive, perinatal and child health continuum (Krans & Davis, 2012; Handler & Johnson, 2016). Besides its potential to reduce maternal and infant complications, prenatal care provides the opportunities for counseling women about unhealthy behavioral practices, breastfeeding, and the importance of well-child visits (Cogan, Josberger, Gesten, & Roohan, 2012; Kogan, Alexander, Jack, & Allen, 1998; Reichman, Corman, Noonan, & Schwartz-Soicher, 2010). Therefore, understanding why some pregnant women have inadequate prenatal care is important to public efforts aimed at improving the health of women, infants and children.

2. THEORETICAL FRAMEWORK

Research in public health can generally be viewed as either related to health outcomes or health behaviors. With this broad classification, prenatal care utilization can be viewed as a health behavior. Therefore, most of the studies of healthcare service utilization in the literature have relied on theories of health behavior as their guiding conceptual frameworks. Theoretical models that can be used as frameworks to understand determinants of prenatal care utilization and to guide focused interventions to increase its use include Andersen's behavioral model for health services use (Andersen, 1968; Andersen, 1995), the Health Belief Model (Rosenstock, 1974; Rosenstock, Strecher, & Becker, 1988), and the Integrated Behavioral Model (Fishbein, 2000; Fishbein & Cappella, 2006; Kasprzyk, Montaño, & Fishbein, 1998). Of these three models, Andersen's behavioral model is the most comprehensive because it integrates both individual-level and contextual factors in accounting for the determinants of health care utilization. The other two models focus more on individual-level factors as determinants of behavior. Consequently, Andersen's behavioral model is used as the theoretical framework for the studies in this dissertation and will be discussed below.

2.1 Andersen's Behavioral Model of Health Services Use

The original Andersen's behavioral model for health services utilization posits that access to and utilization of a healthcare service can be predicted or explained by the predisposition of people to utilize the healthcare service, factors that enable or impede their utilization of the service, and their perceived and evaluated need for the service (Andersen, 1968). The original model has been updated four times to include health service system (resources and organization) and how personal health behaviors interact with the use of health services to influence health outcomes. The modifications were made to reflect the dynamic and recursive nature of the model and to focus on contextual and individual determinants of health services use (Andersen, 2008; Andersen, Davidson, & Baumeister, 2013).

Based on Andersen's behavioral model (Andersen, Davidson, & Baumeister, 2013), both the individual and contextual determinants of health services use can be described as *predisposing, enabling,* and *need* factors. At the individual level, *predisposing* factors for prenatal care utilization include: 1) demographic factors such as maternal age and marital status; 2) social factors such as maternal level of education, maternal occupation, race/ethnicity, and social networks, interactions and affiliations; and 3) maternal health beliefs (attitudes, values, and knowledge) about general health, pregnancy and prenatal care. *Enabling* factors include personal/family resources that must be present for a pregnant woman to utilize prenatal care. These resources include factors such as household income, health insurance status, and social support from family members and friends. *Perceived needs* are factors related to how a pregnant woman views her general health and functional state, including her background medical conditions or previous medical and obstetric experiences, and whether she perceives or judges her current pregnancy-related problems (symptoms, illness and worries) to be of sufficient importance to seek professional help. In contrast, *evaluated need* represents professional judgment about a woman's health status and her need for medical care that may inform her need for utilization of prenatal care (Andersen, 1968; Andersen, 1995; Andersen, Davidson, & Baumeister, 2013).

Similarly, at the contextual level, *predisposing* factors for prenatal care utilization include: 1) community demographic composition with respect to age, gender, and marital status; 2) community social structure including ethnic and racial composition, racial residential segregation, crime rate, and aggregate measures of educational level and employment rate; and 3) organizational/community values and cultural norms, and prevailing political perspectives relating to how prenatal care services should be organized, financed, and made accessible to pregnant women.

Enabling factors at the contextual level are existing community-level characteristics that facilitate use of health services such as per capita community income and other related measures; the

number, distribution, and type (public or private) of prenatal care facilities and healthcare personnel; rate of health insurance coverage; measures of proximity (transportation, travel time, and waiting time) to healthcare services; and the organization of the healthcare delivery system. *Need* factors at the contextual level are community-level characteristics including environmental and population health indices that suggest community health service needs (Andersen, 1995; Anderson & Davidson, 2007; Andersen, Davidson, & Baumeister, 2013).

Although this model posits that perceived need is the ultimate determinant of health care utilization, the health beliefs (attitudes, values, and knowledge) that a pregnant woman has about her general health, pregnancy, and prenatal care may influence her perceptions of the need to use prenatal care. The influence of other people may also affect her perception of need. Injunctive norms are related to the expectations of significant others in one's personal or social networks with respect to performing a particular behavior while descriptive norms are related to whether most of the significant others perform the behavior (Kasprzyk, Montaño, & Fishbein, 1998). Essentially, the health beliefs of a pregnant woman may explain how social structure influences enabling resources, and her perceived need and subsequent utilization of prenatal care (Andersen, 1995).

Andersen's behavioral model has been applied as the conceptual framework in many studies to explore barriers to women's healthcare utilization including participation in interconceptional care (Hogan et al., 2014), to identify determinants of the receipt of clinical preventive services among reproductive-age women (McCall-Hosenfeld, 2012), to evaluate factors associated with inadequate prenatal care utilization (Bernardes et al., 2014), and to understand the salient factors responsible for the racial/ethnic disparities in prenatal care utilization between pregnant African-American and pregnant white American women (Laviest, Keith, & Gutierrez, 1995).

2.2 Study Theoretical Framework

Andersen's behavioral model of health services use was used to guide the conceptual framework of the studies in this dissertation. Out of the behavioral models that have been used in the literature, it is the only model that explicitly highlights the direct and indirect effect of neighborhood contexts on prenatal care utilization. The other behavioral models such as the Health Belief Model (HBM) and the Integrated Behavior Model (IBM) focus more on individual-level determinants of prenatal care utilization. In addition, Andersen's behavioral model recognizes the dynamic and recursive nature of the neighborhood composition and neighborhood context: neighborhood context may influence individual-level determinants of health services use that may in turn influence neighborhood contexts in a dynamic system (Galea, Riddle, & Kaplan, 2010; Glass & McAtee, 2006). This is a fundamental component of social epidemiological theories, particularly eco-social theory, which have been gaining ground in the last 20 years (Krieger, 2014; Morris & Halkitis, 2015).

Andersen's behavioral model was adapted as the conceptual framework for this study with some modifications (Figure 1). The major modifications include:

1) The model was adapted to reflect prenatal care utilization, not health services use in general.
2) The primary outcome in this study is prenatal care utilization; therefore, the components related to other health utilization outcomes and other health behaviors in the Andersen's behavioral model were dropped.
3) The study conceptual framework recognizes the healthcare system (health policy, resources, and organization) as separate from the neighborhood context.
4) In the conceptual framework below, specific independent variables at the individual and neighborhood level that are used in the dissertation are highlighted.

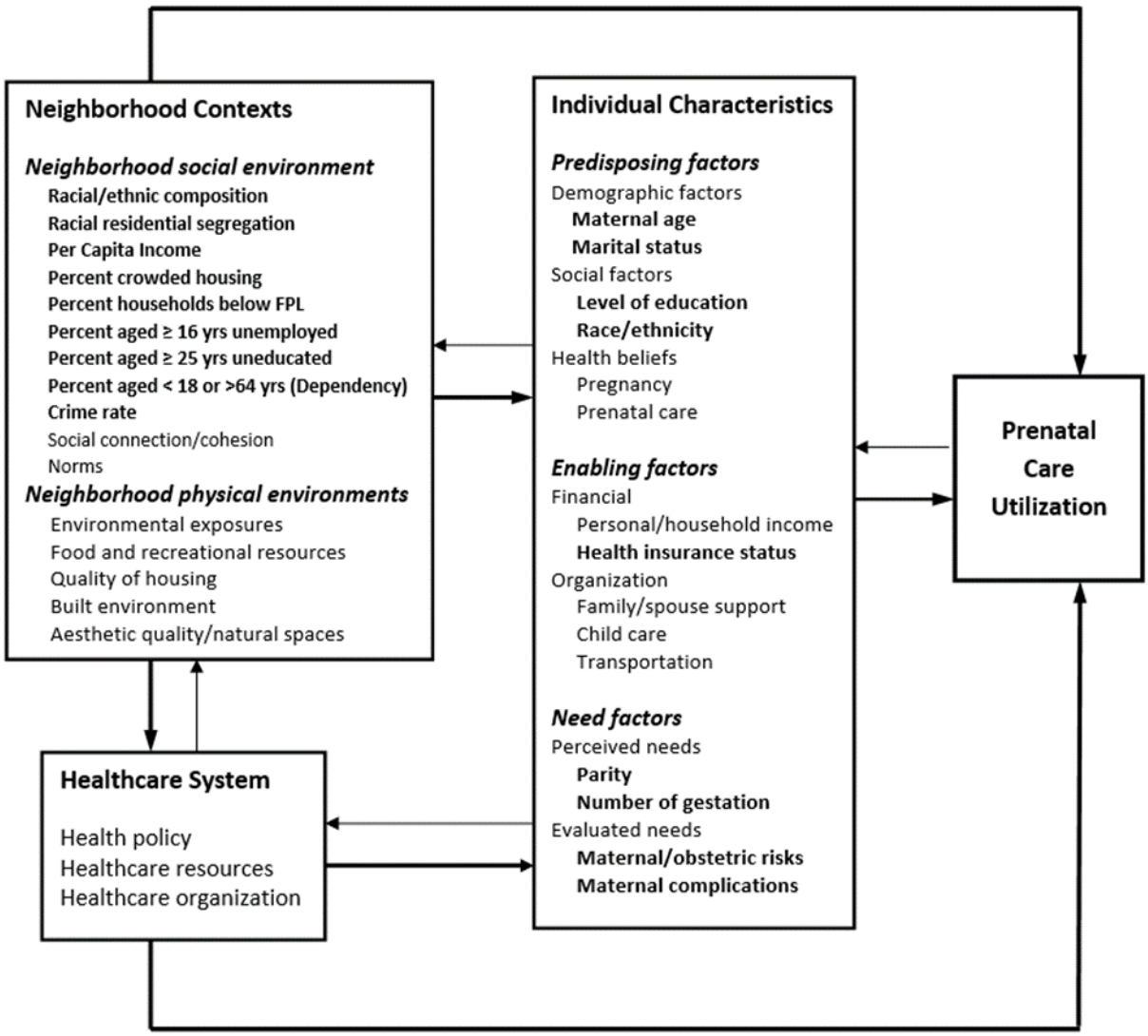


Figure 1. Conceptual framework for individual-level factors and neighborhood contexts for prenatal care utilization

Adapted from the Andersen's behavioral model of health service use (Andersen, Davidson, & Baumeister, 2013)

The review of the literature and other subsequent sections of this dissertation are based on the study conceptual framework (Figure 1).

The neighborhood contextual factors examined for this dissertation are *percent dependency, percent uneducated, percent living in poverty, percent unemployed, percent crowded housing and per capita income*, collectively referred to as neighborhood socioeconomic indicators or *neighborhood hardship*; crime rate; racial/ethnic composition; and racial residential segregation. Residential segregation has been proposed to be a fundamental cause of racial/ethnic disparities in health because of its role in shaping individual educational and employment opportunities and the socioeconomic, physical and environmental contexts of neighborhoods (White, Haas, & Williams, 2012; Williams & Collins, 2001).

White, Haas and Williams (2012) described the mechanisms through which racial residential segregation shapes healthcare system infrastructure, neighborhood socioeconomic, physical and environmental contexts, and individual-level characteristics to influence health care access, utilization, and quality of health care services across the life course. Given the intricate relationships between racial residential segregation and other neighborhood social contexts, and the fundamental role of residential segregation in racial disparities in health care utilization, accurate specification of the pathways that relate racial residential segregation, neighborhood socioeconomic indicators, and violent crime to prenatal care utilization is essential to making valid statistical inferences and conclusion from neighborhood studies (Acevedo-Garcia & Lochner, 2003).

The simple mediational pathway between racial residential segregation and prenatal care utilization that guides the study objectives and the interpretation of the study findings in the dissertation is illustrated in Figure 2 below:

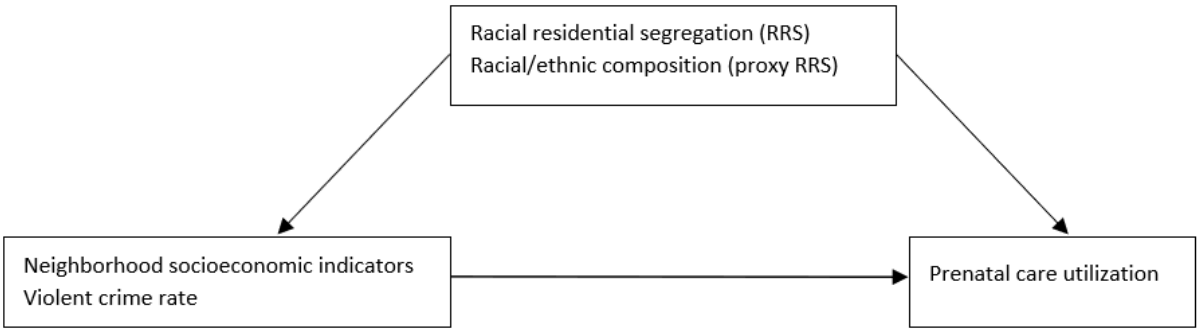


Figure 2. A simple mediational pathway between racial residential segregation and prenatal care utilization

3. LITERATURE REVIEW

3.1 Introduction

Prenatal care is one of the most commonly used preventive health care services in the United States (Schappert & Burt, 2006). In 2015, the total number of births registered in the United States was about 4 million (Hamilton, Martin, & Osterman 2016). The latest national data on prenatal care utilization from the United States Department of Health and Human Services (USDHHS), Centers for Disease Control and Prevention (CDC) showed that in 2015 only 77.0% of women who registered their birth initiated prenatal care in the first trimester and 4.4% received late (care beginning in the last trimester of pregnancy) or no care during pregnancy (USDHHS, CDC, 2017). In 2014, the percentage of births to women who received at least adequate prenatal care (adequate and adequate-plus as defined by Kotelchuck's index) in Illinois was only 78.1%, a slight increase from 76.9% in 2010. In the same year, the city of Chicago had the lowest percentage (72%) compared to other cities in in Illinois (Illinois Department of Public Health, 2015).

Studies have shown that women who have the greatest risk of experiencing adverse pregnancy outcomes based on their socio-demographic characteristics are often those who do not receive adequate prenatal care during pregnancy (Alexander, Kogan, & Nabukera, 2002; Kogan, Alexander, Jack & Allen, 1998). One out of three pregnant African-American or Hispanic women does not initiate prenatal care in the first three months of pregnancy (Osterman, Martin, Mathews, & Hamilton, 2011). In the city of Chicago, African-American women and women younger than 20 years are those most likely to not receive prenatal care (Illinois Department of Public Health, 2015).

The literature on prenatal care utilization is vast; therefore, the review is divided into three broad sections: 1) A brief history of prenatal care in United States; 2) Determinants of prenatal care

utilization including individual-level determinants of prenatal care utilization, health policy and organization, and neighborhood-level determinants; and 3) Methodological issues in prenatal care research including measurement and methodological issues related both to prenatal care utilization and neighborhood contexts.

3.2 A Brief History of Prenatal Care

For over a century, prenatal care has been recognized as a means for early detection of maternal and fetal risks during pregnancy for the purpose of preventing the complications associated with those risks. In addition, prenatal care provides opportunities for maternal education and counseling. The history of prenatal care can be traced back to the works of John William Ballantyne (Ballantyne, 1901) in Europe and Mrs. William Lowell Putnam of the Boston Infant Social Service Department in the United States, who began a program of nurse visits to women who enrolled in the home delivery service of the Boston Lying-in Hospital (Thompson, Walsh, & Merkatz, 1990).

In 1915, J. Whitbridge Williams asserted that efficient prenatal care could reduce fetal mortality by up to 40 percent, especially deaths that resulted from dystocia, toxemia, and preterm birth (Williams, 1915). Following his publication, many studies confirmed reductions in the rate of low birthweight with adequate utilization of prenatal care. In 1985, the Institute of Medicine (IOM) concluded that “the overwhelming weight of the evidence is that prenatal care reduces low birthweight” (IOM, 1985). Some years later, the United States Public Health Service (1989) and the National Committee to Prevent Infant Mortality (1988) also supported the role of prenatal care in improving the rate of low birth weight and infant mortality. Subsequent to the report by the Institute of Medicine in 1985, the United States Congress enacted a series of legislative initiatives that increasingly expanded Medicaid eligibility to low income pregnant women and children independent of their welfare status, beginning with the Omnibus Budget Reconciliation Act of 1986 (Hill, 1992).

However, more recent evidence, after the IOM report about the role of prenatal care in reducing adverse pregnancy outcomes has been equivocal at best (Alexander & Kotelchuck, 2001**;** Fiscella, 1995; Walford, Sonya, Wiencrot, & Lu, 2011), and the findings from studies on the effectiveness of the Medicaid expansion with respect to adverse pregnancy outcomes are inconclusive (Baldwin et al., 1998; Dubay, Joyce, Kaestner, & Kenney, 2001; Howell, 2001; Long & Marquis, 1998; Ray, Mitchel Jr & Piper, 1996). As a result, the focus on prenatal care as a major public health effort to improve adverse pregnancy outcomes started to dwindle during the last decade of the 20th century (Handler and Johnson, 2016). The initial attention to prenatal care shifted towards improving preconceptional and interconceptional care (Floyd et al., 2013; Frayne et al., 2016; Johnson et al., 2006; Wise, 2008). More recently, however, there is a "call to revisit the prenatal period as a focus for action within the reproductive and perinatal care continuum" (Handler & Johnson, 2016, p. 2217).

3.3 Determinants of Prenatal Care Utilization

Despite the emphasis placed on the value of prenatal care (Institute of Medicine, 1985; United States Public Health Service, 1989), studies have shown that some groups of women do not initiate care early or have adequate number of prenatal care visits based on expert recommendations. Women who have the greatest risk of experiencing adverse pregnancy outcomes based on their socio-demographic characteristics are often those that do not receive adequate prenatal care during pregnancy (Alexander, Kogan & Nabukera, 2002; Kogan, Alexander, Jack, & Allen, 1998). In the literature, both individual and neighborhood-level factors have been found to be associated with the use of prenatal care. However, there are many more studies on individual-level factors associated with prenatal care utilization than studies focused on neighborhood contextual factors. The conceptual framework designed for this study (Figure 1) was used to guide the review of literature on the determinants of prenatal care utilization.

3.3.1 Individual-level determinants of prenatal care utilization

Individual characteristics that have been found to be associated with prenatal care utilization can be grouped into *predisposing*, *enabling* and *need* factors. Predisposing factors for prenatal care utilization include: 1) demographic factors such as maternal age and marital status; 2) social factors such as maternal level of education, maternal occupation, and race/ethnicity; and 3) maternal health beliefs (attitudes, values, and knowledge) about general health, pregnancy and prenatal care. Enabling factors include personal/family resources such as household income, health insurance status, social support from family members, and maternal social networks, interactions, or affiliations.

Perceived needs are factors related to how a pregnant woman views her general health and functional state, including her background medical conditions or previous obstetric experiences, and whether she perceives or judges her current pregnancy-related problems (symptoms, illness and worries) to be of sufficient importance and magnitude to seek professional help. The influence of her significant others may also shape how she perceives her need for use prenatal care (Kasprzyk, Montaño, & Fishbein, 1998). Evaluated need represents professional judgment about a woman's health status and her need for medical care that may inform her need for increased utilization of prenatal care (Andersen, 1968; Andersen, 1995; Anderson & Davidson, 2007).

It is important to emphasize that individual-level factors are inextricably linked; therefore, some demographic factors are simply markers for more complex factors that are directly related to utilization of prenatal care. For example, while young maternal age can be argued to be an independent demographic factor that is associated with inadequate utilization of prenatal care, the reason for the association may be explained by the fact that a pregnant teen is more likely to be a member of a minority racial/ethnic group, to be unmarried, or have less than college education than a pregnant adult woman.

3.3.1.1 Individual-level predisposing factors

Maternal age is one of the most common predisposing factors at the individual level for prenatal care utilization. Although the birth rate for teenagers aged 15–19 has been falling almost continuously since 1991, the percentage of the total births from teenage pregnancy in the United States is still of public health significance (Hamilton & Mathews, 2016). In 2015, at least one out of the 20 births in the United States was to a pregnant teen (Martin, Hamilton, Osterman, Driscoll, & Mathews, 2017). Moreover, the United States teen birth rate has remained higher than the rates for other industrialized countries (Hamilton & Mathews, 2016). The fact that teenage pregnancy may result in adverse pregnancy outcomes has been well documented in the literature (Chen et al., 2007; Ferré, 2016; Liran, Vardi, Sergienko, & Sheiner, 2013), and some studies have attributed the increased rates of adverse birth outcomes among teen mothers to inadequate prenatal care utilization (Partington, Steber, Blair, & Cisler, 2009; Tilghman & Lovette, 2008). However, studies that have specifically examined the independent effect of young maternal age on prenatal care utilization are sparse in the literature.

In a cross-sectional study of 220,694 births in New York City between 1991 and 1992, Perloff and Jaffee (1999) found that maternal age was independently associated with late or no entry into prenatal care. Compared with mothers who were 20 years and older, young mothers were more likely to initiate prenatal care late or have no care (OR= 1.29; 95% CI: 1.24–1.40). In a related study, Hueston and colleagues (2008) examined the pattern of initiation of prenatal care by teenage girls (less than 20 years) in the United States using national birth certificate data between 1978 and 2003. The study population was grouped into three age groups: preteens (10–14 years), younger adolescents (15–16 years), and older adolescents (17–19 years). The authors found a consistent relationship between age and the timing of prenatal care initiation. Among the three age groups, preteens had the highest and older adolescents had the lowest percentage of pregnancies with delayed or no prenatal care. Using older

adolescents as the reference group, both preteens and younger adolescents were more likely to have late or no prenatal care, after adjusting for survey year, race, marital status, education, residence, and prior births (OR=1.61, 95% CI: 1.56–1.65; OR=1.22; 95% CI: 1.21–1.24, respectively).

In their efforts to understand why pregnant adolescents initiate prenatal care late in pregnancy, Young, Mcmahon, Bowman, Thompson and Douglas (1989) conducted a survey of pregnant women who were residents of Allegheny County, Pennsylvania, and who initiated prenatal care in the third trimester. The authors found that concealment of pregnancy was the most common reason for younger adolescents (11-17 years) and poor motivation was the most common reason for older adolescents (18-19 years) to enroll late for prenatal care. Other similar investigations have shown that late recognition of pregnancy due to early vaginal bleeding (Stevens-Simon, Roghmann, & McAnarney, 1991), not being aware of pregnancy symptoms (Lee & Grubbs, 1995), and lack of family or partner support (Wiemann, Berenson, Pino, & McCombs, 1997) are some other reasons why adolescents do not initiate prenatal care early in pregnancy.

In the literature, older mothers (40 years and over) are not as well studied as teenage mothers probably because the number of births to mothers in this age group is very small. In 2015, the percentage of total live births to older mothers in the United States was only 3% (Martin, Hamilton, Osterman, Driscoll, & Mathews, 2017). Older mothers, like teenage mothers, tend to delay entry into prenatal care. Data from the United States Department of Health and Human Services (USDHHS), Centers for Disease Control and Prevention (CDC) show that the tendency for women to have late or no prenatal care increases as they get older than 35 up to 49 years before it declines (USDHHS, CDC, 2017). Plausible explanations for this pattern may be related to increasing confidence with increasing number of successful births since age is closely related to parity. However, both the perceived and evaluated needs to begin prenatal care early increase from age 50 for medical and obstetric reasons. Since the

birth rate for women aged 40 to 44 years has been increasing over the last 3 decades (Martin, Hamilton, Osterman, Driscoll, & Mathews, 2017), it is important that researchers examine prenatal care utilization among older mothers.

Besides maternal age, marital status is regarded as an individual-level predisposing factor for prenatal care utilization. Partner support during pregnancy has been shown to have a positive influence on maternal behaviors, including utilization of prenatal care. D'Ascoli and colleagues (1997) used a large observational dataset of 108,921 women who were 21 years of age or older obtained from the 1990-1991 Minnesota live birth file to examine the association between marital status and prenatal care utilization. Their study showed that unmarried women have more than a tenfold risk of receiving no prenatal care (vs. any prenatal care) than married women, regardless of their educational status. Given the fact that partner support during pregnancy is particularly relevant for low-income women from minority racial/ethnic groups, Zambrana, Dunkel-Schetter and Scrimshaw (1991) focused their study on Mexican-immigrant, Mexican-American, and African-American women in Los Angeles County. They found that having a relationship with the baby's father is more important in predicting the timing of prenatal care and the number of prenatal care visits than maternal or paternal level of education among these groups of women.

The finding that marital status is associated with prenatal care utilization is in support of the theory that social support from the baby's father during pregnancy can help a pregnant woman overcome socioeconomic barriers such as inability to pay for care, lack of transportation to site of care, and getting time off work; and psychological barriers related to maternal health beliefs and fear of seeking care (Dunkel-Schetter, Sagrestano, Feldman, & Killingsworth, 1996). In fact, the support received by a pregnant woman from her baby's father has more influence on her behavior towards prenatal care than the support received from any other family member. A study conducted by Giblin,

Poland and Ager (1990) showed that intimacy explained a much larger proportion of variance in the amount of prenatal care received by a pregnant woman than any other form of social support, such as comfort and security.

Maternal level of education is another individual-level predisposing factor that has been found to be related to prenatal care utilization. Education level is an important social factor that can modify how a woman perceives her susceptibility to adverse pregnancy outcomes, the severity of the outcomes if they occur, the benefits of utilizing prenatal care to prevent potential adverse outcomes, her ability to overcome the barriers to utilization of prenatal care, and her response to cues that suggest need for prenatal care (Champion & Skinner, 2008). Both paternal and maternal education are important determinants of prenatal care utilization. However, very few studies have examined the role of paternal level of education in prenatal care utilization (D'Ascoli, Alexander, Petersen, & Kogan, 1997).

Studies have shown that maternal level of education has a strong influence on prenatal care utilization. A cross-sectional study of 220,694 births in New York City between 1991 and 1992 conducted by Perloff and Jaffee (1999) showed that maternal level of education is an independent individual-level factor that affects utilization of prenatal care, after controlling for other individual-level and neighborhood contextual factors. In addition, there is evidence that the association between maternal level of education and prenatal care utilization reflects a *dose-response* relationship. Beck and colleagues (2002) examined data obtained from the 17 states in the United States that had fully implemented the Pregnancy Risk Assessment Monitoring System (PRAMS) in 1999. The investigators found that the prevalence of late or no prenatal care utilization decreased with advancing maternal level of education in all the states.

Although maternal level of education has an almost linear relationship with prenatal care utilization independent of race/ethnicity (Brown, 1988), its effect on prenatal care utilization is not the

same for all racial/ethnic groups. Using data obtained from a survey administered between 1988 and 1989 by the Michigan Department of Public Health to all Michigan hospitals that had an obstetrical unit, Laviest (1997) found that while maternal level of education was a determinant of adequate prenatal care utilization for both African-American and white American women, education had a significantly stronger effect on adequacy of prenatal care received for African-Americans than for white Americans.

Paternal education level has also been found to influence prenatal care utilization. D'Ascoli and colleagues (1997) examined the relationship between use of prenatal care and paternal level of education. The authors found that for each level of maternal education, increasing level of paternal education decreased the risk of delayed initiation of prenatal care and not receiving adequate care. This study underscores the fact that both maternal and paternal level of education may be important individual-level determinants of adequate prenatal care utilization.

In the literature, there is no individual-level determinant of prenatal care utilization that has been more examined than race/ethnicity. The most recent data from the United States Department of Health and Human Services (USDHHS), Centers for Disease Control and Prevention (CDC) showed evidence of racial/ethnic disparities in prenatal care utilization (USDHHS, CDC, 2017). Among women with live births in 2015, 81.9% of Non-Hispanic white Americans began care in the first trimester of pregnancy, and 3.3% received late or no care. Non-Hispanic African-Americans were far less likely than Non-Hispanic white Americans to begin care in the first trimester (66.6%) and twice as likely to receive late or no prenatal care (7.8%). Similarly, Hispanic mothers were less likely to begin care in the first trimester (72.0%) and more likely to obtain late or no care (5.3%) than Non-Hispanic white Americans mothers.

The fact that there are racial disparities in late/no prenatal care and in inadequate prenatal care utilization has been documented in the literature for many decades (Ingram, Makuk, & Keinman, 1986;

Kotelchuck; 1994; Alexander, Kogan & Nabukera, 2002; Cox, Zhang, Zotti, & Graham, 2011). However, studies that critically examine the role of maternal characteristics including health insurance status, or factors beyond the individual level that may explain the disparities are very few (Bengiamin, Capitman, & Ruwe, 2010; Bromley, Nunes, & Phipps, 2012; LaVeist, Keith, & Gutierrez, 1995). In addition, some of the few studies that specifically examine the relationships focused only on health insurance status (Bengiamin, Capitman, & Ruwe, 2010), or examined a limited number of individual-level characteristics (Bromley, Nunes, & Phipps, 2012). Furthermore, there is no published study that has explicitly examined racial/ethnic disparities in prenatal care utilization with respect to the racial/ethnic composition of place of residence.

A related social factor to racial disparities in prenatal care utilization is racial discrimination, a term that is often used interchangeably with racism in the literature (Giscombé & Lobel, 2005). Racism can be defined as "beliefs, attitudes, institutional arrangements, and acts that tend to denigrate individuals or groups because of phenotypic characteristics or ethnic group affiliation" (Clark, Anderson, Clark, & Williams, 1999, p. 805). Racial discrimination as a psychosocial stressor has been associated with adverse pregnancy outcomes among African-American women (Mustillo, Krieger, Gunderson, Sidney, McCreath, & Kiefe, 2004). In addition, discriminatory treatment of pregnant African-American women has been shown to affect provider-patient interactions resulting in low quality health care and adverse pregnancy outcomes (Collins et al., 2000; Collins, David, Handler, Wall, & Andes, 2004; Benkert, Peters, Clark, & Keves-Foster, 2006). It is very possible that racism experienced by African- Americans is one of the major barriers to accessing prenatal care services (Alexander, Kogan, & Nabukera, 2002; Mayberry, Mili, & Ofili, 2000). This is particularly so among less empowered pregnant African-American women who may be hesitant to engage in prenatal care to avoid racialized experiences during prenatal care visits (Slaughter-Acey, Caldwell, & Misra 2013).

Using an index to measure both experienced personal and group (family, friends, and neighbors) racism, Slaughter-Acey and colleagues found that initiation of prenatal care in the first trimester by African-Americans was significantly associated with perceived group racism but not with personal experiences of racism (Slaughter-Acey, Caldwell, & Misra, 2013). The findings can be explained by the fact that some African-American women may suppress their personal experience of racism to avoid being powerless or vulnerable (Harrell, 2000). In a qualitative study among African-American women, Salm-Ward and colleagues (2013) found that pregnant African-American women underutilize prenatal care services because they perceive being treated differently by health care providers based on their race, type of insurance and level of income. It is possible that pregnant African-American women are not comfortable during prenatal care if their care providers do not treat them with respect or do not give them continuous and compassionate care (Lori, Yi, & Martyn, 2011).

A related psychosocial concept to patient-provider interactions in healthcare delivery is implicit bias that may result from negative opinions or thoughts towards a person or social group without conscious awareness (Baumeister & Vohs, 2007). Implicit bias is often unacknowledged and is difficult to control. Recent evidence suggests that racial disparities in health service utilization may be related to the implicit bias held by health care providers against minority racial/ethnic groups (Zestcot, Blair, & Stone, 2016). In a systematic review of implicit racial/ethnic bias among health care professionals, 14 out of the 15 studies that were reviewed found low to moderate levels of implicit bias among health care professionals. In the review, implicit bias was found to be significantly related to patient-provider interactions, and may manifest as dominant communication styles, poor empathy, and less patient-centered care (Hall et al., 2015).

In an exploratory experimental study, physicians who were primed with subliminal racial/ethnic stimuli to activate their implicit cognitions about Blacks or Hispanics evaluated the condition of a

hypothetical patient as less serious compared to physicians whose implicit cognitions about whites were activated (Stepanikova, 2006). In another study of 40 primary care physicians and 269 patients in urban community-based practices, physician implicit bias and stereotyping were found to be associated with directly observed poor patient-provider interactions and poor rating of interpersonal care by patients, especially among African Americans (Cooper et al., 2012). Therefore, it is possible that the racial disparities in prenatal care utilization may result from the implicit bias held by prenatal care providers towards pregnant women from minority racial/ethnic groups mediated through unfavorable patient-provider interactions.

Predisposing individual-level factors for prenatal care utilization also include maternal health beliefs and behaviors. Prenatal care utilization may be limited by the attitude of a woman towards her general health, pregnancy, and prenatal care; her beliefs and cultural values, and her psychological attributes and life-style choices. The attitudes towards her general health and pregnancy may influence her efforts to seek prenatal care. One important factor that affects a woman's attitudes towards her pregnancy and prenatal care is whether the pregnancy was planned or not. Women with an unplanned or unwanted pregnancy tend to have negative attitudes towards pregnancy and prenatal care (Ayoola, Nettleman, Stommel, & Canady, 2010). This is especially true for adolescent and unmarried mothers.

In the United States, about half of all pregnancies are unplanned and at least three out of four young, or unmarried, not cohabitating mothers have an unplanned pregnancy (Finer & Zolna, 2016). These are significant statistics because up to 6% of the total live births in the United States are attributed to teenage mothers, and about 40% to unmarried mothers (Martin, Hamilton, Osterman, Driscoll, & Mathews, 2017). Unplanned pregnancy is also more common among women from minority racial/ethnic groups (Finer & Henshaw, 2006). In a study conducted by Cheng and colleagues (2009) using the Maryland PRAMS data from 2001–2006, it was found that women who had an unwanted

pregnancy were less likely to initiate prenatal care during the first trimester than those who planned their pregnancy. Similar findings have been found in many other studies (Joyce, Kaestner, & Korenman, 2000; Korenman, Kaestner, & Joyce, 2002; Kost & Lindberg, 2015). A plausible explanation for these findings is that women who intend to become pregnant are likely to recognize pregnancy early because of their anticipation of the pregnancy and, thus, make behavioral changes in the first months of pregnancy. Another explanation is that women with an unplanned pregnancy, especially those with an unwanted pregnancy, may delay initiation of prenatal care while considering discontinuation of the pregnancy.

Prenatal care utilization is also influenced by maternal health beliefs. The Health Belief Model (HBM) contains several concepts that explain why a pregnant woman may take actions to prevent adverse outcomes: *perceived susceptibility*, *perceived severity*, *perceived benefits*, *perceived barriers*, *self-efficacy*, and *cues to action* (Champion & Skinner, 2008). Essentially, a pregnant woman will utilize prenatal care if she perceives the threats that her pregnancy could end in an adverse pregnancy outcome, perceives the severity of the adverse pregnancy outcome before it occurs, believes that prenatal care will reduce her perceived threats, perceives that the benefits of prenatal care outweigh her perceived barriers to utilizing prenatal care, and feels competent to overcome those barriers. Environmental, family, or public cues may serve as triggering mechanisms that make utilization of prenatal care necessary and appealing.

Some investigators have applied the HBM to examine how psychosocial factors may influence utilization of prenatal care. Zweig, LeFevre and Kruse (1988) examined the relationships between the constructs of the HBM and prenatal care utilization among 385 married women in Callaway County, Missouri. They found that women who perceived they were susceptible to potential problems during pregnancy and also perceived the problem to be severe were more likely to adequately utilize prenatal

care. Byrd, Mullen, Selwyn and Lorimor (1996) used data obtained from the interview of women in the postpartum unit of a public hospital in Houston and found that perceiving benefits of prenatal care for the baby was associated with early initiation of care among low-income Hispanic women.

By far, the construct that is most often mentioned by mothers as a reason for their inadequate prenatal care utilization is *perceived barriers* (Byrd, Mullen, Selwyn, & Lorimor, 1996; Leatherman, Blackburn, & Davidhizar, 1990; Mikhail & Curry, 1999). Besides lack of health insurance coverage, inadequate family support, transportation problems, lack of child care for existing children, and health system barriers are common barriers to adequate prenatal care utilization. Attitudinal barriers that are often mentioned as reasons for inadequate utilization of prenatal care include ambivalence, denial or concealment of pregnancy as a result of unintended or unwanted pregnancy (Young, Mcmahon, Bowman, Thompson, & Douglas, 1989; Braveman, Marchi, Egerter, Pearl, & Neuhaus, 2000), and fear related to use of prenatal care. The Institute of Medicine (Brown, 1988) mentioned at least four types of fear related to use of prenatal care: fear of providers or medical procedures (Byrd, Mullen, Selwyn, & Lorimor, 1996; Rogers & Schiff, 1996; Teagle & Brindis, 1998), fear of others' reactions to the pregnancy (Young, Mcmahon, Bowman, & Thompson, 1989), fear that one's illegal status in the country will be discovered (Berk & Schur, 2001), and fear that health-compromising habits such as smoking or substance abuse will be uncovered during prenatal care (Mikhail & Curry, 1999).

Besides maternal health beliefs, maternal health behaviors related to social lifestyle choices have been associated with inadequate prenatal care utilization. Substance use during pregnancy has been associated with poor prenatal care-seeking behavior. Pregnant women who excessively consume alcohol or use illicit drugs may delay initiation of prenatal care or have only a few prenatal care visits because they are often impaired by their poor psychosocial conditions and unstable living arrangements

(Brady, Visscher, Feder, & Burns, 2003; Funkhouser, Butz, Feng, McCaul, & Rosenstein, 1993; Hankin, McCaul, Heussner, 2000; Schempf & Strobino, 2009; Wu et al., 2013).

3.3.1.2 Individual-level enabling factors

Individual-level enabling factors for utilization of prenatal care include personal/household income, health insurance status, and maternal social support and network. Poverty is one of the most important correlates of inadequate prenatal care utilization. The rate of inadequate prenatal care utilization among women with household incomes below the federal poverty level is higher the rate among those with higher incomes. There are few studies that specifically examine the direct association between personal/household income and adequate use of prenatal care (Braveman, Egerter, Cubbin, & Marchi, 2004; Singh, Torres, & Forrest, 1985). Most studies rely on health insurance status as a measure of the ability of women to afford the costs of prenatal care. Some, however, consider income as a confounding variable when examining other determinants of prenatal care utilization (Frisbie, Echevarria, & Humme, 2001). It is plausible that income has a direct association with the use of prenatal care independent of insurance status, especially when consideration is given to financial needs related to transportation to the site of care and/or paying for child support to attend care (Braveman, Egerter, Cubbin, & Marchi, 2004; Frisbie, Echevarria, & Humme, 2001).

Like personal/household income, the health insurance status of a woman before and during pregnancy may influence how she utilizes prenatal care. As a major effort of the United States Congress to increase access to prenatal care, there was a series of expansions of Medicaid eligibility in favor of pregnant women beginning in 1986 (Hill, 1992). Although there have been improvements in the proportion of pregnant women that receive prenatal care since these expansions (Hessol, Vittinghoff, & Fuentes-Afflick, 2004; Howell, 2001; Rittenhouse, Braveman, & Marchi, 2003), pregnant women with Medicaid coverage are more likely to initiate prenatal care late or receive inadequate care than those

with private health insurance (Oberg, Lia-Hoagberg, Skovholt, Hodkinson, & Vanman, 1991; Perloff & Jaffee, 1999). However, they are more likely to adequately utilize prenatal care than those without any health insurance (Marín et al., 2009; Ayoola, Nettleman, Stommel, & Canady, 2010).

Not knowing that one is eligible for Medicaid during pregnancy may explain why some low-income mothers do not initiate prenatal care early compared to women with private health insurance. (Rosenberg, Handler, Rankin, Zimbeck, & Adams, 2007). Moreover, women with only Medicaid coverage during pregnancy may rely more on clinic settings for their prenatal care than those with private insurance (Cohen & Coco, 2009; Uddin, Simon & Myrick, 2014). In many communities, such clinics are often overburdened and getting an appointment at the right time may be very difficult (Cohen & Coco, 2009). Furthermore, women who rely solely on Medicaid may not be able to get a prenatal care appointment early in pregnancy because of difficulties in finding a provider that accepts public health insurance (Gifford, 1997; Meyer et al., 2016).

The observed differences in prenatal care utilization between women with Medicaid coverage and those with private insurance may actually be due to the differences in their socio-demographic characteristics. Another important methodological issue with respect to differences in prenatal utilization between mothers with Medicaid coverage and those with no health insurance is related to misclassification bias. A mother may be categorized to have used Medicaid during pregnancy when in fact she received her coverage just to pay for her delivery. This may undermine the true effect of Medicaid on prenatal care utilization.

Besides the support from her baby's father, a pregnant woman may also receive support from her family members or social networks. However, the latter form of support appears to be much less influential on prenatal care utilization than support from the baby's father (Schaffer & Lia-Hoagberg 1997; Zambrana, Dunkel-Schetter, & Scrimshaw, 1991). Many studies have found a significant

association between paternal support and prenatal care utilization (Giblin, Poland, & Ager, 1990; Schaffer & Lia-Hoagberg 1997; Zambrana, Dunkel-Schetter, & Scrimshaw, 1991). The three types of social support that are often examined in research related to prenatal care utilization are emotional support, informational support, and instrumental or tangible support. Emotional support is essential to overcoming the psychosocial stress associated with pregnancy and receiving prenatal care (Nepal, Banerjee, & Perry, 2011; Rini, Schetter, Hobel, Glynn & Sandman, 2006). Information sharing between a pregnant woman and her baby's father, family members or significant others within her social network may influence how she perceives the social norm about pregnancy and prenatal care (Lapinski, Anderson, Cruz & Lapine, 2015). Informational support is also relevant to the decision-making process of selecting the appropriate site of care and overcoming the barriers in the health care delivery system. Instrumental support can be helpful in paying for prenatal care services and having someone to look after existing children during prenatal care visits.

Each of the three forms of social support has the potential to influence prenatal care utilization. However, only a few studies have specifically examined the association between maternal social support or networks and prenatal care utilization. St Clair, Smeriglio, Alexander and Celentano (1989) examined the influence of social networks on the use of prenatal care in a sample of 185 low-income, inner-city, maternity patients in Baltimore, Maryland. They found that women who had large networks of friends and relatives were more likely to receive adequate prenatal care than those embedded in strong-tie, non-disperse networks where most members were immediate family and relatives.

3.3.1.3 Individual-level need factors

Maternal need for prenatal care may be considered as *perceived need* or *evaluated need*. *Perceived need* is related to *perceived threats*, *perceived susceptibility* and *perceived benefit,* which are already discussed in this dissertation under maternal health beliefs and behaviors. *Perceived need* and

evaluated need are closely related as conditions that are often perceived as threats by pregnant women are usually evaluated by prenatal care providers as potential risks that may complicate pregnancy. In the literature, common *evaluated needs* that have been investigated with respect to prenatal care utilization include parity; multiple gestation; history of adverse pregnancy outcomes such as preterm birth; and pre-existing or detected medical conditions that may complicate pregnancy, especially hypertension and diabetes mellitus.

Studies have consistently shown that as the number of previous live birth increases, the probability that a woman will receive late or no care generally increases (Ayoola, Nettleman, Stommel, & Canady, 2010; Brown, 1988; Lewis, Mathews, & Heuser, 1996). Women with two or more children are less likely to receive late or no prenatal care when they are pregnant than those having their first or second pregnancy. Besides the fact that prenatal care providers generally view multiparous women as low-risk relative to primigravida (women with their first pregnancy), possible explanations for the pattern of prenatal care utilization include the increasing confidence that a woman has with increasing number of successful pregnancy, and the problems related to getting child care for existing children to attend prenatal care visits.

Most prenatal care providers, if not all, consider multiple gestations to be high risk. Therefore, they recommend additional prenatal care visits for women with multiple gestations. Lauderdale, VanderWeele, Siddique and Lantos (2010) used data obtained from the 2004 natality files to examine the characteristics of women who had “super-adequate” care (modified *adequate-plus* category of the Adequacy of Prenatal Care Index). The investigators found the odds of receiving super-adequate care for mothers with twin or higher-order multiple gestations to be much higher than for mothers with singleton gestations, after controlling for socio-demographic variables (OR=4.93, 95% CI: 4.85–5.02 for twin; OR= 12.65, 95% CI: 11.20–14.29 for triplet or more).

Besides multiple gestations, prenatal care providers may also recommend higher than routine number of prenatal visits for women with medical risks that may complicate pregnancy. Using data extracted from records maintained by the University of Florida between 1987 and 1994, Clarke, Miller, Albrecht, Frentzen and Cruz (1999) found that women who had late antepartum conditions including hypertension problems had significantly higher odds of receiving adequate-plus care, relative to adequate care. Another category of risk that may be identified during pregnancy is psychosocial risk. Contrary to expectations, these women appear to be more likely to underutilize prenatal care than to have care beyond routine recommendations (Krans, Davis, & Palladino, 2013; Krans, Moloci, Housey, & Davis, 2014). The reasons for this include lack of standardized instruments for assessing psychosocial risk, and the belief by some care providers that addressing psychosocial risks does not improve pregnancy outcomes (Martikainen, Bartley, & Lahelma, 2002).

3.3.2 Prenatal care: health policy and organization

3.3.2.1 Maternal health policy

While many low-income women benefit from Medicaid, there is still a considerable proportion of women without health insurance during pregnancy. National data show that 32% of pregnant women have unstable or no health insurance coverage from the month before pregnancy to the time of delivery (D'Angelo et al., 2016). Lack of health insurance in the months preceding pregnancy can be a barrier to adequate utilization of prenatal care (Rosenberg, Handler, Rankin, Zimbeck, & Adams, 2007). Some women may not be eligible for Medicaid coverage based on the fact that their income is marginally above the poverty level limit set for coverage. Maternal and Child Health policies at both the federal and state government level in the United States do not assure universal and continuous access to health insurance and health care for pregnant women.

Besides the US government's inability/unwillingness to provide universal and continuous health insurance coverage to all women of reproductive age, another major problem is not making prenatal care services available and accessible to all pregnant women. A study that examined the relationship between prenatal care utilization and density of prenatal clinics showed that women who had a higher density of clinics in their neighborhood have a lower risk of late or no prenatal care during pregnancy (McLafferty & Grady, 2004).

Situational factors that are often mentioned by low-income women as reasons for inadequate prenatal care utilization include problems with transportation and child care (Lia-Hoagberg, 1990; Mikhail & Curry, 1999; Braveman, Marchi, Egerter, Pearl, & Neuhaus, 2000). If there are no child care services within a reasonable distance from maternity care, and no family member or friend is available to provide child care while a woman attends her scheduled prenatal visit, the burden of child care may outweigh the perceived benefits of receiving care. Prioritizing location of maternity care to reflect the socio-demographic factors of women most in need and providing access to transportation and child care for low-income women are potential ways to eliminate these problems (Braveman, Marchi, Egerter, Pearl, & Neuhaus, 2000; McLafferty & Grady, 2004).

3.3.2.2 Organization of prenatal care

Poorly organized prenatal care may be a deterrent to adequate utilization. Factors such as delay in getting prenatal care appointments, limited clinic hours, long waiting time at the clinic, and poor patient-provider interactions are commonly cited reasons why some women do not have adequate prenatal care (Teagle and Brindis, 1998; Roberts et al., 1998; Johnson et al., 2007; Handler, Rosenberg, Raube, & Kelley, 1998). Use of prenatal care can also be influenced by the attitudes and styles of prenatal care providers (Lori, Yi, & Martyn, 2011; Shaffer, 2002; Tandon, Parillo, & Keefer, 2005; Salm-Ward, Mazul, Ngui, Bridgewater, & Harley, 2013).

In a descriptive qualitative study, Salm-Ward and colleagues (2013) examined the perceptions of prenatal care experiences among African-American women living in a low-income Milwaukee neighborhood and documented that women perceived many provider practices and personal interactions during prenatal care as discriminatory. For Hispanic mothers, language and cultural issues are other major factors that result in poor patient-provider interactions (Shaffer 2002; Tandon, Parillo and Keefer (2005). As discussed above, the implicit bias held by prenatal care providers towards pregnant women from minority racial/ethnic groups may be mediated through unfavorable patient-provider interactions that impede their adequate utilization of prenatal care (Cooper et al., 2012; Hall et al., 2015).

Standardized instruments have been used to measure women's perception of satisfaction with prenatal care in both retrospective (Higgins, Murray, & Williams, 1994; Moore & Hepworth, 1994) and prospective quantitative studies (Handler, Rosenberg, Raube, & Lyons, 2003). While some of these investigators found a significant association between satisfaction and use of care (Higgins, Murray, & Williams, 1994; Moore & Hepworth, 1994) others did not (Handler, Rosenberg, Raube, & Lyons, 2003). The difference in the findings of these studies may be due to the difference in their study methodology with respect to the sampling techniques and the instruments used to measure satisfaction.

3.3.3 Neighborhood-level determinants of prenatal care utilization

Although the effect of the neighborhood in which one lives on health has long been observed, systematic approaches to quantify the independent effect of social, physical and environmental contexts of neighborhood on health outcomes and behaviors began only in recent times (Oakes, Andrade, Biyoow, & Cowan, 2015). In the literature, there are many reviews of studies that have examined the relationship between neighborhood factors and health outcomes such as obesity (Feng, Glass, Curriero, Stewart, & Schwartz, 2010; Papas et al., 2007), mental health (Kim, 2008; Mair, Roux, & Galea, 2008;

Truong & Ma 2006) and adverse pregnancy outcomes (Metcalfe, Lail, Ghali, & Sauve, 2011; Ncube, Enquobahrie, Albert, Herrick, & Burke, 2016; Vos, Posthumus, Bonsel, Steegers, & Denktaş, 2014), and health behaviors such as physical activity and dietary habits (Bancroft et al., 2015; Casagrande et al. 2009). However, the literature on the influence of neighborhood characteristics on utilization of healthcare services is sparse (Hussein, Roux, & Field, 2016; Kirby & Kaneda, 2005; Prentice, 2006). Therefore, it is not surprising that there are not extensive studies on neighborhood-level determinants of prenatal care utilization compared to those focused on individual-level determinants.

The neighborhood social contexts examined in this dissertation include neighborhood socioeconomic indicators, violent crime, community racial/ethnic composition, and racial residential segregation. In the literature, only a few studies have examined the association between neighborhood socioeconomic indicators and prenatal care utilization (Braveman, Egerter, Cubbin, & Marchi, 2004; Charreire & Combier, 2009; Cubbin et al., 2008; Daoud et al., 2015; Kieffer, Alexander, & Mor, 1992; McLafferty & Grady, 2004; Perloff & Jaffee, 1999; Shoff, Chen, & Yang, 2014; Shoff, Yang, & Matthews, 2012). A few of these studies also examined the association between racial/ethnic composition and prenatal care utilization (Kieffer, Alexander, & Mor, 1992; Shoff, Chen, & Yang, 2014; Shoff, Yang, & Matthews, 2012). However, there are no published studies that have assessed the relationship between racial residential segregation or neighborhood violent crime rate and prenatal care utilization.

One of the earliest studies that focused on the relationship between neighborhood factors and prenatal care utilization was conducted by Kieffer, Alexander and More (1992). They examined area-level predictors of variations in the use of prenatal care services using census tract as the unit of analysis, an ecological study. Their study showed that area-level socioeconomic indicators predicted 61% of the variation in the percentages of inadequate use of prenatal care across census tracts. Among

the area-level variables examined, level of education, percent racial/ethnic composition, and percent of mothers at high age-for-parity risk were significant predictors of inadequate prenatal care.

In a cross-sectional study of 220,694 births in New York City between 1991 and 1992, Perloff and Jaffee (1999) examined individual and neighborhood factors associated with late entry into prenatal care. Neighborhood contextual factors were operationalized as *economic opportunity structure* and *health care opportunity structure.* A series of multivariable regression models was generated to identify factors most strongly related to late entry into prenatal care and to ascertain the relative influence of the individual- and neighborhood-level factors on initiation of prenatal care. After controlling for individual-level factors, the investigators found that 15% of New York City's pregnant women started prenatal care late and that residence in a neighborhood with a limited economic or health care opportunity structure significantly increased the risk of late initiation of prenatal care. A major flaw of this study, however, was that the investigators did not account for within-group correlation in their multilevel model (Raudenbush & Bryk, 2002). In addition, one of the two neighborhood contexts, *economic opportunity structure,* was an overly summarized variable that has limited practical usefulness with respect to intervention at the policy level.

Braveman, Egerter, Cubbin and Marchi (2004) examined the relationship between neighborhood poverty and late/no prenatal care among California women using data obtained from the 1999–2001 Maternal and Infant Health Assessment (MIHA) survey and the 1994–1995 Access to Maternity Care (ATM) survey. Using multivariable regression analysis that accounted for the effects of the clustered survey sampling design, the investigators found that women who lived in poor neighborhoods were more likely to have delayed or no prenatal care than those who lived in neighborhoods that were not poor. Although the investigators adjusted for many confounding variables including socio-demographic, health insurance status, maternal attitudes, and maternal behaviors

(smoking and alcohol use), the study was limited to one measure of neighborhood context. In addition, the authors did not use the appropriate statistical techniques for regression models that include both individual- and neighborhood-level variables.

In another study, Cubbin and colleagues (2008) made use of PRAMS data from 1997–1998 in Washington and Florida linked to 2000 census tract-level data to examine the association between prenatal care utilization and neighborhood-level socioeconomic contexts using the Townsend Material Deprivation Index (Townsend, Phillimore, & Beattie 1988). A multivariable regression model that accounted for the survey design effects was used in their analysis. The study showed a significant association between the neighborhood deprivation index and late/no prenatal care only among women in Washington. Stratified analysis by race/ethnicity yielded an unexpected result. In Florida, African-American women in low-deprivation neighborhoods had higher odds of late/no prenatal care than those in moderate-deprivation neighborhoods. In Washington, however, living in high-deprivation neighborhoods was associated with increased odds of late/no prenatal care among whites.

A major methodological issue with this study is the large gap between the time the neighborhood-level socioeconomic index and prenatal care utilization were measured, which was at least 2 years. Like the studies by Perloff and Jaffee (1999) and Braveman et al. (2004), the investigators did not account for intra-group correlation in their analysis. Moreover, the four components of the Townsend Material Deprivation Index (proportion of crowded occupied housing units, renter-occupied housing units, occupied housing units without a motor vehicle, and unemployed persons in the civilian labor force) do not appear to capture other important constructs of neighborhood-level socioeconomic indicators including per capita income and education.

An innovative approach to the relationship between place and health that is gaining momentum in the last two decades is the use of Geographical Information Systems (GIS). They can be used for

visualization and mapping, and for spatial analysis of health-related data (Cromley & McLafferty, 2012). While there are many studies that have used GIS tools to examine spatial distribution of health outcomes, including adverse pregnancy outcomes (Anthopolos, James, Gelfand, & Miranda, 2011; Byrnes, 2015; South, 2012), only a very few studies have used these tools to map prenatal care utilization and analyze the determinants of PNC use at the neighborhood level (Charreire & Combier, 2009; McLafferty & Grady, 2004; Shoff, Yang, & Matthews, 2012; Shoff, Chen, & Yang, 2014).

McLafferty and Grady (2004) used GIS analysis to examine the association between prenatal clinic density and prenatal care utilization in Brooklyn, New York. Geocoded clinic density data obtained using kernel estimation method were linked with birth file data based on the mother's census tract of residence. Their study showed young maternal age, Black racial/ethnicity and low level of education to be associated with increased risk of late/no prenatal care among the study population. Moreover, women who had a higher density of clinics in their neighborhood had a lower risk of starting prenatal care late or not obtaining care at all.

In another study, Charreire and Combier (2009) examined the relationship between neighborhood deprivation and prenatal care utilization among 30,338 mothers who received prenatal care in a highly urbanized French district (Seine-Saint-Denis) using linked data from three sources: 1999–2001 health certificates (for prenatal care data), the 1999 national population census (for neighborhood data), and the national reference file on health professionals (for geographical location of healthcare services). Prenatal care was defined to be poor when initiated in the last 3 months of pregnancy or when there were fewer than four prenatal care visits during pregnancy. A neighborhood deprivation index was created from a *social deprivation index* (single parenting, no higher education, percent foreign population, unemployment, and no car ownership) and a *housing deprivation index* (house built before 1949, and toilets outside residence). The authors found significant spatial correlation between the

neighborhood deprivation index and poor prenatal care utilization (Moran's *I* statistic=0.024; $p< 0.05$); they also found spatial disparities in the use of prenatal care using cluster analysis.

Geographical Information Systems tools can also be used to test for associations between spatial attributes. Conventional statistical methods such as ordinary least squares regression and multilevel regression analysis produce *global* statistics for making inference. These methods assume that the relationships between variables are stationary (constant) across the study area. Geographical weighted regression (GWR) is an innovative statistical method that controls for local variations in the relationships between variables over space within a single modeling framework (Brunsdon, Fotheringham, & Charlton, 1996; Fotheringham, Brunsdon, & Charlton, 2002). It is more suited for analyzing spatial data because it controls for spatial heterogeneity (non-stationarity) and can also be specified to control for spatial dependence due to spatial lag/homogeneity. Spatial heterogeneity is variation in the effect of a variable on another variable across spatial units while spatial dependence refers to the correlation between spatially referenced data across spatial units (Anselin & Getis, 2010). Spatial homogeneity is a form of spatial dependence where nearby locations have propensity to influence each other and possess similar attributes (Goodchild, 1992).

The use of GWR in healthcare research is novel (Bagheri, Holt, & Benwell, 2009; Comber, Brunson, Radburn, 2011; Shah & Bell, 2013; Shoff, Yang, & Matthews, 2012) and only a few studies have applied it to prenatal care utilization (Shoff, Yang, & Matthews, 2012). Using geographically weighted regression, Shoff, Yang and Mathews (2012) examined the local variations in the effects of county-level measures of health insurance status, availability of prenatal care providers, and female socioeconomic status on prenatal care utilization in the United States. Their study showed local variations in the effects of all the county-level measures on prenatal care utilization except availability of prenatal care providers.

While geographically weighted regression (GWR) accounts for spatial homogeneity and heterogeneity, this method does not, as it is generally used, include measures of the effects of individual-level characteristics in its models. Multilevel regression addresses this problem by accounting for the influence of individual-level characteristics in the estimation of the contextual effects of neighborhood on a health outcome or behavior (Oakes, Andrade, Biyoow, & Cowan, 2015), while controlling for within-group correlation (non-independence) inherent in multilevel data (Raudenbush & Bryk, 2002). However, multilevel regression does not account for spatial dependence and spatial heterogeneity of neighborhood contexts (Anselin & Getis, 2010). Given the different advantages of the two approaches to neighborhood studies, researchers are beginning to integrate multilevel analyses techniques with spatial regression analysis to address the problem of restricting analysis to ecological level while accounting for spatial dependency and spatial heterogeneity (Chaix, Merlo, & Chauvin, 2005; Chen & Truong, 2012; Dong & Harris, 2015).

Neighborhood violent crime has been found to be associated with some health outcomes including adverse pregnancy outcomes (Collins & David, 1996; Messer, Kaufman, Dole, Herring, & Laraia, 2006: Messer, Kaufman, Dole, Savitz, & Laraia, 2006; Morenoff, 2003; O'campo, Xue, Wang, & Caughy, 1997). However, to date, there is no published study of the role of neighborhood violent crime in prenatal care utilization. The reason for this may be due to the fact that violent crime data are not readily accessible; in addition, when these data are available, there may be insufficient information to link the data with relevant maternal characteristics to examine the effect of neighborhood violent crime on prenatal care utilization.

There are strong theoretical reasons to believe that violent crime may influence health outcomes and behavior. Research on exposure to violent crime among children and adolescents has shown that repeated encounters with violence (both direct and indirect) can lead to development of

emotional problems, substance use, and increasing pessimism in one's own ability and in the ability of health professionals to improve health (Fick & Thomas, 1995). Neighborhood violent crime may also affect an individual's willingness to leave her home to seek health care because of perceived likelihood of being a victim of crime or emotional response to the possibility of crime (Lorenc et al., 2012).

Recent evidence suggests that the geographic distribution of health care resources often follows the spatial distribution of racial/ethnic groups. Two neighborhood characteristics that are related to racial/ethnic group distribution are neighborhood racial/ethnic composition and racial residential segregation. Although they are closely related, they measure different concepts. Racial/ethnic composition simply measures the frequency distribution of the different racial/ethnic groups in a defined geographical location. However, racial residential segregation refers to the degree to which the members of two or more racial/ethnic groups live separately from one another within a defined geographical location (Massey & Denton, 1988). In one study, the correlation between racial/ethnic composition and racial residential segregation ranged between 0.06 and 0.28 (Mellor & Milyo, 2004).

Racial residential segregation has been regarded as a fundamental cause of racial disparities in health (White, Haas, & Williams, 2012; Williams & Collins, 2001). At the individual-level, educational and employment opportunities are shaped by racial residential segregation. Also, the socioeconomic, physical, and environmental contexts of neighborhoods are largely determined by racial residential segregation (White, Haas, & Williams, 2012). Consequently, the causes of racial disparities in health and in health care utilization, especially between African-Americans and white Americans, may be rooted in racial residential segregation. Limited educational and employment opportunities and high concentrations of poverty that characterize segregated neighborhoods can hinder the ability of residents in these communities to adequately utilize healthcare services independent of individual-level characteristics (Gaskin, Dinwiddie, Chan, & McCleary,2012; Kirby & Kaneda 2005).

In addition, studies have shown that the hospitals in African-American neighborhoods have fewer technological resources, higher medical negligence, and are less likely to have physicians who are board certified than the hospitals in white American neighborhoods (Bach, Pham, Schrag, Tate, & Hargraves, 2004; Nelson, 2002). The mechanisms relating residential segregation to racial disparities in health care utilization have been described in the literature (Vaughan-Sarrazin, Campbell, Richardson & Rosenthal, 2009; White, Haas, & Williams, 2012). The conceptual framework developed by White, Haas and Williams (2012) illustrates the mechanisms through which racial residential segregation shapes healthcare system infrastructure, neighborhood socioeconomic, physical and environmental contexts, and individual-level characteristics to influence health care access, utilization, and quality of health care services across the life course.

Given its fundamental role in racial disparities in health care utilization, studies on racial residential segregation require accurate specification of the pathways that link it to utilization of healthcare services. This is essential as many neighborhood-level factors may mediate the effect of racial residential segregation on health services use (Vaughan-Sarrazin, Campbell, Richardson, & Rosenthal, 2009; White, Haas, & Williams, 2012). In the literature, residential segregation has been found to be related to neighborhood socioeconomic indicators (Massey, 2016; Massey & Fischer, 2000; Quillian, 2012), violent crime (Peterson & Krivo, 2005; Shihadeh & Flynn, 1996), and health service utilization (Gaskin, Dinwiddie, Chan, & McCleary, 2012). Therefore, it is possible that the effect of racial residential segregation on prenatal care utilization is mediated through these neighborhood characteristics. To the extent that the effect of racial residential segregation on a health outcome/behavior is hypothesized to be mediated through multiple variables, its residual or direct effect on the outcome can be measured (Acevedo-Garcia & Lochner, 2003).

There are five dimensions of racial residential segregation that have been described in the literature: exposure, evenness, concentration, centralization and clustering (Massey & Denton, 1988). Exposure and evenness are the two most often used dimensions of racial residential segregation, and they do not require specific spatial information such as geographical area dimensions and/or coordinates in their estimation. Exposure and evenness were considered as the measure of racial residential segregation for this dissertation because they are conceptually more relevant to the study objectives than the other dimensions of racial residential segregation. Exposure is a measure of the extent to which a member of a racial/ethnic group is likely to be in contact with other members of the same racial/ethnic group (isolation), or of a different racial/ethnic group (interaction) in a defined geographical place, while evenness is a measure of dissimilarity in racial distribution across the geographical units of a place (Massey & Denton, 1988).

Residential segregation studies generally use metropolitan statistical areas (MSAs) as the macro-unit of analysis for assessing the effect of racial residential segregation on health. This is largely because MSAs often reflect housing and labor markets that are regarded to be responsible for racial residential segregation and neighborhood inequality (Osypuk & Acevedo-Garcia, 2010). Although formal measures of racial residential segregation are often used for macro-units including city and county, and proxy measures used for smaller macro-units such as census tract and zip-code (White & Borrell 2011), the choice of unit of analysis to measure racial residential segregation should be directed by the theoretical framework guiding the study objectives (Diez-Roux & Mair, 2010). A formal measure of residential segregation has been used for unit that is as small as census tract (Grady, 2006), zip-code (Acevedo-Garcia, 2001; Dai, 2010), and community-area (Guest, Almgren, & Hussey, 1998) in the literature.

Racial/ethnic composition is sometimes used as a proxy measure of racial residential segregation in the literature; however, it does not completely reflect the social processes and dynamics

of racial inequality, or the geographic/spatial interaction patterns between racial/ethnic groups (Williams & Collins, 2001; White & Borrell, 2011). Nevertheless, racial/ethnic composition is useful when the focus is on an individual's experience of exposure to members of another racial/ethnic group, rather than the exposure of a racial/ethnic group to another racial/ethnic group. This can be easily conceptualized if an individual is regarded as a unit rather than a member of a larger unit of individuals of the same racial/ethnic group. *Actual* individual experience, in contrast to *average* individual experience, of neighborhood racial/ethnic environment has been used to highlight this difference (Mason, Messer, Laraia, & Mendola, 2009).

In addition, racial/ethnic composition can be used to categorize neighborhoods based on their majority racial/ethnic group in order to examine effect modification of the association between an exposure and a health outcome or behavior by neighborhood racial/ethnic context (Gaskin, Dinwiddie, Chan, McCleary, 2012; Inagami et al., 2006). Using a measure of residential segregation for grouping may not be as straightforward when the research interest focuses on more than two racial/ethnic groups. This is because most measures of racial residential segregation are estimated with respect to only two racial/ethnic groups (White, 1986). While evenness can be measured with respect to two racial/ethnic groups (dissimilarity index), or more than two groups (entropy index), measures of exposure, in their typical use, are limited to only two racial/ethnic groups (Massey & Denton, 1988; White, 1986).

Using data from the 2006 Medical Expenditure Panel Survey and the 2000 US Census, Gaskin, Dinwiddie, Chan and McCleary (2012) examined race/ethnic disparities in health care use with respect to place of residence. Neighborhood was defined by ZIP-code to classify place of residence into four groups by their predominant racial/ethnic group. They found disparities in health care utilization with respect to race/ethnicity and racial/ethnic composition of place of residence. In addition, they also

found that residents in Hispanic neighborhoods, irrespective of race, had lower levels of health care use than the residents of other neighborhoods. However, their study methodology did not allow for explicit assessment of the influence of place of residence on racial disparities in health care use, and the difference in health care use among members of the same racial/ethnic group living in different neighborhoods that differ by race/ethnic composition.

In the literature, most studies on racial residential segregation have focused on its detrimental effects on neighborhood and individual-level characteristics, especially among African-Americans. However, racial residential segregation can also be viewed in terms of social networks and supportive communities, with the potential to mitigate the detrimental impact of racial discrimination on the health of the minority racial/ethnic groups (Bécares, Nazroo, & Stafford, 2009). The data from the Black Women's Health Study collected from 42,445 United States Black women during the 1997 follow-up wave showed a linear inverse relationship between neighborhood percent Black and perceived discrimination (Hunt, Wise, Jipguep, Cozier, & Rosenberg, 2007). Similar findings have been found in many other studies (Krysan & Farley, 2002; Oliver & Wong 2003). In a study conducted by Vogt-Yuan (2007), it was found that living in a neighborhood where one's race/ethnic group is the majority improves emotional well-being for African-Americans and Hispanics, and social support explains part of the relationship for African-Americans.

Hutchinson and colleagues (2009) examined the relationship between neighborhood racial composition, social capital, and Non-Hispanic Black all-cause mortality between 1997 and 2000 in 68 Philadelphia neighborhoods. Neighborhood social capital was measured by a summative score of the likelihood of neighbors helping one another, a measure of the trust among neighbors, and a measure of sense of belonging. They found that neighborhoods with a higher social capital score had lower age-adjusted Non-Hispanic Black mortality; the lowest mortality rate was observed among those living in

high percent Non-Hispanic Black neighborhoods with high social capital. Thus, racial residential segregation may provide a structural barrier to interpersonal racial discrimination while fostering social cohesion, mutual social support, and a strong sense of community and belongingness (Bécares, Nazroo, & Stafford, 2009; Pickett & Wilkinson, 2008; Smaje, 1995).

3.4 Measurement and Methodological Issues

3.4.1 Prenatal care: measurement and methodological issues

Despite the widespread use of prenatal care, the evidence for its effectiveness remains equivocal, especially with respect to improving the rate of low birth weight and preterm birth (Alexander & Kotelchuck, 2001**;** Fiscella, 1995; Walford, Sonya, Wiencrot, & Lu, 2011). According to experts, prenatal care is likely to be effective if a woman initiates the care in the first trimester of her pregnancy and attends all the recommended prenatal care visits (AAP & ACOG, 2012; United States Public Health Service, 1989). The inability to establish the effectiveness of prenatal care has been related to the inadequacy of the current methods that are used to measure prenatal care utilization (Alexander & Kotelchuck, 2001**;** Walford, Sonya, Wiencrot, & Lu, 2011). The currently available methods for measuring prenatal care utilization focus solely on quantifying the use of care without reference to the content or quality of care (Alexander & Kotelchuck, 2001).

Historically, methods for assessing utilization of prenatal care evolved from determining whether a woman had any prenatal care during pregnancy or not, or initiated care in the first trimester of pregnancy without reference to the number of subsequent visits during pregnancy (Forrest & Singh, 1987). While the first prenatal care visit in the first trimester is considered very important for the initial assessment for socio-demographic, medical, and psychosocial risks, subsequent prenatal care visits are equally important for the identification of risks that may develop in the course of pregnancy (AAP &

ACOG, 2012; United States Public Health Service, 1989). In addition, researchers have long known that the number of subsequent visits is dependent on the gestational age at delivery (Terris & Glasser, 1974). To address these problems, at least four indices have been developed to measure utilization of prenatal care, each of which uses the month that care was initiated, and the total number of visits adjusted for the gestational age at delivery (Alexander & Cornely, 1987; Alexander & Kotelchuck, 1996; Kessner, Singer, Kalk, & Schlesinger, 1973; Kotelchuck, 1994).

The first recognized index of prenatal care utilization was developed by Kessner and colleagues (1973), an index commonly known as the three-factor health services utilization, Kessner's or IOM index. The index was designed to capture: 1) the month in which care is initiated; 2) the number of prenatal care visits; and 3) the type of obstetric service, while adjusting for gestational age at delivery. Kessner's index is no longer favored by many researchers because it relies heavily on the timing of initiation of prenatal care and does not follow the American College of Obstetrics and Gynecology's (ACOG) recommendation for term and post-term pregnancy. The index is restricted to only nine visits to delineate adequate care use, perhaps, because of the computer data capacity limitation in New York at that time (Kotelchuck, 1994).

Another index of prenatal care utilization, graduated index (GINDEX), was developed by Alexander and Cornelly (1987). The developers of GINDEX expanded the three categories of the Kessner's index (*adequate*, *intermediate*, and *inadequate*) to six categories (*no care*, *adequate*, *intermediate*, and *inadequate*, *intensive*, *missing*) to disaggregate women with missing data from the inadequate category, and those that received no care from the inadequate category. In addition, a new category, *intensive*, was created for women who had an unexpectedly large number of prenatal care visits given the month their prenatal care was started and their gestational age at delivery. However, the

GINDEX did not address the problem that restricted the number of visits to nine. Subsequently, the GINDEX was revised as Revised GINDEX (R-GINDEX) to address this issue (Alexander& Kotelchuck, 1996).

In 1994, Kotelchuck developed another index known as the Adequacy of Prenatal Care Utilization (APNCU) or Kotelchuck index. The APNCU index was developed independently and was not a modification of the Kessner or the R-GINDEX. The index has two major components or dimensions: 1) the Adequacy of Initiation of Prenatal Care based on the month in which prenatal care is initiated; and 2) the Adequacy of Received Services based on the number of visits from initiation of care until delivery, adjusted both for gestational age at delivery and time of entry into care. This index ultimately assigns women to one of four categories of prenatal care utilization: *inadequate*, *intermediate*, *adequate*, and *adequate-plus*. For the Adequacy of Initiation of Prenatal Care, the month in which care is initiated is grouped not based on the trimester of pregnancy, like Kessner's and the R-GINDEX, but on four levels of grouping: months 1-2, months 3-4, months 5-6, and months 7-9 which correspond to adequate-plus, adequate, intermediate, and inadequate, respectively. Women with no prenatal care are grouped into the inadequate care category for this dimension.

For the Adequacy of Received Services, the observed/expected (O/E) prenatal care visit ratio is used to group women into four categories. The expected number of visits is based on ACOG's recommendation for uncomplicated pregnancy, adjusted for the gestational age at initiation of prenatal care and at delivery. The ratio of observed to expected prenatal care visits is grouped as: *Inadequate* (less than 50% of expected visits), *Intermediate* (50–79%), *Adequate* (80–109%), and *Adequate-Plus* (≥ 110%). The two dimensions can be combined into a single summary, the adequacy of prenatal care utilization (APNCU) index (Kotelchuck, 1994). The advantages of the APCU index over the other indices are that its component indices can be used separately or together, and the observed/expected ratio can be used as a continuous variable and or regrouped to serve the purpose of research.

Major flaws common to all of these indices are that none reflects the content and quality of prenatal care, and none completely controls for the problem of gestational age bias (Alexander & Kotelchuck, 2001). These methodological problems with the measurement of prenatal care utilization partially explain why prenatal care has not been shown to be unequivocally effective in reducing adverse pregnancy outcomes.

Besides the methodological problems related to inadequacy of the currently available indices for measuring prenatal care utilization discussed above, other methodological issues are related to missing or inaccurate data, problems with completely correcting for gestational age, and selection bias. Missing data or inaccurate information on birth certificates are major problems in research related to prenatal care utilization. Measurement of prenatal care utilization depends not only on the month of initiation of care and the number of prenatal care visits but also on accurate estimation of gestational age at delivery. Most of the research on prenatal care utilization relies on secondary data analysis; therefore, it is often too late for investigators to ensure that all the information necessary for data analysis is accurate and complete.

In the National Vital Statistics Reports on data on the new birth certificates in the United States for the year 2008, 6.5% of the data were missing for the month in which prenatal care was initiated (Osterman, Martin, Mathews, & Hamilton, 2011). Many studies have shown that the number of visits recorded in birth certificates is either lower or higher than what is found in medical records, and that there is disagreement in the date of the last menstrual period (LMP) and the month prenatal care began between the two data sources (Clark, Fu, & Burnett, 1997; Dobie et al., 1998; Piper et al., 1993; Roohan et al., 2003). In these studies, percent complete agreement between data obtained from medical records and birth certificates ranged from 71–87% for last menstrual period; 31–70% for initiation of prenatal care visit in the first trimester; and 14–38% for total number of prenatal care visits.

Kurtzman and colleagues (2014) examined the extent to which missing prenatal care visit information in the last months of pregnancy affected the classification of prenatal care utilization among women who had singleton live birth between 2007 and 2011 in nine counties in New York. The investigators found that 42.4 percent of mothers would be reclassified from intermediate to adequate utilization of care if the expected number of visits used for Kotelchuck's Adequacy of Prenatal Care Utilization (APNCU) index was based on the date of the last reported prenatal care visit and the gestational age at that visit instead of the gestational age at delivery. They showed that the percentage of women with at least adequate care would increase, exceeding the Healthy People 2020 objective for prenatal care, if the method of classification of prenatal care utilization was based on the number of visits a woman completed up to her last recorded visit date rather than gestational age at delivery.

None of the currently available indices for measuring utilization of prenatal care completely adjusts for gestational age at delivery (Alexander & Kotelchuck, 2001). One of the commonly used methods for measuring utilization of prenatal care, the APNCU index (Kotelchuck, 1994) is based on the recommendations of the American College of Obstetrics and Gynecology (ACOG), and the American Academy of Pediatrics (AAP). The typical scheduled prenatal visits for uncomplicated first pregnancy recommended by the two professional associations is an initial visit in the first trimester, then visits every 4 weeks for the first 28 weeks of gestation, every 2 weeks until 36 weeks of gestation, and weekly thereafter (AAP & ACOG, 2012). However, the index assigns about one-third of the total number of prenatal care visits to the last 4–5 weeks of pregnancy. The caveat of the index is that a woman who had a preterm birth can easily be reclassified from *adequate* to *adequate plus* with just one additional prenatal visit. This would not be the case had the women had a term delivery. In essence, the shorter the gestational age at delivery, the fewer the number of expected visits, and the more sensitive is the observed/expected ratio to additional prenatal care visits (Kotelchuck, 2003). This has significant

implications in the interpretation of findings of the studies in which the index is used (Koroukian & Rimm, 2002; Lauderdale, VanderWeele, Siddique, & Lantos, 2010).

Selection bias is another major methodological issue in research related to prenatal care utilization (Bell & Zimmerman, 2003, Frick & Lantz, 1996). "There are differences in the ways that women seek and receive prenatal care that are not random and are not amenable to observation or measurement" (Frick & Lantz, 1996, p. 373). Four types of selection bias have been described in the literature: *favorable*, *adverse*, *confidence* and *estrangement* selection bias (Frick & Lantz, 1996). Some women might attend prenatal care more frequently than recommended because they perceive they are more susceptible to pregnancy complications than others (*favorable* selection); this is in contrast to those who attend prenatal care more frequently because they are actually at higher risk (poor medical or obstetric history) of pregnancy complications than others (*adverse* selection). There are also some women that do not attend prenatal care until very late in pregnancy because their perceived need for care is low (*confidence* selection); this is in contrast to those that do not receive adequate care in spite of their high risk for pregnancy complications (*estrangement* selection). These four types of selection bias are often not considered in studies related to prenatal care utilization despite their significant implications for the interpretations of study findings.

3.3.2 Neighborhood: measurement and methodological issues

In the literature, different terms have been used to describe the *place* where people live and its effect on health behaviors and outcomes. Common terns that have been used include *neighborhood*, *community,* and *area*. However, the most common term, by far, is *neighborhood*, which refers to a person's immediate residential environment, hypothesized to have both social and material characteristics relevant for health (Diez-Roux, 2001). Despite this appealing definition, defining the neighborhood boundary is a major problem that plagues research related to neighborhood contexts.

In addition, the dimensions of neighborhood are multifaceted; therefore, researchers have employed different measures to operationalize both neighborhood compositional and contextual factors. Some of the measures are a single neighborhood variable, especially percent poverty (Braveman, Egerter, Cubbin, & Marchi, 2004; Daoud et al., 2015), or a constructed variable that combines variables from multiple socio-demographic domains to create one or more indices for the purpose of the study (Perloff & Jaffee, 1999), which is often done without theoretical or analytical justification (Rajaratnam, Burke, & O'campo, 2006). A few researchers, however, have used standardized measures of neighborhood contexts (Cubbin et al., 2008). Some of the standardized measures are described below.

Twelve broad domains that have been used to characterize neighborhood contexts in the literature are population composition, housing, family structure, mobility, education, employment, occupation, income/wealth, social resources, deviant behavior, violence and crime, and physical conditions (Rajaratnam, Burke & O'campo, 2006). *Neighborhood deprivation* is a term with no standard definition used when a combination of these factors is utilized to measure neighborhood contexts. Common indices that have been used to measure neighborhood context include the Townsend Deprivation Index (Townsend, Phillimore, & Beattie 1988), Carstairs-Morris score (Carstairs & Morris, 1990), the Index of Multiple Deprivation (Noble et al., 2004), Jarman's score (Jarman, 1983), and the Neighborhood Deprivation Index (Messer et al., 2006). Of the listed indices, only the Neighborhood Deprivation Index was developed using United States population data.

The Neighborhood Deprivation Index was developed using data obtained from the 2000 United States Census and birth certificates of infants born between 1995 and 2001 in three urban areas (Philadelphia, Pennsylvania; Baltimore City, Maryland; and pooled data from 16 cities in Michigan), and five racially heterogeneous counties in Maryland and North Carolina. Variable selection was guided by

the findings of a literature review that identified seven domains of neighborhood characteristics that were consistently represented in the United States literature related to health outcomes (Rajaratnam, Burke & O'campo, 2006). The domains are housing, education, employment, occupation, poverty, residential stability, and racial/ethnic composition. Twenty aggregate variables (one for education, two for employment, five for housing, four for occupation, five for poverty, one for racial composition, and two for residential stability domain) were selected from the census data for principal component and factor analyses.

Of the 20 variables selected for analyses, eight (percent of crowded housing, percent of female headed households with dependents, percent of males in management and professional occupations, percent of households in poverty, percent of households on public assistance and households earning less than $30,000 per year- to estimate poverty, percent with less than a high school education, and percent unemployed) were retained for the index. Although only the first principal component was retained, the eight variables accounted for 51 to 73% of the total variability across the eight study areas. The index has been used to examine the relationship between neighborhood contexts and adverse pregnancy outcomes (Elo et al., 2009; O' Campo et al., 2008; Ma, 2015; Mason, Messer, Laraia, & Mendola, 2009).

Most of the indices designed to measure neighborhood factors rely on administrative data, especially census data. Census data include aggregate variables of individual characteristics such as education levels, income and poverty that are summarized for a particular census tract. Some researchers have argued that aggregate data are akin to compositional estimates of a neighborhood; therefore, they are limited in their ability to assess neighborhood contexts, especially the built environment (Dunstan et al., 2005; Laraia, 2006). To address this limitation, systematic social observations (SSO) of neighborhoods by trained outside raters is becoming a popular alternative

research strategy to measure neighborhood contexts, especially the built environment (Sampson & Raudenbush, 2004; Zenk et al., 2007). Although the method is appealing, methodological issues peculiar to this form of measurement include the bias towards the visible and readily identifiable neighborhood characteristics, observer bias, and the possibility of missing important neighborhood characteristics when observations are made at the wrong or only one or a few times of the day, week, or season (Schaefer-McDaniel, Dunn, Minian, & Katz, 2010).

Methodological issues in research related to neighborhood effects on health can be viewed as those related to: 1) neighborhood conceptualization with respect to defining the appropriate geographical boundary, and operationalizing neighborhood context; 2) the appropriate statistical analysis technique for modeling multilevel data; and 3) causal inference in neighborhood studies.

Studies of neighborhood effects on health vary in terms of the geographical boundary used to define the neighborhood. Often, researchers do not have a theoretical explanation for the boundary used. Even when there are existing theories that can be used to define the boundary, data are often not available for the relevant group of interest. Therefore, most studies rely on census data for neighborhood information. However, use of census data may be problematic. First, residents in a particular tract may not necessarily be aware of the tract boundary or may have a different subjective definition of what they regard as neighborhood (Coulton, Korbin, Chan, & Su, 2001). Second, the neighborhood context obtained from census data and assigned to an individual may not be the actual measure of the context experienced by that individual. Third, census data aggregate variables that are more related to compositional than contextual neighborhood factors.

Another methodological issue is the difference between the compositional and the contextual effects of neighborhood. Variables that reflect the characteristics of neighborhood have been classified into two basic types: aggregate or derived, and integral or global variables (Diez-Roux, 1998). Aggregate

variables summarize the characteristics of individuals in a neighborhood in the form of means, proportions, or measures of dispersion (for example, percent of adults with more than 12 years of education), while integral variables describe characteristics of the neighborhood that are not derived from individual-level characteristics of its residents (for example, level of infrastructure and built-environment).

Since compositional effects of a neighborhood are generally measures of aggregate variables, some researchers have argued that use of aggregate variables may not provide additional information beyond what can be obtained from the characteristics of the individuals that live in the neighborhood (Hauser, 1974; Farkas, 1974; Macintyre, Ellaway, & Cummins, 2002). However, the composition of a group may influence the predominant types of interpersonal contacts, norms, and values and, thus, capture neighborhood characteristics that are more than just mere summaries of individual characteristics, which can be operationalized as neighborhood contexts (Diez-Roux, 1998).

An appropriate, and in fact the most commonly used, statistical technique to tease out neighborhood contexts from the characteristics of the individuals in the neighborhood is multilevel regression analysis. By incorporating multiple levels of independent variables to model an individual-level health outcome or behavior, multilevel analysis allows researchers to examine the effects of macro- and micro-level variables as well as their interactions, while controlling for within-group interdependence (correlation) and avoiding the psychologistic and the sociologistic fallacies (Diez-Roux, 1998). The psychologistic fallacy is the assumption that an individual-level outcome can be explained exclusively in terms of individual-level characteristics while the sociologistic fallacy is committed when a researcher ignores the role of individual-level factors when examining the association between neighborhood-level factors and a health outcome or behavior (Diez-Roux, 1998).

Generally, two regression approaches are commonly used in the literature to account for the within-group correlation in multilevel data: multilevel regression models, also known as hierarchical, mixed, or random coefficient models (Stiratelli, Laird, & Ware, 1984; Wong & Mason, 1985; Greenland, 2000), and marginal regression models, also known as population average or generalized estimation equation (GEE) models (Liang & Zeger, 1986). The two approaches with respect to the research focus of interest, interpretation of regression coefficients, and sensitivity to misspecification of variance structure are discussed below.

Multilevel regression models involve explicit modeling and partitioning of the variance structure of the outcome within and between neighborhoods; therefore, they allow for the estimation of the individual-level variation, neighborhood heterogeneity (variance), and the proportion of the total variation attributable to variation between neighborhood (intra-class correlation). Therefore, a multilevel regression model approach to neighborhood effect studies allows researchers to examine how the associations between individual-level variables and a health outcome, or a health behavior vary across neighborhoods, in addition to quantifying the fixed effects of explanatory variables on the outcome within and between neighborhoods.

In contrast, marginal models involve modeling the outcome variable as a function of the explanatory variables without explicitly accounting for the heterogeneity across neighborhoods. The within-neighborhood correlation (neighborhood heterogeneity) is considered a nuisance; thus, the underlying random part of the model is ignored. Specifically, the within-neighborhood correlation in the multilevel data is taken into account by robust estimation of the variances of the regression coefficients. Therefore, when the *working correlation* structure that underlies the estimation from a marginal model is assumed to be independent, the estimated regression coefficients and their standard errors from the

model are equivalent to the parameter estimates that would be obtained from an ordinary regression model applied to the same multilevel data (Hu, Goldberg, Hedeker, Flay, & Pentz, 1998).

The choice of the appropriate approach to use for a given study largely depends on the study objectives (Heagerty & Zeger, 2000). While a mixed model provides unit-specific regression coefficient estimates, conditional on neighborhood random effects, a marginal model provides population-average estimates. Unit-specific regression coefficients from a mixed model may be used to estimate the effects of explanatory variables on the outcome of interest in a "typical" neighborhood (a neighborhood with random effect = 0), or by holding the neighborhood random effect constant. In contrast, population-average regression coefficients from a marginal model are used to estimate the effects of explanatory variables on the outcome that is based on averaging over neighborhood random effects (Raudenbush & Bryk, 2002).

Essentially, a marginal model is appropriate when the focus of research is estimating only the fixed effects of the relationship between the explanatory variables and the outcome, with no emphasis on neighborhood heterogeneity. Although population-average regression coefficients can be derived from a mixed model using the second-order Maclaurin series expansion (Raudenbush & Bryk, 2002), using a marginal model when the focus of research is estimating only the fixed effects is often the preferred approach. This is because the estimated regression coefficients from mixed models are more sensitive to the underlying distributional assumptions for the random effects than those estimated from marginal models (Heagerty & Zeger, 2000; Liang & Zeger, 1986). However, a mixed model is the appropriate approach when the focus of the research includes assessing the magnitude of neighborhood variations in addition to estimating the fixed effects of individual- and neighborhood-level variables on a health outcome or behavior (Larsen, Petersen, Budtz-Jørgensen, & Endahl, 2000; Larsen & Merlo, 2005; Merlo, Chaix, Yang, Lynch, & Råstam, 2005).

Fixed-slope, random-intercept multilevel regression models have been used to examine neighborhood effects on adverse pregnancy outcomes such as preterm birth (Messer et al., 2008; O'campo et al., 2008), low-birth weight (Schempf, Strobino, & O'Campo, 2009), small for gestational age (Elo et al., 2009), and maternal weight gain (Mendez et al., 2014). However, to the best of my knowledge, no published study has explicitly used either multilevel regression or marginal regression models to examine neighborhood contextual effects on prenatal care utilization. Out of the few researchers that acknowledged the importance of correcting for within-neighborhood correlation in multilevel data, the reason often cited for not using a multilevel regression model is inadequate number of individuals per neighborhood unit (Braveman, Egerter, Cubbin, & Marchi, 2004; Cubbin et al., 2008).

There are some potential problems that may arise when individual-level factors are accounted for in neighborhood studies that used multilevel data. These problems can be in form of model misspecification, selection bias, or multi-collinearity (Diez-Roux, 2001; Oakes, 2004). Model misspecification is a problem related to confounding that may arise either because important individual-level characteristics are missing in a model in which neighborhood factors are found to be significant, or the model is over-adjusted by including individual-level factors that are intermediate variables in the casual pathway to the outcome (Diez-Roux, 1998).

Another common problem in neighborhood research is selection bias that may result when socio-demographic characteristics that sort individuals to a particular neighborhood are related to the outcome of interest (Blalock, 1984, Diex Roux, 1998). Besides model misspecification and selection bias, multi-collinearity may occur when there are correlations between neighborhood-level variables, and between neighborhood-level and individual-level variables. When the correlations are very strong, it may result in unstable standard errors that may warrant dropping one variable for another. The use of an index summary of neighborhood contexts is often used to overcome this problem.

As is the case for individual-level observation studies, drawing causal inference from multi-level analyses of observational data is difficult without violation of one or more fundamental assumptions underlying such inference. Oakes (2004) described four fundamental identification problems in neighborhood research using observational data: social stratification confounding, endogeneity of emergent neighborhood context, issues with extrapolation, and violation of the stable unit-treatment value assumption (SUTVA).

Social stratification (structural) confounding results from controlling for selection bias in neighborhood studies involving the use of multilevel data. To the extent that selection bias is controlled, as one adjusts for individual level characteristics, the propensity that an individual living in a disadvantage (or advantaged) neighborhood could live in an advantage (or disadvantage) neighborhood becomes lower (Oakes, 2004). However, as much as there is enough variability in individual-level variables across the levels of a neighborhood characteristic in multilevel data, the estimation of the association between the neighborhood variable and the outcome of interest is possible and meaningful (Diez-Roux, 2004).

In addition, neighborhood contexts may be regarded as emergent endogenous variables that, by definition, are conditionally dependent on the individual characteristics of the residents (Diez-Roux, 2004; Oakes, 2004). This is particularly true when the neighborhood characteristic under study is an aggregate measure of the individual-level characteristics of the residents. Some researchers have argued that neighborhood contexts may be completely endogenous, making the estimation of their effects not identifiable (Oakes, 2004). However, some neighborhood characteristics, especially those that are structural or integral, such as healthcare infrastructure, neighborhood safety, number of functional recreational parks, and urban design, are also determined by exogenous factors at the policy level (Diez-Roux, 1998; Diez-Roux, 2004).

Extrapolation is making statistical inference beyond the support of the observed data, which may undermine the exchangeability assumption needed to make a causal inference. Although extrapolation is not unique to neighborhood studies involving multilevel data, exchangeability assumption for making causal inferences with respect to neighborhood effects requires that all individuals in a neighborhood be perfectly "exchangeable" for individuals in another neighborhood (Robins & Greenland, 1992). Lastly, causal inference requires that the effect of neighborhood contexts on residents not be affected by the effects of the surrounding neighborhoods (SUTVA), which is only realistic in completely controlled, randomized neighborhood trials (Little & Rubin, 2000).

While randomized community trials may address the problems related to making causal inference in multilevel observational neighborhood studies, they are often considered not ethical for most studies, including those related to prenatal care utilization unless the study focus is on standard prenatal care compared to enhanced models. Also, randomized community trials are very costly; therefore, they are conducted using few communities, making generalizability difficult. Moreover, community trials may not be adequate for teasing out the complex multiple pathways linking neighborhood contexts with individual-level characteristics for purpose of specific knowledge of the underlying mechanisms (Merlo & Chaix, 2006). An attempt to understand the complex relationships in community trials would invariable involve the use of multilevel-level analysis (Subramanian, 2004), though, with less inferential bias. Therefore, multilevel observational studies are still useful for obtaining valuable information that may guide theory development and inform health policy change without necessarily establishing causal relationships.

4. METHODOLOGY

4.1 Study Population

The primary purpose of this dissertation is to examine the effect of neighborhood social contexts (neighborhood socioeconomic indicators, community violent crime rate, community racial/ethnic composition, and racial residential segregation) on prenatal care utilization, and on racial disparities in prenatal care utilization among Chicago residents who had a live birth between January 1, 2010 and December 31, 2014.

4.2 Study Design and Data Source

The studies in this dissertation are all cross-sectional studies that utilized secondary data obtained from the birth certificates of infants born to Chicago residents between January 1, 2010 and December 31, 2014. The data were geocoded to the Chicago community areas in which the mothers were resident during pregnancy to link them with the neighborhood characteristics of the community areas. The information on a birth certificate is typically collected at the time of infant's birth while the mother is still in the hospital using a standardized worksheet (Appendix A). Generally, the sources of birth certificate information are the mother, her prenatal and childbirth records, and her physician or midwife. After collection, the information is sent from hospitals to the Illinois Department of Public Health (IDPH) electronically through the Illinois Vital Records System (IVRS).

For the purpose of this dissertation, neighborhood is defined as Chicago community area (CCA). Community area is a larger geographical boundary than census tract; as such, it provides a higher level of precision of boundary estimates. In addition, in Chicago, community areas provide more meaningful geopolitical and sociocultural boundaries than census tracts. There are 77 community areas in the city of Chicago and each area contains a highly varied number of census tracts, ranging from 1 to 34. Selected

socioeconomic indicators of public health significance and measures of racial residential segregation were derived from census tract-level estimates obtained from the United States Census Bureau, American Community Survey.

The American Community Survey (ACS) is a nationwide, continuous survey designed to provide communities with timely and reliable demographic, social, economic, and housing data every year (Torrieri, 2014). The sampling frame for ACS consists of all valid, residential housing unit addresses in all county and county equivalents in all the 50 states, including the District of Columbia, in the United States. Nearly 3 million addresses are sampled during American Community Survey each year, resulting in about 2 million final interviews. The survey data are released by the United States Census Bureau in the form of both single-year and multiyear (3-year and 5-year) estimates. Single-year and multiyear estimates obtained from ACS are *period* estimates that represent data collected over a period of time.

While single-year and multiyear estimates are available for areas with population size of 65,000 or more, data for geographical areas with fewer than 20,000 people, such as census tracts and census block groups, are produced only in the form of 5-year estimates to increase the level of precision of the estimates. As a result, a 5-year estimate that includes information collected over a 60-month period was used to derive the community socioeconomic indicators and the measures of racial residential segregation used for the studies in this dissertation. Specifically, the 5-year estimates collected between January 1, 2009 and December 31, 2013 were used for this dissertation to reflect the neighborhood experience of Chicago residents who had a live birth between January 1, 2010 and December 31, 2014.

Community-level violent crime rates in Chicago for the year 2010 to 2014 were obtained from the Chicago Police Department (CPD). There are four categories of crime of violence as defined by the Uniform Crime Reporting (UCR) Program of the United States Department of Justice (USDJ), Federal Bureau of Investigation (FBI). The four categories and their UCR codes are: 1) murder and non-negligent

manslaughter (09A); 2) rape (11A-D, 36A-B); 3) robbery (120); and 4) aggravated assault (13A) (USDJ, FBI, 2013). The Chicago Police Department adopts the FBI's National Incident-Based Reporting System (NIBRS) for reporting incidence of violent crime in Chicago. The corresponding categories of violent crime and their Illinois Uniform Crime Reporting Codes used for this dissertation are: 1) homicide 1st & 2nd degree (0110, 0130); 2) criminal sexual assault (0261-66, 0271-5, 0281, 0291, 1753-4); 3) robbery (031A-B, 0312-3, 0320, 0325-6, 0330, 033A-B, 0331, 0334, 0337, 0340); and 4) aggravated battery and assault (041A-B, 0420, 0430, 0450-53, 0461-62, 0479-98, 0510, 051A-B, 0520, 0530, 0550-58) (Chicago Police Department, 2017).

4.3 Study Variables

4.3.1 Outcome variable

This dissertation contains three separate but related studies. Prenatal care utilization was measured at both the community and individual level to address the specific objectives of each study. At the community level, prenatal care utilization was operationalized as *percent inadequate prenatal care utilization (PNCU)* defined as the percentage of women who received inadequate prenatal care utilization based on Kotelchuck's APNCU Index described below. At the individual level, it was operationalized as: 1) *late/no prenatal care (PNC)* defined as starting prenatal care after the first trimester or having no prenatal care, and 2) *inadequate prenatal care utilization (PNCU)* defined as having *inadequate* or *intermediate* prenatal care utilization compared to *adequate* or *adequate-plus* based on Kotelchuck's APNCU Index.

The community-level estimates of prenatal care utilization were used for Study 1*, Effect of Neighborhood Socioeconomic Indicators and Violent Crime on Prenatal Care Utilization: a GIS Analysis,* to address study objectives 1–3. Individual-level estimates were used for Study 2, *Effect of Neighborhood Socioeconomic Indicators and Violent Crime on Prenatal Care Utilization: a Multilevel Regression*

Analysis, to address the study objectives 4–6; and Study 3, *Racial disparities in Prenatal Care Utilization: Individual-level Characteristics and Place of Residence*, to address study objectives 7–9 (See Study Objectives, section 1.4).

Kotelchuck's *Adequacy of Prenatal Care Utilization (APNCU) Index* is a summary index of both 1) the *Adequacy of Initiation of Prenatal Care* that is based on the month, rather than trimester, in which prenatal care is initiated, and 2) the *Adequacy of Received Services* based on the number of visits from initiation of care till delivery, adjusted for both gestational age at delivery and time of entry into care (Kotelchuck, 1994). The summary index was used to group Chicago mothers into four categories: *adequate-plus*, *adequate*, *intermediate*, and *inadequate*. Figure 3 shows the construction of Kotelchuck's summary APNCU Index. A descriptive outline of the index and its two factors is presented in Table I.

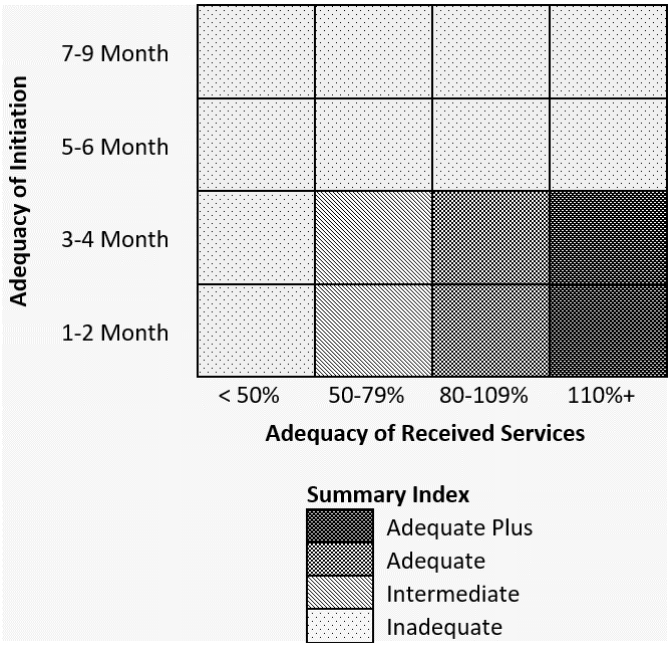


Figure 3. Construction of Kotelchuck's summary APNCU Index

Adapted from Kotelchuck, 1994

Table I
OUTLINE OF THE ADEQUACY OF PRENATAL CARE UTILIZATION INDEX[a]

I. Month prenatal care began (Adequacy of Initiation of Prenatal Care)

- Adequate Plus: 1st or 2nd month
- Adequate: 3rd or 4th month
- Intermediate: 5th or 6th month
- Inadequate: 7th month or later, or no prenatal care

II. Proportion of the number of visits recommended by the American College of Obstetricians and Gynecologists received from the time prenatal care began until delivery (Adequacy of Received Services)

- Adequate Plus: ≥110%
- Adequate: 80–109%
- Intermediate: 50–79%
- Inadequate: <50%

III. Summary Adequacy of Prenatal Care Utilization Index

- Adequate Plus: Prenatal care begun by the 4th month and 110% or more of recommended visits received
- Adequate: Prenatal care begun by the 4th month and 80–109% of recommended visits received
- Intermediate: Prenatal care begun by the 4th month and 50%–79% of recommended visits received
- Inadequate: Prenatal care begun after the 4th month or less than 50% of recommended visits received

[a] Adapted from Kotelchuck, 1994.

4.3.2 Exposure variables

The primary exposure variables are neighborhood socioeconomic indicators, community violent crime rate, racial residential segregation, and community racial/ethnic composition. The conceptual definitions of the community-level variables are shown in Table II. The neighborhood socioeconomic indicators examined are *percent dependency, percent uneducated, percent living in poverty, percent unemployed, percent crowded housing* and *per capita income,* summarized as *neighborhood hardship* in this dissertation (see Theoretical Framework, Figure 1). The indicators were selected *a priori* based on the review of the literature of studies related to neighborhood effects on health outcomes and behaviors (Leventhal & Brooks-Gunn, 2000; Pickett & Pearl, 2001; Rajaratnam, Burke & O'campo, 2006). The indicators measure the common and important domains of neighborhood characteristics that have been identified to influence health outcomes and behaviors (Rajaratnam, Burke & O'campo, 2006). The domains are: family structure, education, employment, occupation, housing, income/wealth, violence and crime, and population composition.

The neighborhood socioeconomic indicators were calculated using census tract-level estimates obtained from the United States Census Bureau, American Community Survey 5-year estimates, tables B01001, B15002, B17017, B23001, B25014, B19301, and B19313. A summary score of the socioeconomic indicators, the *Hardship Index,* was calculated according to the method developed by the Nelson A. Rockefeller Institute of Government. The index has been used to compare social and economic conditions among cities and communities (Nathan & Adams, 1976; Nathan & Adams, 1989; Montiel, Nathan, & Wright, 2004).

For this dissertation, *Neighborhood Hardship Index* was calculated by summing the standardized ratios of the six selected socioeconomic indicators and dividing the total by 6. In essence, the *Hardship Index* of a community area represents the average of the standardized ratios of all the selected

Table II

VARIABLE LIST WITH CONCEPTUAL DEFINITION AND OPERATIONALIZATION FOR COMMUNITY-LEVEL SOCIOECONOMIC INDICATORS INCLUDING THE VIOLENT CRIME RATE

Community-level variable[a]	*Conceptual definition*
Percent dependency	The percent of community residents under 18 or over 64 years of age
Percent uneducated	The percent of community residents aged 25 years or older without a high school diploma
Percent below poverty level	The percent of community households living below the federal poverty level
Percent unemployed	The percent of community residents aged 16 years or older in the labor force that are unemployed
Percent crowded housing	The percent of community occupied housing units with more than one person per room
Per capita income	Average income per community resident obtained by dividing the community total income by its total population
Hardship Index	A composite score of the standardized ratios of community-level socioeconomic indicators: *percent dependency, percent uneducated, percent living in poverty, percent unemployed, percent crowded housing* and *per capita income.* The index ranged from 0-100.
Community racial/ethnic composition	A four-level variable (NH-White, NH-Black, Hispanic, and *Mixed* communities) based on the majority racial/ethnic group greater than or equal to 60% of the residents in a community-area.
Non-Hispanic Black isolation (index)	A measure of the extent to which a Non-Hispanic Black is likely to be in contact with other members of the same racial/ethnic group in a community area. The index ranges between 0 and 100
Violent crime rate	Community level violent crime rate per 100 residents comprising of four categories as defined by the Chicago Police department: homicide (1st & 2nd degree), criminal sexual assault, robbery, and aggravated battery and assault

[a] Each of the community-level variables was categorized into four quantiles (Q1-Q4) based on its distribution, where the most advantaged community areas are grouped into Q4 and the most disadvantaged areas grouped into Q1.

socioeconomic indicators. Standardization of the indicators before calculating the index ensured that each of the indicators was given equal weight. The index is not an absolute but a relative score that compares where each community area falls relative to others on a scale of 0 to 100, with a higher number indicating greater hardship. The formula used for calculating the standardized ratio of each of the socioeconomic indicators is given below:

$$X = \frac{Y - Y_{\min}}{Y_{\max} - Y_{\min}} * 100 \quad (4.1)$$

where X is the standardized value of socioeconomic indicator to be calculated, Y is the unstandardized value obtained from American Community Survey, Y_{min} is the minimum value for Y across all community areas, and Y_{max} is the maximum value for Y across all community areas.

In addition to neighborhood socioeconomic indicators, community violent crime rate, racial residential segregation, and community racial/ethnic composition were also examined for their associations with prenatal care utilization. The association of neighborhood hardship, community violent crime rate, and racial residential segregation with inadequate prenatal care utilization were examined using the geographical information systems and multilevel level regression analysis. Community racial/ethnic composition was used to examine the role of place of residence in racial/ethnic disparities in prenatal care utilization. Violent crime generally includes homicide, criminal sexual assault, robbery, and aggravated assault and battery. In this dissertation, it was measured as the number of violent crimes per 100 residents in a community area to aid interpretation of study findings, with no loss of significant digits.

As discussed in the literature review, there are five dimensions of racial residential segregation in the literature: exposure, evenness, concentration, centralization and clustering (Massey & Denton, 1988). Exposure and evenness do not require specific spatial information such as geographical area dimensions and/or coordinates in their estimation, unlike the other dimensions of racial residential

segregation. Given the fact that a measure of interaction between members of the same racial/ethnic group, or different racial/ethnic groups is conceptually relevant to address the study objectives, of the five dimensions of racial residential segregation, only exposure and evenness were considered for this dissertation. In addition, other dimensions of racial residential segregation could not be easily derived from the available data. Exposure is a measure of the extent to which a member of a racial/ethnic group is likely to be in contact with other members of the same racial/ethnic group (isolation), or of different racial/ethnic group (interaction) in a defined geographical place, while evenness is a measure of dissimilarity in racial distribution across the geographical units of a place (Massey & Denton, 1988). A measure of exposure was used for this dissertation because it is more closely correlated with prenatal care utilization than evenness.

Exposure was measured as Non-Hispanic Black isolation, given that, for historical reasons, the isolation of Non-Hispanic Blacks is more related to neighborhood social, physical, and environmental contexts than any other minority racial/ethnic group isolation, and the level of segregation of Hispanics from white Americans is moderate, relative to that of African-Americans (Massey, 2001; Williams & Collins, 2001). The formula used to calculate Non-Hispanic Black isolation is given below:

$$ {}_xP_x^* = \sum_{i=1}^{n} \left[\frac{x_i}{X}\right]\left[\frac{x_i}{t_i}\right] \tag{4.2} $$

where x_i is the number of Non-Hispanic Blacks in census tract *i* in a community area, t_i is the total number of residents in the census tract, and X is the number of residents in the community area.

In addition, racial/ethnic composition, a proxy measure of racial residential segregation, was used to categorize Chicago community areas by majority racial/ethnic group. This was done to determine if racial disparities in prenatal care utilization vary by community racial/ethnic composition, and to determine if the association between community racial/ethnic composition and prenatal care

utilization varies by race/ethnicity. There are three major racial/ethnic groups in Chicago: Non-Hispanic (NH-) white, NH-Black, and Hispanic. Consequently, Chicago was categorized into groups of communities based on the percentage of NH-whites, NH-Blacks, and Hispanics in each Chicago community area. Racial/ethnic composition was used for the grouping instead of a formal measure of racial residential segregation because measures of exposure, in their typical use, are limited to only two racial/ethnic groups (Massey & Denton, 1988; White, 1986).

Community areas where the percentage of the NH-white population was equal to or greater than 60% were grouped as NH-White communities. The same percentage cut-off point (60%) was used to define NH-Black and Hispanic communities. The remaining community areas that could not be grouped into any of the three groups were defined as *Mixed* communities to ensure all community areas were included in analysis. Different percentage cut-off points that ranged between 50 and 90% have been used in the literature (Gaskin, Dinwiddie, Chan, McCleary, 2012; Kramer & Hogue, 2009). A percentage cut-off point of 60% was used based on the distribution of the racial/ethnic composition of Chicago community areas, and to ensure the fourth group, *Mixed* communities, have a considerable total number of residents to minimize off-support inferences.

The individual-level factors examined in this dissertation are categorized into three groups based on the overarching study's theoretical framework: 1) predisposing factors- maternal sociodemographic characteristics and health-related attitudes or behaviors; 2) enabling factors- health insurance status; and 3) perceived and evaluated need factors- parity, plurality, and evidence of medical and reproductive risk factors before or during pregnancy for adverse pregnancy outcomes. Except for race/ethnicity with respect to assessing racial/ethnic disparities in prenatal care utilization, the individual-level factors are treated as covariates in the studies conducted for this dissertation. The description of the covariates and how they were operationalized are shown in Table III.

Table III
VARIABLE LIST WITH CONCEPTUAL DEFINITION AND OPERATIONALIZATION FOR INDIVIDUAL-LEVEL COVARIATES

Variable	*Conceptual definition*	*Operationalization*
Individual-level predisposing factors		
Maternal sociodemographic factors		
Maternal race/ethnicity	Self-identified racial/ethnic category according to the United States Census definition	1= Non-Hispanic White 2= Non-Hispanic Black 3= Hispanic 4= Other race/ethnicity
Maternal age	Age at current birth based on the mother's age as recorded on the birth certificate	1= less than 19 years 2= 20–34 years 3= 35 years and above
Maternal level of education	Number of years of attending formal education as recorded on the birth certificate	1= Less than 12 years 2= 12 years 3= More than 12 years
Marital status	Self-reported marital union between baby's mother and father as recorded on the birth certificate	0= Married 1= Not married
Maternal attitudes and behaviors		
Smoking during pregnancy	Any smoking of cigarette during pregnancy	1= Smoked cigarette 0= Did not smoke
Alcohol use during pregnancy	Any use of alcohol during pregnancy	1= Used alcohol 0= Did not use alcohol
Individual-level enabling factors		
Health insurance status	Self-reported principal source of payment for prenatal care as recorded on the birth certificate	1= Private Insurance 2= Medicaid 3= Uninsured/Self-pay 4= Others
Individual-level need factors		
Parity	Total number of prior live births (living and deceased), not including index birth	1= No prior live birth 2= 1 or 2 live births 3= 3 or more prior live births
Plurality	Total number of gestation during index pregnancy	1= Singleton gestation 2= Multiple gestations
Medical/reproductive risk[a]	Evidence of any medical or reproductive risk before or during pregnancy as recorded on birth certificates that might result in an adverse pregnancy outcome	1= Yes 0= No

[a] Medical/reproductive risks include evidence of diabetes mellitus, and hypertensive disorders diagnosed before and during pregnancy, history of previous preterm birth, Cesarean section and fertility treatment.

4.4 Statistical Analysis

This dissertation contains three separate but related studies. Prenatal care utilization was measured at both the community (*percent inadequate PNCU*) and individual level (*late/no PNC* and *inadequate PNCU*) to address the specific objectives of each study. The community-level estimates of prenatal care utilization were used for Study 1, mapping and Geographical Information Systems (GIS) analysis of inadequate prenatal care utilization (PNCU). The individual-level estimates were used for Study 2, multilevel regression analysis of the effect of neighborhood characteristics on inadequate PNCU and Study 3, the role of individual-level characteristics and community racial/ethnic composition in racial disparities in late/no prenatal care (PNC) and inadequate PNCU. For regional analysis, Chicago community areas were grouped into seven regions (North, Northwest, West, Central, Southwest, South and Far South) based on the seven health systems planning regions used by the Chicago Department of Planning and Development (Salem & Ferguson, 2005).

4.4.1 Effect of Neighborhood Socioeconomic Indicators and Violent Crime on Prenatal Care Utilization: a GIS Analysis

Study objective 1: To estimate and map the prevalence of inadequate prenatal care utilization, neighborhood socioeconomic indicators, and violent crime by Chicago community areas.

A polygon shapefile of the city of Chicago projected to *NAD 1983 State Plane Illinois East FIPS 1201 Feet* was used to create separate chlropleth maps that show the spatial distribution of percent inadequate prenatal care utilization (PNCU), and three community-level variables: neighborhood hardship (a summary score of neighborhood socioeconomic indicators), Non-Hispanic Black isolation (a measure of racial residential segregation), and community violent crime rate by Chicago Community Area (CCA). For all mapping, natural breaks (Jenks) was used as the classification method.

Study objective 2: To describe and relate the spatial patterns of inadequate prenatal care utilization, neighborhood socioeconomic indicators, violent crime, and racial residential segregation in Chicago community areas.

Incremental spatial autocorrelation analysis was conducted for each of the community-level attributes (percent inadequate PNCU, neighborhood hardship, violent crime rate, NH-Black isolation) to determine the best distance threshold for the subsequent spatial pattern analysis. The *beginning distance* for the autocorrelation analysis was determined using the *average nearest neighbor* method. The O'Hare Chicago community area was excluded to obtain the minimum distance that ensured each community area had at least eight neighbors. It was excluded because of its large size and isolated location relative to the other community areas.

Global Moran's *I* spatial autocorrelation statistic (Moran, 1948; Goodchild, Haining & Wise, 1992) was used to assess global clustering or dispersion of each of the community-level attributes. The formula for calculating Moran *I* index is given as:

$$I = \frac{n}{\left(\sum_i \sum_j w_{ij}\right)} \frac{\sum_i \sum_j w_{ij}(x_i - \bar{x})\left(x_j - \bar{x}\right)}{\sum_i (x_i - \bar{x})^2} \tag{4.3}$$

where x_i is the attribute value for feature *i*, x_j is the attribute value for feature *j*, w_{ij} is the spatial weight between features *i* and *j*, *n* is the total number of features according to the specified spatial weight matrix, and $\bar{x}$ is the average of the attribute values for all features. The value of Moran's *I* index typically falls between -1 and +1. A significant negative Moran's *I* index indicates that nearby features tend to have dissimilar values (dispersion) while a significant positive index indicates that nearby features tend to have similar values (clustering). A zero value indicates a complete random spatial pattern with no evidence of dispersion or clustering.

In addition to a global test of spatial autocorrelation, Anselin Local Moran's *I* spatial correlation was used to calculate Local Moran's *I* index for percent inadequate PNCU, neighborhood hardship, community violent crime rate, and NH-Black isolation. In the absence of a theoretical conceptualization of the structure of spatial relationships among Chicago community areas, *zone of indifference* was used for conceptualization of spatial relationships, where features within the distance band (critical distance) of a target feature receive a weight of one for that feature. Once the critical distance is exceeded, weights diminish sharply with distance between the target feature and other features within the study area. Four layouts of clusters and outliers were created for each of the community-level attributes (inadequate PNCU, neighborhood hardship, violent crime rate, and NH-Black isolation) to compare their spatial patterns. The formula for the estimation of Local Moran's *I* statistic is given as:

$$I_i = \frac{x_i - \bar{X}}{S_i^2} \sum_{j=1, j \neq i}^{n} \left[w_{ij} \left(x_j - \bar{X} \right) \right] \tag{4.4}$$

where x_i is the attribute value for feature *i*, where x_j is the attribute value for other features (where $j \neq i$), w_{ij} is the spatial weight between features *i* and *j* according to the specified spatial weight matrix, *n* is the total number of features, and

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \tag{4.5}$$

$$S_i = \sqrt{\frac{\sum_{j=1, j \neq i}^{n} (X_j - \bar{X})^2}{n - 1}} \tag{4.6}$$

A positive local Moran's *I* value for a target feature implies that the feature has similarly high or low values as its neighbors, and thus a part of a cluster. A negative local Moran's *I* value means that the target feature is a spatial outlier that has a value that is different from the values of its surrounding neighbors. In either case, the *p*-value for the local Moran's *I* must be small enough, depending on the level specified as α criterion, for a cluster or outlier to be considered statistically significant. Spatial

clusters can be *High-High* clusters (clusters of high attribute values) and *Low-Low* clusters (clusters of low attribute values).

Study objective 3: To examine the spatial associations of neighborhood socioeconomic indicators, violent crime, and racial residential segregation with inadequate prenatal care utilization across Chicago community areas.

In addition to the spatial pattern analyses, ordinary least squares (OLS) and geographically weighted regression (GWR) models were used to evaluate the associations between the three community-level attributes (neighborhood hardship, violent crime rate, and NH-Black isolation) and percent inadequate PNCU. Unlike *global* regression analytic methods such as ordinary least squares (OLS) regression and multilevel regression methods that imply that the relationships between variables in a model are stationary (constant) across the study area, GWR is an exploratory statistical technique that controls for local variations in the relationships between variables over space within a single modeling framework (Brunsdon, Fotheringham & Charlton, 1996; Fotheringham, Brunsdon & Charlton, 2002).

Geographically weighted regression is more suited for analyzing spatial data because it controls for spatial heterogeneity (non-stationarity) and can also be specified to control for spatial dependence due to spatial lag/homogeneity (Anselin & Getis, 2010; Shoff, Chen & Yang, 2014; Sparks & Sparks, 2010). The formula used to estimate local regression coefficients is given as:

$$y_i = \beta_{0i}(u_i, v_i) + \sum_{k=1}^{p} \beta_{ki}(u_i, v_i)x_{ki} + \varepsilon_i, i = 1, \dots, n, \qquad (4.7)$$

where y_i is the value of the outcome variable at location *i* where (u_i, v_i) is the (x, y) coordinate at that location; and β_{0i} and β_{ki} are the local estimated intercept and regression coefficient for *k*th independent variable, x_k, for location *i*, respectively. Geographically weighed regression requires

assigning a specific (x, y) coordinate to the observations at each location *i*. In this study, each community area was assigned the coordinates at the centroid in the estimation of its local regression coefficients, which is a common GIS approach to the analysis of polygon features.

In GWR, the local regression coefficients for each location *i* are estimated using the locally weighted least squares estimation method. Different parameter estimates are yielded for each polygon feature by weighting all observations according to their spatial proximity to location *i* defined by a specified Gaussian kernel density function. In this study, distance-based weights were used to create the weighted matrix used for the GWR. This method was chosen to avoid non-weighted isolated polygons, and to ensure that observations closer to a location *i* are given more weight to have greater influence on parameter estimates $\beta_i(u_i, v_i)$ than those farther away. The kernel function used for the weighting is:

$$w_{ij} = \exp\left(-d_{ij}^2/h^2\right) \tag{4.8}$$

where w_{ij} is the spatial weight between observation point *j* and regression point *i*, d_{ij} is the distance between observation point *j* and regression point *i*, and *h* is the kernel bandwidth beyond which the weights are set to zero. The optimal kernel bandwidth distance for this study was determined using the Akaike Information Criterion (AICc) to ensure a model with the best goodness of fit (Akaike, 1974).

For all spatial data analysis, distance method was specified as Euclidean, and row standardization was used where indicated. The false discovery rate (FDR) correction was applied to account for multiple testing and spatial dependency (Caldas de Castro & Singer, 2006), and the randomization null hypothesis was used as the basis for statistical significance testing (Brunsdon, Fotheringham & Charlton, 1996). Mapping and all GIS analysis were conducted using ArcGIS (version 10.3).

4.4.2 Effect of Neighborhood Socioeconomic Indicators and Violent Crime on Prenatal Care Utilization: a Multilevel Regression Analysis

Multilevel logistic regression analysis was conducted to examine the contextual effects of neighborhood on prenatal care utilization above and beyond individual-level factors. The analysis involved a sequence of multilevel logistic regression models formulated to answer different specific questions: 1) an *intercept-only model* with no individual or neighborhood-level independent variable (*Unconditional random-intercept model*); 2) a model with only the individual-level independent variables that vary over neighborhood units (*Random-intercept regression model*); 3) a model with both individual and neighborhood-level independent variables that allows for the estimation of the contextual effects of neighborhood on prenatal care utilization among all racial/ethnic groups (*Random-intercept with non-random slopes model*); and 4) a model with both individual and neighborhood-level independent variables that allows for the estimation of the contextual effects of neighborhood on prenatal care utilization by race/ethnicity (*Intercepts- and slopes-as-outcome regression model*).

For all the multilevel regression models that were used in this study (Study 3), the sampling model is given as:

$$Y_{ij} \mid \varphi_{ij} \sim \mathrm{B}\left(\varphi_{ij}\right) \tag{4.9}$$

which means that the outcome variable (Y_{ij}) for woman *i* in community-area *j*, given her probability of the outcome (φ_{ij}), has a binomial distribution. The link function that was used to constrain the probability of the outcome to lie between 0 and 1 ($0 \leq \varphi_{ij} \leq 1$) is given as:

$$\varphi_{ij} = \frac{1}{1 + \exp\left(-\eta_{ij}\right)} \tag{4.10}$$

where η_{ij} is the log-odds (logit) of the outcome for woman *i* in community *j*.

An *unconditional random-intercept model* was used for the preliminary analysis of the multilevel data to estimate: 1) the average probability of inadequate prenatal care utilization; and 2) the proportion of the total variance in log odds of inadequate PNCU that is explained by neighborhood-level characteristics [intra-class correlation coefficient (ICC)]. The *intercept-only model* with random effects is given as:

Level-1

$$\eta_{ij} = \beta_{0j} \tag{4.11}$$

Level-2

$$\beta_{0j} = \gamma_{00} + u_{0j} \tag{4.12}$$

Mixed model

$$\eta_{ij} = \gamma_{00} + u_{0j}, \quad u_{0j} \sim \mathrm{N}(0, \tau_{00}) \tag{4.13}$$

where β_{oj} is the average log-odds of inadequate PNCU for women in community-area *j*, u_{oj} is the random effect associated with community-area *j,* which is assumed to have a normal distribution with mean of 0 and variance of τ_{00}, and γ_{00} is the log-odds of inadequate PNCU across Chicago community areas when random effect is equal to 0. The usual error term e_{ij} at level 1 is not included in Equation 4.11 and 4.13 because it is completely determined η_{ij} (Luke, 2004).

Since the residual variance at level-1 is not on the same scale as the variance at level-2, it is not ideal to estimate *intraclass correlation coefficient* (ρ) as the ratio of level-2 variance and the total variance as is typically done for multilevel linear models. Therefore, to estimate ρ, the level-1 model was conceived in term of a continuous latent variable y_{ij} that underlies the observed binary outcome variable Y_{ij} using a *threshold concept* approach where y_{ij} takes a value of 1 when a certain threshold is exceeded, otherwise a value of 0 (Long, 1997). The relation can be expressed as:

$$y_{ij} = Y_{\mathrm{ij}} + e_{\mathrm{ij}}, \qquad e_{\mathrm{ij}} \sim \mathrm{L}\left(0, \frac{\pi^2}{3}\right) \tag{4.14}$$

The approach assumes that the level-1 random effect has a standard logistic distribution (L) with a mean of 0 and variance of $\pi^2/3$. The formula for the intraclass correlation coefficient (ρ) is given as:

$$\rho = \frac{\tau_{00}}{\tau_{00} + \ \pi^2/3} \tag{4.15}$$

This approach to estimate ICC is conceptually appropriate for this study since the outcome variable is not strictly nominal; it is essentially a continuous variable categorized into two groups (see Table I).

A *random-intercept regression model* with only level-1 covariates was used to examine the association between the individual-level covariates (Table III) and inadequate PNCU. In this model, there were no level-2 covariates but the intercept was allowed to vary randomly over level-2 units (community-areas). The model is given as Equation 4.19:

Level-1

$$\eta_{ij} = \beta_{0j} + \sum_{q=1}^{Q} \beta_{qj} X_{qij} \tag{4.16}$$

Level-2

$$\beta_{0j} = \gamma_{00} + u_{0j}, and \tag{4.17}$$

$$\beta_{qj} = \gamma_{q0}, \qquad \text{for each } q = 1, 2, \ldots, Q \tag{4.18}$$

Mixed model

$$\eta_{ij} = \gamma_{00} + \sum_{q=1}^{Q} \gamma_{q0} X_{qij} + u_{0j} \tag{4.19}$$

where γ_{00} is the log-odds of the outcome when random effect is equal to 0, γ_{q0} is the differential effect of covariate X_q (q=1, 2, …., Q) on outcome, u_{0j} is the random effect associated with community-area *j,* conditional on the covariates. All the covariates described in Table III were included in the model since they have been found in the literature to be associated with prenatal care utilization.

Study Objective 4: To estimate the effects of neighborhood socioeconomic indicators and violent crime on prenatal care utilization over and above the influence of individual-level characteristics among Chicago residents.

Three separate *random-intercept with non-random slopes regression models* were used to examine the contextual effects of neighborhood hardship and community violent crime rate on prenatal care utilization after controlling for individual-level covariates, one for each of the two community-level variables, and a third model with both variables. The models were used to separate compositional effects (influence of individual-level variables) from neighborhood contextual effects. To achieve this, the intercept in Equation 4.16 that accounts for individual-level covariates was modeled as the *outcome,* and the community-level characteristics as the explanatory variables. The model is given as Equation 23:

Level-1

$$\eta_{ij} = \beta_{0j} + \sum_{q=1}^{Q} \beta_{qj} X_{qij} \tag{4.16}$$

Level-2

$$\beta_{0j} = \gamma_{00} + \sum_{s=1}^{S} \gamma_{0s} W_{sj} + u_{0j}, and \tag{4.21}$$

$$\beta_{qj} = \gamma_{q0}, \qquad \text{for each } q = 1, 2, \dots, Q \tag{4.18}$$

Mixed model

$$\eta_{ij} = \gamma_{00} + \sum_{q=1}^{Q} \gamma_{q0} X_{qij} + \sum_{s=1}^{S} \gamma_{0s} W_{sj} + u_{0j} \tag{4.23}$$

where γ_{00} is the log-odds of the outcome when random effect is equal to 0, γ_{q0} is the differential effect of covariate X_q (q=1, ….Q, where Q is the total number of covariates) on the outcome controlling for community-level variables, y_{os} is the differential effect of community-level variable W_s (s=1, ….S, where S is the total number of primary exposure variables), u_{oj} is the random intercept effect associated with community-area *j,* conditional on both individual- and community-level variables.

Study objective 5: To estimate the effects of neighborhood socioeconomic indicators and violent crime on prenatal care utilization over and above the influence of individual-level characteristics, independent of racial residential segregation among Chicago residents.

First, a *random-intercept with non-random slopes regression model* was used to examine the contextual effects of Non-Hispanic Black isolation on prenatal care utilization after controlling for only the individual-level covariates. Also, the contextual effect of each of neighborhood hardship and community violent crime rate on prenatal care utilization independent of Non-Hispanic Black isolation was also examined using a similar mixed regression model. Finally, a full regression model that included all the three community-level variables (neighborhood hardship and community violent crime rate and Non-Hispanic Black isolation) was used to examine the contextual effects of neighborhood hardship and violent crime on prenatal care utilization controlling for individual-level covariates, independent of Non-Hispanic Black isolation. This model also allowed the estimation of the residual effect of NH-Black isolation, after controlling for the potential mediators (neighborhood hardship and violent crime) of its association with prenatal care utilization.

Study objective 6: To determine if the effects of neighborhood socioeconomic indicators and violent crime on prenatal care utilization adjusted for individual-level characteristics differ by race/ethnicity among Chicago residents.

An *intercept- and slopes-as-outcome* regression model was used to determine if the effects of neighborhood socioeconomic indicators and community violent crime rate differ by race/ethnicity after adjusting for other individual-level variables. This was achieved by modeling the coefficient (slope) of race/ethnicity in the level-1 model as the outcome with community-level variables as the predictors. The model is an extension of the *random-intercept with non-random slopes* regression model (Equation 4.23) used to address Study objective 5 with the addition of interaction terms (W_s*$RACE$) between the

community-level variables and race/ethnicity. The contextual effects of neighborhood hardship and community violent crime rate on prenatal care utilization by race/ethnicity with and without adjusting for Non-Hispanic Black isolation were also examined. The model is given as:

Level-1

$$\eta_{ij} = \beta_{0j} + \beta_{(RACE)j} X_{(RACE)ij} + \sum_{q=1}^{Q-1} \beta_{qj} X_{qij} \tag{4.21}$$

Level-2

$$\beta_{0j} = \gamma_{00} + \sum_{s=1}^{S} \gamma_{0s} W_{sj} + u_{0j}, and \tag{4.19}$$

$$\beta_{(RACE)j} = \gamma_{(RACE)} + \sum_{s=1}^{S} \gamma_{(RACE)s} W_{sj}, \text{and} \tag{4.22}$$

$$\beta_{qj} = \gamma_{q0}, \qquad \text{for each } q = 1, 2, \dots, (Q-1), excluding\ RACE \tag{4.23}$$

Mixed model

$$\eta_{ij} = \gamma_{00} + \gamma_{(RACE)} X_{(RACE)ij} + \sum_{q=1}^{Q-1} \gamma_{q0} X_{qij} + \sum_{s=1}^{S} \gamma_{0s} W_{sj} + \sum_{s=1}^{S} \gamma_{(RACE)s} W_{sj} X_{(RACE)ij} + u_{0j} \tag{4.24}$$

where $y_{(RACE)}$ is the differential effect of individual-level race/ethnicity on prenatal care utilization controlling for community-level variables, y_{os} is the differential effect of community-level variable W_s (s= 1, 2, …., S where S is the total number of the community-level variables in the model), $y_{(RACE)}$ is the differential effect of the community-level variable W_s by race/ethnicity controlling for other individual-level variables and community-level variables.

4.4.3 Racial Disparities in Prenatal Care Utilization: Individual-level Characteristics and Place of Residence

Study objective 7: To identify maternal characteristics, including health insurance status, that explain the racial disparities in prenatal care utilization among Chicago residents.

A series of logistic regression models was used to sequentially examine the effect of adjusting for nine individual-level variables selected *a priori* (see Table III) and community racial/ethnic composition on racial disparities in late/no prenatal care and in inadequate prenatal care utilization. In addition, for each outcome, a full logistic regression model with all the individual-level variables, community racial/ethnic composition, and their significant interaction terms determined using manual backward selection method and likelihood ratio tests was used to examine racial disparities across the levels of each of the individual-level characteristics. To further examine the relative role of the individual-level characteristics in racial disparities in prenatal care utilization, different combinations of maternal characteristics were examined to identify the characteristics of Non-Hispanic Black and Hispanic mothers with the highest odds of late/no PNC and inadequate PNCU relative to Non-Hispanic white mothers. Only two-way interaction terms were examined.

Study objective 8: To determine if racial disparities in prenatal care utilization vary by Chicago community racial/ethnic composition.

Racial disparities in late/no prenatal care and in inadequate prenatal care utilization among Chicago mothers were examined using two separate (one for each outcome) logistic regression models that adjusted for other individual-level variables and community racial/ethnic composition. For each outcome, the full logistic regression models with an interaction term between race/ethnicity and community racial/ethnic composition described for study objective 7 was used to determine if racial

disparities in late/no prenatal care, and in inadequate prenatal care utilization vary by community racial/ethnic composition after controlling for other individual-level variables.

Study objective 9: To assess the effect of living in a community area where one's race/ethnic group is the majority on prenatal care utilization among Chicago residents.

The full logistic regression models used to address study objective 7 and 8 were also used to examine the effect of living in a community area where one's race/ethnic group is the majority on late/no prenatal care and inadequate prenatal care utilization. Generalized estimating equation was used to account for within-group correlation in Study 3 since estimating only the fixed effects of the variables was sufficient to address the study objectives. The sensitivity of the estimates obtained from the regression models to the percentage cut-off point (60%) used to categorize Chicago community area by majority racial/ethnic group was examined, especially with respect to study objective 8 and 9. The percentage cut-off point was varied between 50 and 70%, at incremental intervals of 5%.

For study 2 and 3, the likelihood ratio test was used to compare goodness of fit of nested models. Mixed logistic regression models (PROC GLIMMIX using maximum likelihood estimation with adaptive quadrature) were used for Study 2 while generalized estimating equations (PROC GENMOD) were used for Study 3. All p values are two sided at a $p<0.05$ level of significance. All multilevel logistic regression analyses were conducted in SAS (version 9.3, SAS Institute Inc, Cary, NC, USA).

5. RESULTS

The results of the dissertation are divided into three major parts: 1) mapping and geographical information systems (GIS) analysis of inadequate prenatal care utilization (PNCU); 2) multilevel regression analysis of the effect of neighborhood characteristics on prenatal care utilization; and 3) assessment of racial disparities in late/no prenatal care (PNC) and inadequate PNCU. Consequently, this section of the dissertation begins with the results of the relevant descriptive analyses of the study population with respect to late/no prenatal care and inadequate prenatal care utilization. Thereafter, the results of the three studies are narrated. In this study, late/no prenatal care was defined as initiating prenatal care after the first trimester or having no prenatal care, and inadequate prenatal care utilization was defined as having inadequate or intermediate prenatal care utilization based on Kotelchuck's Index.

5.1 Descriptive Statistics

Of the 204,212 live births in Chicago during the study period (2010–2014), complete records of trimester of entry into prenatal care and adequacy of prenatal care utilization were available in the birth certificates of 186,373 (91.3%) mothers. Relevant maternal sociodemographic and obstetric characteristics were missing in 6,070 of the 186,373 birth records, and additional 177 records could not be accurately geocoded to community area of residence. The final sample size used for this dissertation is 180,216, which is 88.2% of all recorded live births in Chicago during the study period.

Table IV shows the distribution of the study population by maternal and obstetric characteristics. The percentage of the three major racial/ethnic groups of the study population was about the same, hovering around 30% for each group. Most of Chicago residents who had a live birth between 2010 and 2014 were aged 20-34 years (72.2%), 56.7% had more than 12 years of education

Table IV

DISTRIBUTION OF THE STUDY POPULATION AND PREVALENCE OF LATE/NO PRENATAL CARE (PNC) AND INADEQUATE PRENATAL CARE UTILIZATION (PNCU): CHICAGO, 2010–2014 (N= 180,216)

Variable	*N= 180,216* *n (%)*	*Late/no PNC* *(%)*	*Inadequate PNCU* *(%)*
Maternal race/ethnicity			
Non-Hispanic White	53284 (29.6)	13.6	12.3
Non-Hispanic Black	55939 (31.1)	31.6	38.6
Hispanic	59259 (32.9)	22.9	25.5
Other race/ethnicity	11644 (6.5)	19.7	19.1
Maternal age			
Less than 19 years	16933 (9.4)	40.2	45.2
20–34 years	130019 (72.2)	22.0	25.0
35 years and above	33174 (18.4)	16.4	15.8
Maternal level of education			
Less than 12 years	38140 (21.2)	32.3	38.5
12 years	39918 (22.2)	28.6	33.7
More than 12 years	102068 (56.7)	16.7	17.0
Marital status			
Married	91063 (50.6)	15.2	15.3
Not married	89063 (49.4)	30.3	35.4
Parity			
No prior live birth	78370 (43.5)	21.3	22.6
1 or 2 live births	80299 (44.6)	21.7	24.8
3 or more prior live births	21457 (11.9)	31.4	36.5
Plurality			
Singleton gestation	173617 (96.4)	22.8	25.6
Multiple gestations	6509 (3.6)	20.2	14.5
Medical/reproductive risk			
No	135329 (75.1)	22.8	26.6
Yes	44797 (24.9)	22.3	21.2
Smoking during pregnancy			
No	174676 (97.0)	22.1	24.4
Yes	5450 (3.0)	41.3	50.9
Alcohol during pregnancy			
No	179080 (99.4)	22.6	25.2
Yes	1046 (0.6)	33.9	38.2
Health insurance status			
Private Insurance	69492 (38.6)	11.9	11.0
Medicaid	104012 (57.7)	29.1	33.9
Uninsured/Self-pay	1518 (0.8)	44.7	54.8
Others	5104 (2.8)	32.8	35.0
Community racial/ethnic composition[a]			
NH-White community	32726 (18.2)	13.5	11.0
NH-Black community	43189 (24.0)	30.8	38.7
Hispanic community	33226 (18.4)	22.7	26.9
Mixed community	70985 (39.4)	21.9	22.8

[a] Community racial/ethnic composition: a four-level variable (NH-White, NH-Black, Hispanic, and *Mixed* communities) based on the majority racial/ethnic group greater than or equal to 60% of the residents in the community-area.

and about 51% were married. Most of the births (96.4%) were singletons and a quarter (24.9%) of the mothers had one or more medical/reproductive risks, pre-existing or diagnosed during pregnancy. The most common principal source of payment for prenatal care was Medicaid (57.7%), followed by private health insurance (38.6%). Fewer than one percent of the study population paid for prenatal care out of pocket.

Table IV also shows the prevalence of late/no prenatal care (PNC) and inadequate prenatal care utilization (PNCU) by maternal sociodemographic and obstetric characteristics of the study population. The prevalence of late/no PNC and inadequate PNCU in Chicago during the study period was 22.7% and 25.2%, respectively. Non-Hispanic Black was the racial/ethnic group with the highest prevalence of late/no prenatal care (31.6%) and inadequate PNCU (38.6%) followed by Hispanic (22.9% and 25.5%, respectively). More details about the time (trimester) of entry into prenatal care and the adequacy of prenatal care utilization are shown in Table XIX and XX, Appendix B.

Of the three maternal age groups examined, adolescent mothers were more likely to initiate prenatal care late and receive inadequate prenatal care than any other age group (Table IV). Late/no PNC and inadequate PNCU were more prevalent among mothers who were less educated, not married, had three or more prior live births, and those who smoked or used alcohol in pregnancy. Mothers who had multiple gestations and those with one or more medical/reproductive risks were less likely to initiate prenatal care late and receive inadequate PNCU.

The distribution of the study population and the prevalence of late/no PNC and inadequate PNCU by maternal and obstetric characteristics stratified by race/ethnicity is shown in Table V. Teenage pregnancy was most prevalent among NH-Black mothers while the percentage of pregnant women with less than 12 years of education was highest among Hispanic mothers. Among NH-white mothers, the most common principal method of payment for prenatal care was private health insurance. About 79%

Table V

DISTRIBUTION OF THE STUDY POPULATION AND PREVALENCE OF LATE/NO PRENATAL CARE AND INADEQUATE PRENATAL CARE UTILIZATION BY RACE/ETHNICITY[a], CHICAGO 2010–2014 (N= 180,216)

	Non-Hispanic White (N= 53,284)			*Non-Hispanic Black (N= 55,939)*			*Hispanic (N= 59,259)*		
Variable	*n (%)*	*Late/no PNC (%)*	*Inadequate PNCU (%)*	*n (%)*	*Late/no PNC (%)*	*Inadequate PNCU (%)*	*n (%)*	*Late/no PNC (%)*	*Inadequate PNCU (%)*
Maternal age									
Less than 20 years	600 (1.1)	37.3	37.7	9554 (17.1)	43.8	51.1	6670 (11.3)	35.2	37.5
20–34 years	37228 (69.9)	14.2	13.2	40959 (73.2)	29.6	37.0	43438 (73.3)	21.8	24.8
35 years and above	15456 (29.0)	11.3	9.1	5426 (9.7)	25.4	28.4	9151 (15.4)	19.5	20.0
Maternal education level									
Less than 12 years	1648 (3.1)	34.3	38.0	13477 (24.1)	42.6	53.0	22271 (37.6)	26.0	30.0
12 years	3995 (7.5)	27.7	26.8	17204 (30.8)	33.8	42.2	17314 (29.2)	23.8	26.7
More than 12 years	47641 (89.4)	11.7	10.2	25258 (45.2)	24.3	28.4	19674 (33.2)	18.7	19.2
Marital status									
Married	46108 (86.5)	11.6	10.3	8900 (15.9)	22.4	24.9	25863 (43.6)	18.0	20.1
Unmarried	7176 (13.5)	26.6	25.5	47039 (84.1)	33.4	41.2	33396 (56.4)	26.8	29.6
Parity									
No prior live birth	29253 (54.9)	13.2	11.6	22417 (40.1)	30.2	35.7	20388 (34.4)	24.1	25.4
1 or 2 live births	21685 (40.7)	13.0	11.7	24144 (43.2)	30.4	38.1	29620 (50.0)	21.3	24.4
>=3 prior live births	2346 (4.4)	25.2	26.7	9378 (16.8)	38.4	46.6	9251 (15.6)	25.7	29.1
Plurality									
Singleton gestation	50680 (95.1)	13.7	12.6	53737 (96.1)	31.7	39.1	57961 (97.8)	23.0	25.7
Multiple gestations	2604 (4.9)	12.6	6.1	2202 (3.9)	30.0	25.7	1298 (2.2)	19.3	13.1
Medical/reproductive risk									
No	40572 (76.1)	13.9	13.2	41572 (74.3)	31.9	40.6	44475 (75.1)	22.9	26.9
Yes	12712 (23.9)	12.6	9.6	14367 (25.7)	30.8	32.8	14784 (24.9)	22.9	21.1
Smoking during pregnancy									
No	52510 (98.5)	13.3	12.0	51853 (92.7)	30.8	37.3	58710 (99.1)	22.8	25.3
Yes	774 (1.5)	36.2	36.6	4086 (7.3)	42.7	55.0	549 (0.9)	38.4	40.8
Alcohol during pregnancy									
No	53063 (99.6)	13.6	12.3	55474 (99.2)	31.5	38.5	58928 (99.4)	22.9	25.4
Yes	221 (0.4)	23.1	23.1	465 (0.8)	43.9	50.8	331 (0.6)	28.1	30.5
Health insurance									
Private Insurance	41978 (78.8)	9.2	9.2	9207 (16.5)	18.6	18.6	11139 (18.8)	15.1	15.1
Medicaid	9177 (17.2)	29.8	29.8	44007 (78.7)	33.8	33.8	46722 (78.8)	24.5	24.5
Uninsured/Self-pay	496 (0.9)	36.9	36.9	656 (1.2)	50.8	50.8	250 (0.4)	45.6	45.6
Others	1633 (3.1)	28.8	28.8	2069 (3.7)	38.2	38.2	1148 (1.9)	30.3	30.3
Racial/ethnic composition[b]									
NH-White community	23990 (45.0)	11.4	9.1	1414 (2.5)	26.5	26.7	3449 (5.8)	19.5	15.7
NH-Black community	1175 (2.2)	21.0	25.6	39416 (70.5)	31.6	39.8	2178 (3.7)	25.0	29.2
Hispanic community	2645 (5.0)	21.6	21.9	1050 (1.9)	33.1	36.6	28787 (48.6)	22.5	27.1
Mixed community	25474 (47.8)	14.5	13.7	14059 (25.1)	32.2	36.5	24845 (41.9)	23.7	24.6

[a] Other racial/ethnic groups are not shown.

[b] Racial/ethnic composition: a four-level variable (NH-White, NH-Black, Hispanic, and *Mixed* communities) based on the majority racial/ethnic group greater than or equal to 60% of the residents in the community-area.

of NH-Black and Hispanic mothers' prenatal care was paid for by Medicaid. For all the levels of maternal and obstetric characteristics examined, the prevalence of late/no PNC and inadequate PNCU was higher among Non-Hispanic Blacks than other racial/ethnic groups (Table V).

The major objectives of this dissertation include evaluation of the association between community-level characteristics (neighborhood socioeconomic indicators, community violent crime rate, and racial residential segregation) and inadequate PNCU across Chicago community areas, and assessment of the role of individual-level characteristics and community racial/ethnic composition in racial/ethnic disparities in prenatal care utilization. The six community-level socioeconomic indicators examined are *percent crowded housing*, *per-capita income*, *percent dependency*, *percent living in poverty*, *percent uneducated*, and *percent unemployed*. The indicators were combined to create the *Neighborhood Hardship Index*, a composite measure of neighborhood socioeconomic disadvantage. Racial residential segregation was operationalized as Non-Hispanic Black isolation. Further details about how the exposure variables were measured are provided in the methods section (Table II).

Table VI shows the Pearson correlation coefficients between the six community-level socioeconomic indicators. Given the strong correlation between some of the socioeconomic indicators, Neighborhood Hardship Index was used in further analyses to avoid multicollinearity. The correlation between the index and each of the six indicators ranged between 0.69 and 0.90. Also, there was a positive correlation between percent inadequate PNCU and each of the three community-level variables (neighborhood hardship [$r= 0.84$, $p < 0.001$], community violent crime rate [$r= 0.80$, $p < 0.001$] and NH-Black Isolation [$r= 0.75$, $p < 0.001$]) examined in GIS and multilevel regression analysis. Percent inadequate prenatal care utilization in the city of Chicago was 25.2% and ranged between 6.2% and 51.8% across Chicago community areas.

The prevalence of the three community-level variables (neighborhood hardship and community violent crime rate and NH-Black isolation) and percent inadequate PNCU by Chicago community area is shown in Table XXI, Appendix B. This information was used to map the spatial pattern of percent inadequate PNCU and each of the community-level variables by Chicago community area described below.

Table VI
PEARSON CORRELATION COEFFICIENTS BETWEEN COMMUNITY-LEVEL SOCIOECONOMIC INDICATORS, NEIGHBORHOOD HARDSHIP, VIOLENT CRIME AND NON-HISPANIC BLACK ISOLATION: CHICAGO, 2010–2014

Variable[a]	*Hardship*	*Crowded*	*Per-Capita*	*Dependency*	*Poverty*	*Uneducated*	*Unemployed*	*Violence*	*Isolation*
Hardship	1.00								
Crowded	0.69	1.00							
Per-capita	-0.90	-0.56	1.00						
Dependency	0.73	0.24	-0.75	1.00					
Poverty	0.78	0.35	-0.58	0.44	1.00				
Uneducated	0.82	0.88	-0.72	0.41	0.46	1.00			
Unemployed	0.80	0.19*	-0.66	0.69	0.82	0.39	1.00		
Violence	0.59	0.05*	-0.44	0.46	0.80	0.19*	0.84	1.00	
Isolation	0.46	-0.12*	-0.37	0.46	0.68	0.00*	0.78	0.79	1.00

[a] See Table III for the definition and operationalization of the community-level variables.
* Not significant at α=0.05.

Table VII shows the distribution of Chicago residents and the prevalence of inadequate PNCU by quartiles of community-level characteristics (i.e., neighborhood hardship, violent crime, and NH-Black isolation) stratified by race/ethnicity. The racial/ethnic distribution of Chicago mothers across Chicago community areas with respect to these three exposure variables was not uniform. Only a few NH-white mothers (12.6%) were resident in the same community areas where neighborhood hardship was above the median (Quartile 3 and 4) with majority NH-Black (79.0%) and Hispanic (66.5%) mothers. While

67.3% of the NH-Black mothers were resident in the community areas where the rate of violent crime was most intense (Quartile 4), only a few NH-white (2.1%) and Hispanic (7.6%) mothers were resident in these community areas. As expected, most of the NH-Black mothers (89.0%) were resident in the community areas where the NH-Black isolation was above the median (Quartile 3 and 4). In general, the prevalence of inadequate PNCU increased with increasing level of neighborhood hardship, violent crime, and NH-Black isolation. The difference in the prevalence of inadequate PNCU between community areas grouped in the lowest (Q1) and highest (Q4) quartile was highest among NH-whites for all the three community-level characteristics examined (Table VII).

Table VII
DISTRIBUTION OF CHICAGO RESIDENTS AND PREVALENCE OF INADEQUATE PRENATAL CARE UTILIZATION BY QUARTILES OF COMMUNITY-LEVEL CHARACTERISTICS AND BY RACE/ETHNICITY[a], CHICAGO 2010–2014 (N= 180,216)

	All race/ethnicity N= 180,216		*Non-Hispanic White N= 53,284*		*Non-Hispanic Black N= 55,939*		*Hispanic N= 59,259*	
Community-level variables[b]	*n (%)*	*Inadequate PNCU (%)*	*n (%)*	*Inadequate PNCU (%)*	*n (%)*	*Inadequate PNCU (%)*	*n (%)*	*Inadequate PNCU (%)*
Hardship								
Quartile 1	55568 (30.8)	12.3	36261 (68.1)	8.7	4988 (8.9)	29.2	8305 (14.0)	18.2
Quartile 2	31177 (17.3)	23.8	10325 (19.4)	17.5	6748 (12.1)	34.7	11540 (19.5)	22.8
Quartile 3	44153 (24.5)	33.0	4585 (8.6)	23.5	24263 (43.4)	38.6	12729 (21.5)	26.8
Quartile 4	49228 (27.3)	33.8	2113 (4.0)	25.4	19940 (35.6)	42.2	26685 (45.0)	28.2
Violent crime rate								
Quartile 1	39164 (21.7)	18.0	22419 (42.1)	13.5	1967 (3.5)	33.7	10411 (17.6)	22.4
Quartile 2	54667 (30.3)	19.4	20507 (38.5)	10.8	5536 (9.9)	30.9	24138 (40.7)	24.5
Quartile 3	42856 (23.8)	25.7	9227 (17.3)	10.8	10813 (19.3)	37.2	20233 (34.1)	27.7
Quartile 4	43439 (24.1)	38.6	1131 (2.1)	27.5	37623 (67.3)	40.4	4477 (7.6)	27.5
NH-Black Isolation								
Quartile 1	51058 (28.3)	19.8	20068 (37.7)	13.3	1229 (2.2)	29.3	26545 (44.8)	24.1
Quartile 2	52561 (29.2)	17.4	26584 (49.9)	10.8	4934 (8.8)	32.9	14722 (24.8)	24.0
Quartile 3	46273 (25.7)	32.2	5758 (10.8)	14.0	22484 (40.2)	40.4	16235 (27.4)	28.7
Quartile 4	30234 (16.8)	37.4	874 (1.6)	26.1	27292 (48.8)	38.5	1757 (3.0)	27.8

[a] Other racial/ethnic groups are not shown.
[b] Each of the community-level variables was categorized into four quantiles (Q1-Q4) based on its distribution, where the most advantaged community areas were grouped into Q1 and the most disadvantaged areas grouped into Q4.

5.2 Effect of Neighborhood Socioeconomic Indicators and Violent Crime on Prenatal Care Utilization: a GIS Analysis

Figure 4 shows the map of the 77 Chicago community areas grouped into seven regions (North, Northwest, West, Central, Southwest, South and Far South) based on the seven health systems planning regions used by the Chicago Department of Planning and Development (DPD). The grouping of Chicago community areas into these regions was necessary for analytic and narrative purposes. While there is no general consensus on how to group Chicago community areas into regions, this regional classification was used because it is often used for health-related purposes in Chicago.

5.2.1 Spatial pattern analysis

The spatial pattern of percent inadequate prenatal care utilization (PNCU) and each of the three community-level variables by Chicago community area is shown in Figure 5. Natural breaks (Jenks) was used as the classification method. Most of the communities with relatively low percent inadequate PNCU were in the North, the Northwest, and the Central regions of Chicago while those with relatively high percent inadequate PNCU were in the West and in the three southern (Southwest, South and Far South) regions of Chicago.

The three community areas in the Central region of Chicago (Near North Side, Loop and Near South Side) and their adjoining community areas in the North (Lincoln Park, Lake View and North Center) had the lowest percent inadequate PNCU (6.2–11.9%). West Town in the West and Mount Greenwood in the Far South had similar low levels of percent inadequate PNCU (10.7% and 10.1%, respectively). Though located in the North where percent inadequate PNCU was generally low, Rogers Park and West Ridge had relatively high percent inadequate PNCU (28.0% and 28.5%, respectively).

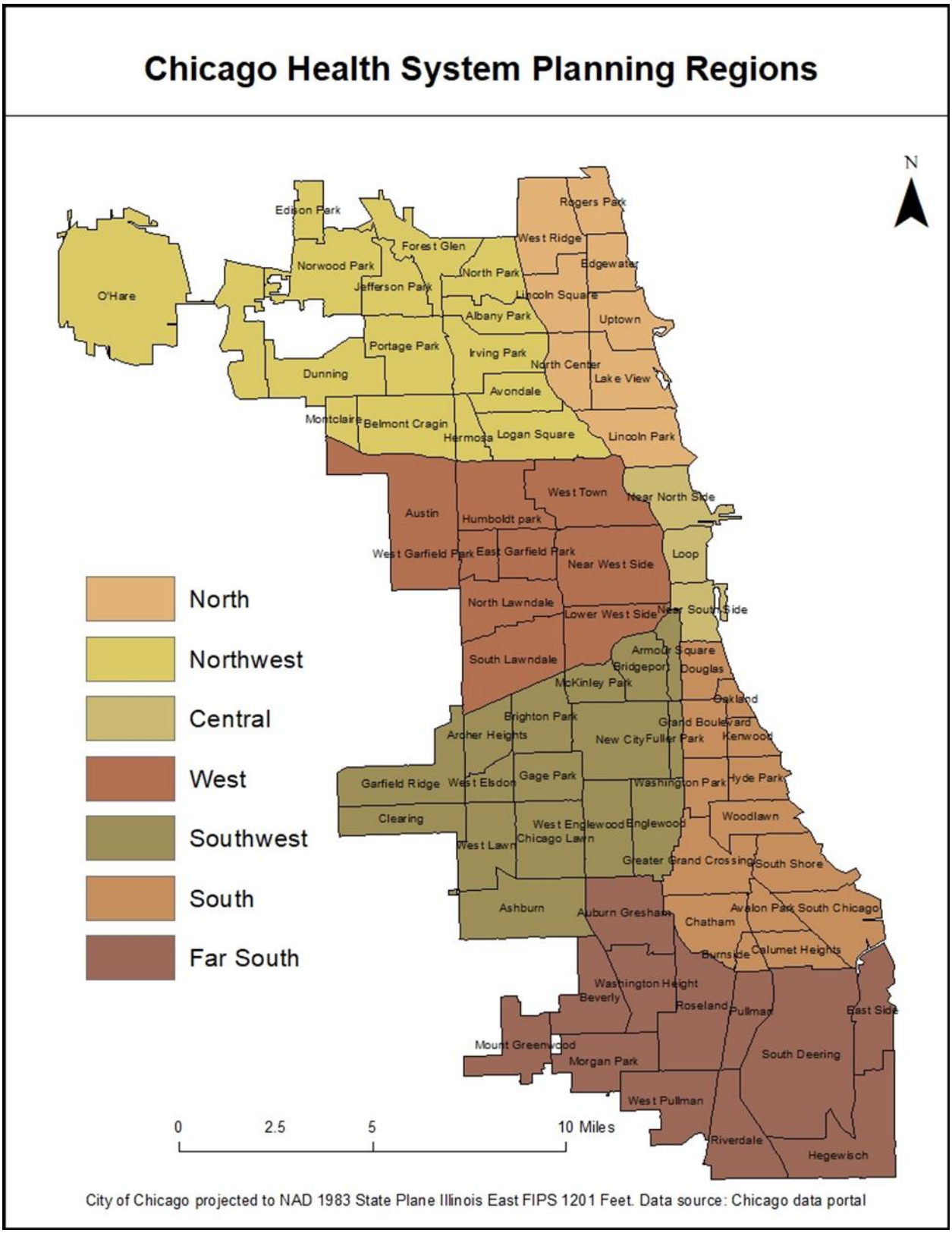


Figure 4. Chicago community areas grouped into seven health systems planning regions used by the Chicago Department of Planning and Development (DPD)

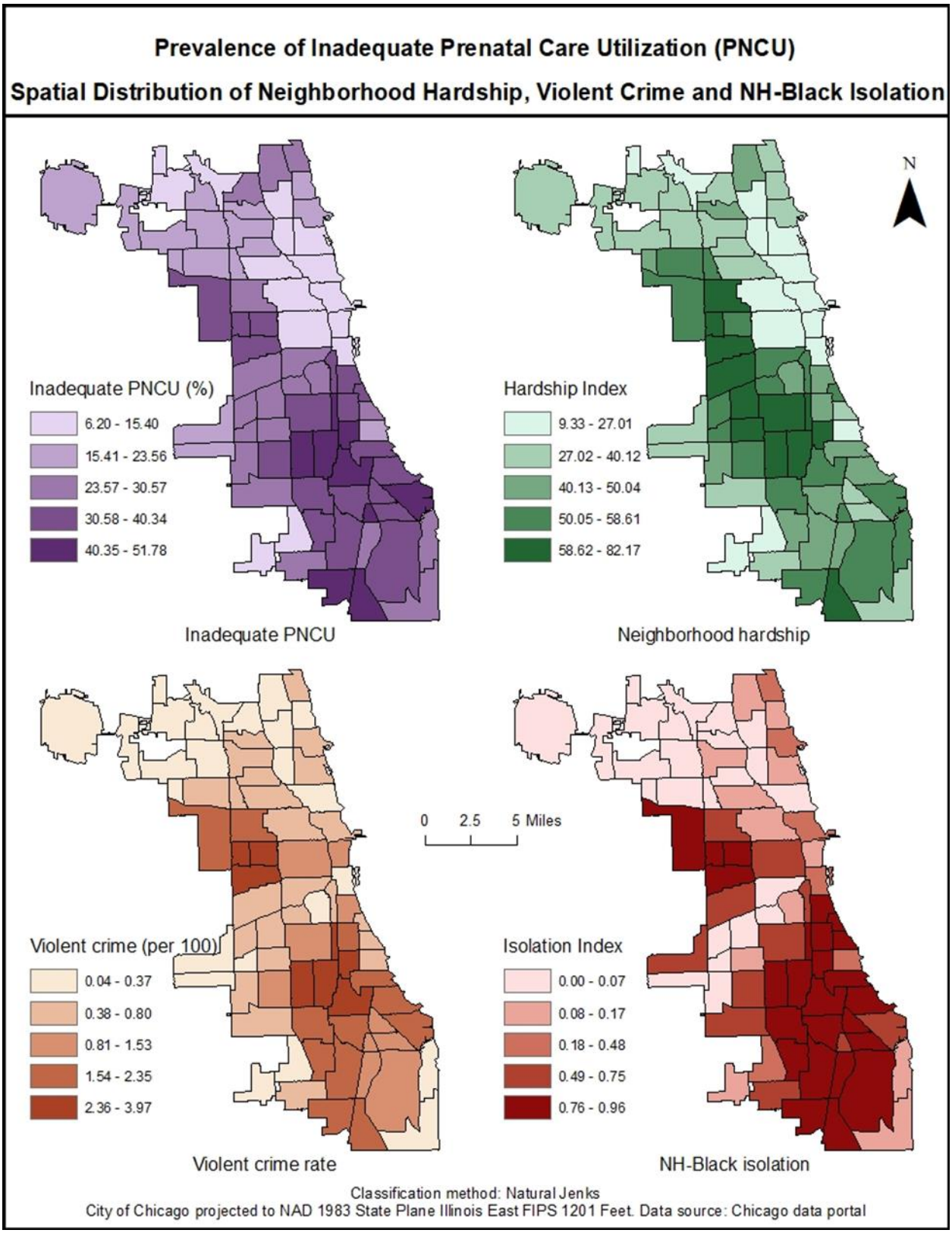


Figure 5. Prevalence of inadequate prenatal care utilization, neighborhood hardship, violent crime rate and Non-Hispanic Black isolation by Chicago community area

In general, the community areas in the West and the three southern (Southwest, South and Far South) regions of Chicago had higher percent inadequate PNCU than any other regions. The communities with the highest percent inadequate PNCU (40.4–51.8%) were Fuller Park, West Englewood and Englewood in the Southwest; Washington Park, Greater Grand Crossing, South Chicago and Burnside in the South; and Riverdale and West Pullman in the Far South regions of Chicago. Three communities in the southern part of Chicago were outliers with respect to percent inadequate PNCU: Hyde Park (19.7%) in the South, and Beverly (13.1%) and Mount Greenwood (10.1%) in the Far South.

The spatial pattern of neighborhood hardship by Chicago community area is similar to the pattern of inadequate prenatal care utilization to a large extent (Figure 5). Neighborhood hardship on a relative scale of 0–100 ranged between 9.3 and 82.2% across Chicago community areas. Like the spatial pattern of inadequate PNCU, the levels of neighborhood hardship for the community areas located in the North (10.9–44.9%), the Northwest (24.7–56.5%), and the Central (9.3–14.1%) regions were generally lower than the levels for the community areas located in the West (22.6–71.2%), the Southwest (35.1–71.1%), the South (25.8–69.0%), and the Far South (24.2–82.2%) regions of Chicago. Level of neighborhood hardship was highly variable in the North and in the West. Community areas located farther north had higher levels of hardship than the other community areas in the North region of Chicago (24.3–44.9% vs. 10.9–14.5%). Similarly, in the West region of Chicago, community areas located farther west had higher levels of hardship than the other community areas in that region (55.3–71.2% vs. 22.6–27.0%).

The location of community areas with high levels of neighborhood hardship was slightly more extensive than that of inadequate PNCU and included more community areas in the West region. The community areas with the highest levels of neighborhood hardship were South Lawndale, West Garfield Park, North Lawndale and Humboldt Park in the West; Gage Park, Englewood, Fuller Park, New City,

Brighton Park and West Englewood in the Southwest; Washington Park in the South; and Riverdale in the Far South regions of Chicago. The same community areas shown by the spatial pattern of percent inadequate PNCU to be outliers in the southern part of Chicago (Figure 5) were also the outliers in the same region with respect to level of neighborhood hardship: Hyde Park (25.8%) in the South, and Beverly (24.2%) and Mount Greenwood (25.8%) in the Far South.

The spatial pattern of community violent crime rate, with a range between 0.04 and 3.97 per 100 residents, was more heterogenous within most of the Chicago regions than the pattern observed for percent inadequate PNCU and neighborhood hardship (Figure 5). Nevertheless, the spatial pattern was similar to that of inadequate PNCU to some extent. In general, the prevalence of violent crime in the West (0.60–2.95), the Southwest (0.22–3.97), the South (0.45–3.52) and the Far South (0.13–2.35) was higher than the prevalence in the North (0.18–0.55), the Northwest (0.04–0.59) and the Central (0.35–0.97) regions of Chicago. In the West region, the communities located farther west had a higher prevalence of violent crime than the other communities in that region (0.8–2.95 vs. 0.60–0.98). In contrast, in the Southwest region, the community areas located in the westernmost part generally had a lower prevalence of violent crime than the other communities in that region (0.22–1.32 vs. 0.30–3.97).

In addition, the spatial pattern of violent crime rate was more locally concentrated than the pattern of percent inadequate PNCU and neighborhood hardship. The community areas with the highest prevalence of violent crime were West Garfield Park, North Lawndale and East Garfield Park in the West (2.51–2.95); Fuller Park, Englewood and West Englewood in the Southwest (2.76–3.97); and Washington Park and Greater Grand Crossing in the South. In the southern part of Chicago, the community areas that were outliers with respect to prevalence of violent crime were Bridgeport, West Elsdon, Garfield Ridge and Clearing in the Southwest region (0.22–0.33); and Beverly, Mount Greenwood, East Side and Hegewisch in the Far South region (0.13–0.34).

The spatial pattern of NH-Black isolation, a measure of racial residential segregation, closely followed the spatial pattern of violent crime and, to a lesser extent, the pattern of inadequate PNCU and neighborhood hardship. The index ranged between 0 and 0.96 across Chicago community areas. In general, the index of NH-Black isolation was low in the Northwest (0.02–0.08), and moderate in the North (0.07–0.33) and the Central (0.15–0.33) regions. The community areas with the highest level of NH-Black isolation were located in the West and in the three southern (Southwest, South and Far South) regions.

In the West, the index of NH-Black isolation ranged between 0.52 and 0.92, not including West Town and Lower West Side where the index was 0.15 and 0.06, respectively. Unlike the community areas in the West region of Chicago, the residents of West Town were mostly NH-whites while the residents of the Lower West Side were mostly Hispanics. In the Southwest of Chicago, the spatial pattern of NH-Black isolation was fairly similar to what was observed for inadequate PNCU, neighborhood hardship, and violent crime. With the exception of Garfield Ridge, Chicago Lawn and Ashburn where the index was 0.58, 0.63 and 0.65 respectively, the community areas located farther west generally had lower level of NH-Black isolation than the other community areas in the Southwest region. Though located in the Southwest region of Chicago, Bridgeport and McKinley Park had a low index of NH-Black isolation (0.11 and 0.05, respectively). The percentage of NH-Blacks in these two community areas was very low compared to the other communities in the east side of the West region of Chicago.

Unlike the pattern in the West and Southwest of Chicago, the pattern of NH-Black isolation in the South and Far South of Chicago was relatively more uniform. In the South, the index of NH-Black isolation ranged from 0.70 to 0.96, excluding Hyde Park where the index was 0.48. The index was also high in the Far South of Chicago (0.48–0.96), not including Hegewisch, Mount Greenwood, and East Side communities in which the index was less than 0.1. The racial/ethnic composition in Hegewisch is

predominantly NH-white and Hispanic. Mount Greenwood has a high percentage of NH-whites, and East Side has a high percentage of Hispanics. The community areas in the West (West Town and Lower West Side) and in the Far South (Hegewisch, Mount Greenwood, and East Side) regions of Chicago that had a low NH-Black isolation relative to the other community areas within the same region also had a low prevalence of violent crime. These findings strongly suggest a spatial relationship between violent crime and NH-Black isolation.

5.2.2 Spatial cluster analysis

Spatial cluster analysis was conducted as a statistical-based method to complement the information that was derived from examining the spatial patterns of inadequate PNCU, neighborhood hardship, community violent crime rate, and NH-Black isolation by Chicago community area. The minimum distance that ensured each community area, excluding O'Hare, had at least eight neighbors obtained from the *average nearest neighbor* estimation was 5.5 miles, which was used for the subsequent incremental autocorrelation and spatial pattern analysis. O'Hare has four neighbors at this distance. A distance band of about 5.5 mile, the first peak distance obtained from spatial incremental autocorrelation for percent inadequate PNCU and the three exposure variables, was used for global and local Moran'*I* indices.

The result of the global test of spatial autocorrelation showed that the spatial distribution of high and/or low values of inadequate PNCU by Chicago community area was more spatially clustered than would be expected by chance (Moran's *I* index= 0.39; z-score= 12.49; $p< 0.0001$). The results of further analysis (Anselin Local Moran's *I* statistic) to map the location of clusters of community areas with high and those with low values of percent inadequate PNCU are presented in Figure 6. The figure also shows the maps of clusters of community areas with high and low values of each of the three community-level variables examined, including the outliers.

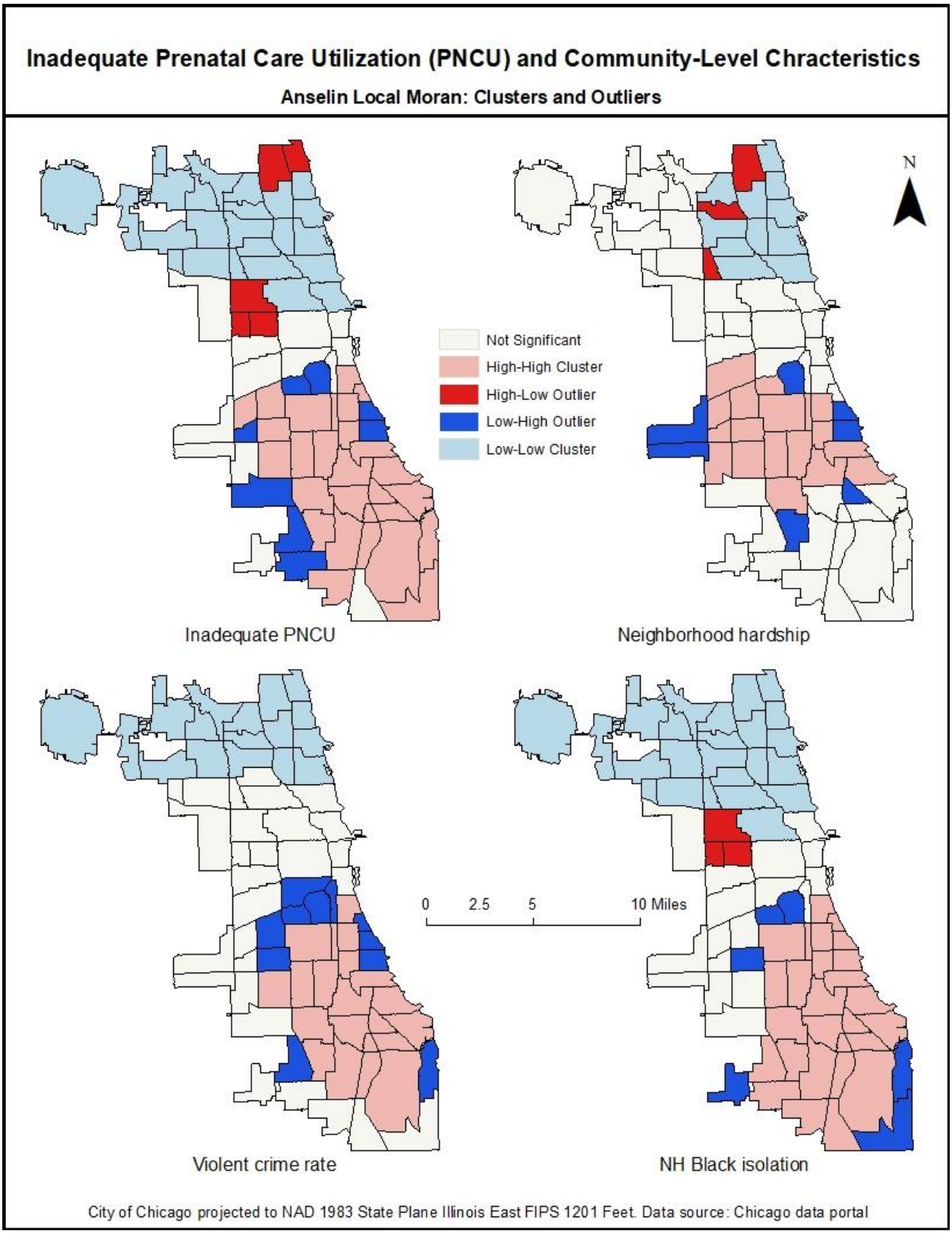


Figure 6. Anselin Local Moran's spatial cluster analysis of inadequate prenatal care utilization, neighborhood hardship, community violent crime rate and Non-Hispanic Black isolation

As expected from the spatial pattern of inadequate PNCU by Chicago community area described above, clusters of community areas with low values were located in the North and Northwest region of Chicago. In the North region, Rogers Park and West Ridge had a significantly higher value of percent inadequate PNCU than the neighboring community areas (depicted as *High-Low* outliers on the map). Although the percent inadequate PNCU among the community areas located in the westernmost part of the West region was higher than those in the Northwest and the North regions, their values were not significantly high enough to be regarded as a cluster. However, three community areas in the West region (Humboldt Park, West Garfield Park, and East Garfield Park) were regarded as having significantly high values relative to the neighboring community areas in the Northwest region.

The community areas in the three southern (Southwest, South and Far South) regions of Chicago were grouped as a *High-High* cluster with some *Low-High* outliers. The high-value cluster spanned almost all the community areas located in the southern part of Chicago excluding only a few communities in the Southwest (Armour Square, Garfield Ridge, Clearing and West Lawn), and two communities in the Far South (Mount Greenwood and Ashburn). All the excluded community areas had a value of percent inadequate PNCU that was less than the mean value [Mean(SD)= 33.60(8.95)] for all the three southern regions, in addition to having at least two neighboring communities with a low value. In addition, seven community areas were classified as *Low-High* outliers in the southern regions of Chicago. They were Bridgeport, McKinley Park, and West Eldson in the Southwest; Kenwood and Hyde Park in the South; and Beverly and Morgan Park in the Far South. Although located in the southern part of Chicago, each of these seven community areas had percent inadequate PNCU that was lower than the mean value [Mean(SD)= 27.42(11.13)] for all community areas in Chicago.

Figure 6 also shows that there was a strong clustering of neighborhood hardship, violent crime, and NH-Black isolation. In fact, the cluster pattern of each of the three community-level variables was

very similar to that of inadequate PNCU. In general, the location of the *Low-Low* cluster of neighborhood hardship, violent crime rate, and NH-Black isolation in the North and Northwest regions was more or less the same as the location of the *Low-Low* cluster of inadequate PNCU. The *Low-Low* cluster of neighborhood hardship included all the communities in the North except West Roger, and a few communities in the Northwest. Similarly, the *High-High* cluster for each of the community-level variables is in the southern part of Chicago as the the *High-High* cluster of inadequate PNCU. The *High-High* cluster of neighborhood hardship was also not as extensive and was limited to the Southwest and the South regions of Chicago. In other words, the percentage of community areas in the significant *Low-Low* cluster of neighborhood hardship, violent crime, and NH-Black isolation that were also in the *Low-Low* significant cluster of inadequate PNCU was 90.1%, 94.1% and 95.8%, respectively. The corresponding percentage of community areas in the significant *High-High* cluster that were also in the significant *High-High* cluster of inadequate PNCU was 77.8%, 100%, and 92.3%, respectively.

5.2.3 Geographically weighted regression

Tables VIII and IX show the results of the ordinary least squares (OLS) regression and the geographically weighted regression (GWR) analyses. Unlike OLS that provides global estimates of the associations between the community-level variables and inadequate PNCU (Table VII), GWR provides local estimates by controlling for spatial heterogeneity across Chicago community areas (Table IX). The associations between neighborhood hardship and inadequate PNCU, and between violent crime and inadequate PNCU were examined with and without adjusting for NH-Black isolation. This was done to assess the effect of neighborhood hardship and violent crime on inadequate PNCU independent of racial residential segregation. While the proportion of variance in percent inadequate PNCU explained by the community-level variables was very high (R-square: OLS= 0.88; GWR=0.94), the results obtained from the GWR provide a better fit to the observed data (AICc: OLS= 435.13; GWR= 399.33).

Table VIII

ORDINARY LEAST SQUARES (GLOBAL) REGRESSION OF THE ASSOCIATION BETWEEN COMMUNITY-LEVEL CHARACTERISTICS AND INADEQUATE PRENATAL CARE UTILIZATION: CHICAGO, 2010–2014 (N= 77)

Community-level variable[a, b]	*β coefficient*	*Standard error*	*95% CI*	*Standardized β coefficient*	*VIF*
	Inadequate PNCU: Neighborhood hardship and violent crime only				
Intercept	4.97	1.52	1.94–7.99		
Neighborhood hardship	0.38	0.04	0.30–0.46	0.56	1.55
Violent crime rate	5.76	0.71	4.34–7.17	0.47	1.55
Adjusted R^2	0.84				
AICc	457.22				
	Inadequate PNCU: Neighborhood hardship, violent crime, and NH-Black isolation				
Intercept	3.74	1.33	1.09–6.38		
Neighborhood hardship	0.38	0.03	0.31–0.45	0.56	1.55
Violent crime rate	2.44	0.88	0.68–4.20	0.20	3.22
NH-Black isolation	10.24	1.96	6.32–14.15	0.34	2.64
Adjusted R^2	0.88				
AICc	435.13				

[a] Neighborhood hardship was measured on a relative scale of 0–100, while NH-Black isolation was measured on a scale of 0–1. Violent crime rate was measured per 100 residents.

[b] AICc: Akaike Information Criterion, corrected

Table IX

GEOGRAPHICALLY WEIGHTED REGRESSION[a] OF THE ASSOCIATION BETWEEN COMMUNITY-LEVEL CHARACTERISTICS AND INADEQUATE PRENATAL CARE UTILIZATION: CHICAGO, 2010–2014 (N= 77)

Community-level variable[b, c]	*Minimum*	*Lower quartile*	*Median*	*Upper quartile*	*Maximum*	Interquartile range
	Inadequate PNCU: Neighborhood hardship and violent crime only					
Intercept	1.91	3.52	6.04	11.03	16.78	7.51
Neighborhood hardship	0.24	0.31	0.35	0.39	0.52	0.08
Violent crime rate	0.51	4.15	4.86	5.41	7.41	1.26
Adjusted R^2	0.93					
AICc	406.08					
	Inadequate PNCU: Neighborhood hardship, violent crime, and NH-Black isolation					
Intercept	-1.30	3.01	4.35	6.30	16.84	3.29
Neighborhood hardship	0.25	0.35	0.37	0.39	0.51	0.05
Violent crime rate	-9.95	0.63	3.04	3.50	5.38	2.86
NH-Black isolation	-0.26	6.45	8.99	11.34	27.00	4.88
Adjusted R^2	0.94					
AICc	399.33					

[a] Fixed distance bandwidth= 4.65 miles. The summary of the results of the geographically weighted regression shows the spread (variability) of the regression coefficient for each of the explanatory variables across space.

[b] Neighborhood hardship was measured on a relative scale of 0–100, NH-Black isolation was measured on a scale of 0–1, and violent crime rate was measured per 100 residents.

[c] AICc: Akaike Information Criterion, corrected.

For the global results (OLS), the associations between neighborhood hardship and inadequate PNCU, and between violent crime and inadequate PNCU were statistically significant with and without adjustment for NH-Black isolation. After adjusting for NH-Black isolation, the regression coefficient for neighborhood hardship was about the same while that for violent crime was reduced, though still significant. This suggests that effect of neighborhood hardship on prenatal care utilization is largely independent of NH-Black isolation while the effect of violent crime on prenatal care utilization is partly dependent on NH-Black isolation.

In the full model, with the three community-level variables, a 10% increase in neighborhood hardship, on a relative scale of 0–100, was associated with an average increase of 3.8% in inadequate PNCU (95% CI: 3.13–4.48). On average, the percentage of residents with inadequate PNCU in Chicago community areas increased by 2.4% for every increase in violent crime rate by 1 per 100 residents (95% CI: 0.68–4.20), and by 10.2% for every increase in NH-Black isolation by 0.1 on the *Isolation Index* (95% CI: 0.06–0.14). Not adjusting for NH-Black isolation, the percentage increase in inadequate PNCU at the community level was about 5.8% for every increase in violent crime rate by 1/100 residents (95% CI: 4.34–7.17). Based on the standardized beta coefficients, neighborhood hardship explained more of the variation in inadequate prenatal care utilization than violent crime and NH-Black isolation. Although the community-level variables were correlated, the variance inflation factor did not suggest any evidence of multicollinearity (Table VIII).

The GWR 5-number parameter summary of the associations between neighborhood hardship and inadequate PNCU, and violent crime and inadequate PNCU with and without adjustment for NH-Black isolation are shown in Table IX. The results suggest evidence of local variation in the regression coefficient of each of the community-level variables across Chicago community areas. Thus, the global summaries of the associations between the variables and inadequate PNCU are not adequate for

understanding the local variability in inadequate PNCU across Chicago community areas. The 5-number parameter summary for neighborhood hardship is about the same with and without adjustment for NH-Black isolation. However, the local coefficients of the association between violent crime and inadequate PNCU were reduced, and their variability across Chicago community area was increased after adjusting for NH-Black isolation. These findings are in line with those obtained from the OLS regression analysis.

Figure 7 displays the variation in the local R-squared and the local regression coefficients of the associations between neighborhood hardship and inadequate PNCU, and between violent crime and inadequate PNCU across Chicago community areas. Community areas where the local regression coefficient was not statistically significant were masked out (white, no color). As shown in the first map of Figure 7, the value of the local R-squared ranged between 0.49 and 0.91 with a mean of 0.83. O' Hare had the least local R-squared value (R2= 0.49), probably because only a few community areas were regarded as its neighbors in the local model regression due to its large size and location relative to the other community areas. Excluding O'Hare, the least local R-square value was 0.66, which suggests that the GWR model fit the observed data for each community area quite well.

Figure 7 also displays the spatially varying association between each of the exposure variables and percent inadequate PNCU. There was a significant positive association between neighborhood hardship and inadequate PNCU in all community areas. However, the strength of the association varied by community area and was highest in the North, the Northwest, the Central, and the westernmost part of the Far South regions of Chicago. Similarly, the association between violent crime and inadequate PNCU varied across Chicago community areas. However, the strength of the association was low in the North and the Northwest regions, moderate in the West and the Central regions, and high in the three southern regions (Southwest, South and Far South) of Chicago, especially in the Far South region.

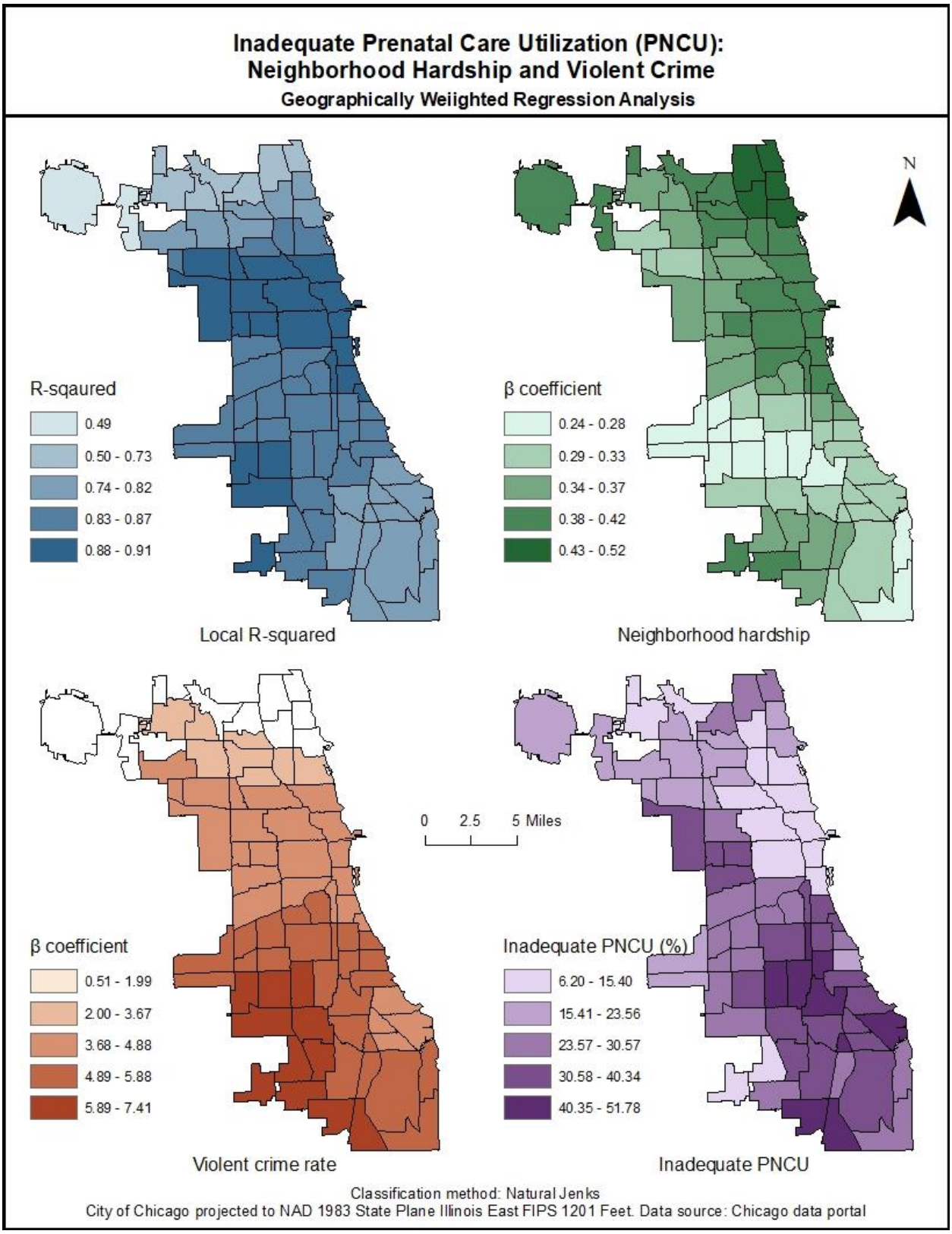


Figure 7. Prenatal care utilization: spatial variation in the regression coefficient for neighborhood hardship and community violent crime rate

A closer look at the four maps in Figure 7 shows that the strength of the association between neighborhood hardship and percent inadequate PNCU was relatively high in the community areas in the North, Northwest and Central regions where percent inadequate PNCU is low. The levels of neighborhood hardship and violent crime were also low in these community areas (Figure 5). Given the complex relationship between the two community-level variables, adjusting for violent crime in the estimation of the association between neighborhood hardship and inadequate prenatal care utilization has varying effects for different community areas– the effect depends on the level of neighborhood hardship and the rate of violent crime. In contrast, the local variation in the coefficient for violent crime is similar to the spatial pattern of percent inadequate PNCU after adjusting for neighborhood hardship, especially in the three southern (Southwest, South and Far South) regions of Chicago.

Figure 8 displays the variation in the local R-square values and the local regression coefficients obtained from a geographically weighted regression model that include neighborhood hardship, violent crime, and NH-Black isolation. The coefficient of the association between neighborhood hardship and inadequate prenatal care utilization, and its variability across Chicago community areas only changed to a small extent after adjusting for NH-Black isolation. However, the association between violent crime and inadequate prenatal care utilization became bidirectional and the strength of the association was generally reduced across Chicago community areas after adjusting for NH-Black isolation.

The association between violent crime and inadequate prenatal care utilization in the community areas in the North and the Northwest regions of Chicago where the strength of association was initially low was no longer significant, and the direction of the association became negative in the community areas where the association was initially not significant (Figure 8). These findings strongly suggest that most of the effects of neighborhood hardship on prenatal care utilization, after adjusting for community violent crime rate, are independent of NH-Black isolation. However, the effects of

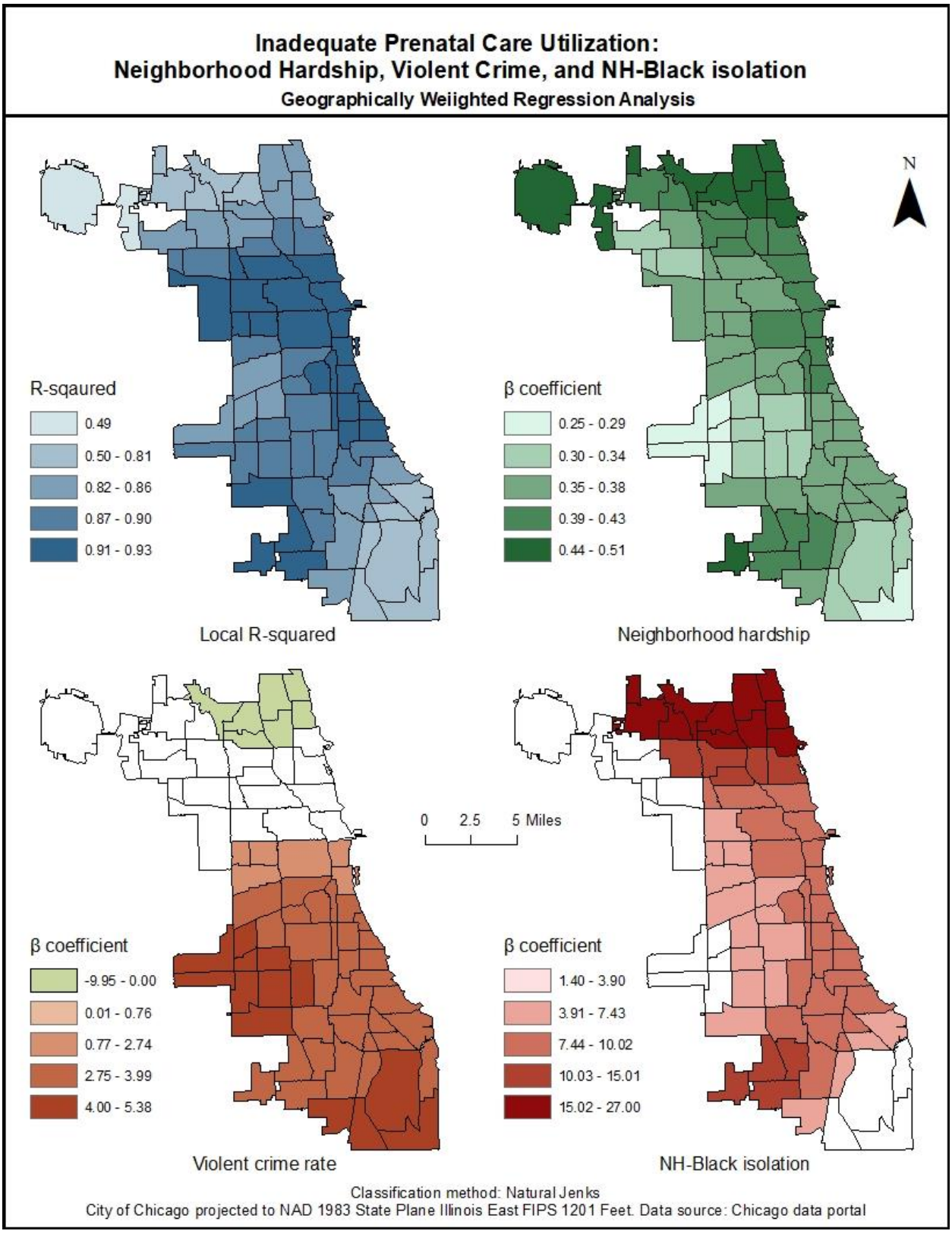


Figure 8. Prenatal care utilization: spatial variation in the regression coefficient for neighborhood hardship and community violent crime rate adjusted for Non-Hispanic Black isolation

community violent crime rate on inadequate prenatal care utilization are related to NH-Black isolation to a considerable extent.

The interpretation of the local variation in the association between NH-Black isolation and inadequate prenatal care utilization is not very straightforward. As previously mentioned, there were similarities in the spatial patterns of violent crime and NH-Black isolation by Chicago community area (Figure 5). The local regression coefficients for NH-Black isolation mapped in Figure 8 are measures of its residual association with inadequate prenatal care utilization. This is because the regression model used to estimate the coefficients included neighborhood hardship and community violent crime rate, both of which are potential mediators of the association between NH-Black isolation and inadequate prenatal care utilization. Consequently, it is not surprising that the residual association of NH-Black isolation with inadequate prenatal care utilization was most marked in the community areas in the North, some communities in the Northwest, and the communities in the westernmost part of the Far South regions of Chicago where the levels of neighborhood hardship and violent crime were relatively low (see Figure 5 and Figure 8).

The relationships between the three community-level variables with respect to inadequate prenatal care utilization are very complex. Figures 10–12, Appendix B provide more information about the magnitude and variability in the coefficient of the association between each of the three community-level variables and inadequate prenatal care utilization, with and without adjustment for other community-level variables to illustrate their complex, intertwined relationships.

In sum, there is evidence of spatial disparities in prenatal care utilization in the city of Chicago. Also, the spatial pattern of inadequate prenatal care utilization closely follows the spatial distributions of neighborhood hardship, community violent crime rate, and Non-Hispanic Black isolation across Chicago community areas. The high-level cluster of inadequate prenatal care utilization and each of the three

community-level variables include most of the community areas in the South, the Southwest, and the Far South regions of Chicago. The community areas with high levels of percent inadequate prenatal care utilization, neighborhood hardship, community violent crime rate and NH-Black isolation include Fuller Park, Englewood and West Englewood in the Southwest region, Washington Park in the South, and Riverdale in the Far South region.

Each of the three community-level variables is significantly associated with inadequate prenatal care utilization and their coefficients of association vary across the city of Chicago. Neighborhood hardship explained more of the variation in inadequate prenatal care utilization than violent crime and NH-Black isolation. Unlike violent crime and NH-Black isolation, neighborhood hardship is ubiquitously associated with inadequate prenatal care utilization in all Chicago community areas. The strength of the association between violent crime and inadequate prenatal care utilization is low in the North and the Northwest regions, moderate in the West and the Central regions, and high in the three southern regions (Southwest, South and Far South) of Chicago, especially in the Far South region.

5.3 Effect of Neighborhood Socioeconomic Indicators and Violent Crime on Prenatal Care Utilization: a Multilevel Regression Analysis

Table X shows the estimates obtained from the *unconditional random-intercept* logistic regression model used to assess for the variability in inadequate prenatal care utilization across Chicago community areas. Based on the likelihood-ratio test that compared the *unconditional* model with and without a random intercept, there was a significant amount of variability in the probability of having inadequate prenatal care utilization at the neighborhood level (Chi-Square= 11808.9, *df*=1, *p*<0.0001). About 10.9% of the variability in the log odds of inadequate prenatal care utilization could be accounted for at the community level (τ_{00}= 0.404, ICC=0.109). For a typical community (u_{oj}= 0), the probability of receiving inadequate prenatal care was 0.26 (Y_{00}= -1.07, se=0.073). The probability of inadequate PNCU

Table X

PRELIMINAY MULTILEVEL REGRESSION MODELS FOR THE ASSOCIATION BETWEEN COMMUNITY-LEVEL CHARACTERISTICS AND INADEQUATE PRENATAL CARE UTILIZATION: CHICAGO, 2010–2014 (N=180,216)

Variables	*Unconditional Model OR (95% CI)*	*Model 1*[a] *OR (95% CI)*	*Model 2*[b] *OR (95% CI)*
Individual-level variables			
Maternal race			
Non-Hispanic White		Reference	Reference
Non-Hispanic Black		1.43 (1.36–1.50)	1.35 (1.22–1.50)
Hispanic		0.90 (0.86–0.94)	0.96 (0.86–1.07)
Other race/ethnicity		1.29 (1.22–1.37)	1.04 (0.89–1.23)
Maternal age			
Less than 19 years		1.55 (1.49–1.61)	1.69 (1.35–2.12)
20–34 years		Reference	Reference
35 years and above		0.80 (0.77–0.83)	0.83 (0.76–0.90)
Maternal level of education			
Less than 12 years		1.50 (1.45–1.55)	1.72 (1.53–1.93)
12 years		1.34 (1.30–1.38)	1.59 (1.44–1.74)
More than 12 years		Reference	Reference
Marital status			
Married		Reference	Reference
Not married		1.36 (1.32–1.40)	1.33 (1.21–1.47)
Parity			
No prior live birth		Reference	Reference
1 or 2 live births		1.19 (1.15–1.22)	1.18 (1.09–1.28)
3 or more prior live births		1.60 (1.54–1.66)	1.48 (1.20–1.82)
Plurality			
Singleton gestation		Reference	Reference
Multiple gestations		0.54 (0.50–0.58)	0.56 (0.51–0.60)
Medical/reproductive risk			
No		Reference	Reference
Yes		0.75 (0.73–0.78)	0.91 (0.84–0.98)
Smoking during pregnancy			
No		Reference	Reference
Yes		1.68 (1.58–1.78)	1.58 (1.49–1.68)
Alcohol during pregnancy			
No		Reference	Reference
Yes		1.34 (1.17–1.53)	1.33 (1.16–1.52)
Health insurance status			
Private Insurance		Reference	Reference
Medicaid		1.93 (1.86–2.00)	1.44 (1.35–1.54)
Uninsured/Self-pay		5.90 (5.29–6.59)	3.64 (2.95–4.48)
Others		2.25 (2.10–2.41)	1.69 (1.48–1.93)
Error variance[c]			
Level-2 intercept (τ_{00})	0.404 (0.066)[d]	0.056 (0.010)	0.047 (0.008)
Model fit (-2LL)	191672.6	181139.9	180096.4

[a] Model 1 is a random-intercept logic regression model with only the individual-level variables.

[b] Model 2 is a random-intercept with only the individual-level variables and their significant interactions: race/ethnicity with education, parity, and insurance status; insurance status with maternal age, education, marital status, and parity; maternal age with marital status and parity; education with marital status and parity; marital status with parity; and gestation with med/reproductive risk.

[c] Likelihood ratio test of significance of random intercept (Chi-Square= 11808.9, *df*=1, p<0.0001).

[d] Intra-class correlation (ICC)= 10.9%.

ranged between 0.06 and 0.50 across Chicago community areas, with an estimated population (marginal) average of 0.27.

The estimates obtained from two separate random-intercept logistic regression models, one with only the individual-level variables (Model 1) and the other with only the individual level variables with their significant interactions (Model 2), are also shown in Table X. Model 2 explains more of the variability in inadequate PNCU at the individual level than Model 1 because the proportional change in neighborhood variance relative to the *unconditional* model is slightly higher after the addition of individual-level significant interactions terms (88% vs. 86%); it also fits the observed data better than Model 1 (Chi-Square= 1043.5, df=63, p<0.0001). Thus, Model 2 was used to examine the contextual effects of neighborhood on prenatal care utilization above the compositional influences of the characteristics of the residents. All the individual-level variables included in Model 2 were associated with inadequate prenatal care utilization.

The significant association between each of the individual-level variables and inadequate prenatal care did not change in any of the models that include community-level variables (Table XI, Model 3a-9a). The proportion of the residual neighborhood variance in Model 2 explained by the addition of the three community-level variables examined was 43% (Table XI, Model 9a). This suggests that neighborhood hardship, community-level violent crime rate, and NH-Black isolation accounted for a considerable proportion of variability in inadequate PNCU across Chicago community areas after adjusting for the individual-level compositional influences.

Table XI also show the estimates from *random-intercept with non-random slopes* regression models used to examine the contextual effects of the three community-level characteristics. The contextual effects of each community-level variable on prenatal care utilization was examined before (Model 3a–5a) and after (Model 6a–9a) adjusting for the effects of other community-level variables.

Adjusting for Non-Hispanic Black isolation allowed for the estimation of the contextual effects of neighborhood hardship and violent crime on prenatal care utilization independent of racial residential segregation. On the other hand, adjusting for neighborhood hardship and violent crime allowed for the estimation of the residual effect of NH-Black isolation on prenatal care utilization (see Theoretical Framework, Figure 2). Neighborhood hardship alone explained more of the variability in inadequate PNCU across Chicago community areas than NH-Black isolation and community violent crime rate combined (Table XI, Model 3a vs. 8a: τ_00= 0.030 and 0.037, respectively).

Each of the three community-level variables was associated with inadequate prenatal care utilization above the influence of individual-level variables and their significant interactions, not adjusting for other community-level variables (Table XI, Models 3a–5a). The significant association between neighborhood hardship and inadequate PNCU (OR=1.09, 95% CI: 1.06–1.12) was only slightly reduced after adjusting for community violent crime rate (OR=1.08, 95% CI: 1.05–1.12), or NH-Black isolation (OR=1.07, 95% CI: 1.04–1.10). However, the significant association between community violent crime rate and inadequate PNCU (OR=1.11, 95% CI: 1.05–1.17) was no longer significant after adjusting for neighborhood hardship or NH-Black isolation.

These findings suggest that neighborhood hardship has some effects on prenatal care utilization beyond individual-level compositional effects, independent of racial residential segregation and community violent crime in Chicago (Table XI, Model 9a). However, the effects of violent crime on prenatal care utilization among Chicago mothers is dependent on both neighborhood hardship and racial residential segregation (Non-Hispanic Black isolation). Both neighborhood hardship and community violent crime rate appeared to mediate the effects of NH-Black isolation on prenatal care utilization. The significant effects of NH-Black isolation on inadequate PNCU (OR= 1.03, 95% CI: 1.02–1.04) was no longer significant after adjusting for neighborhood hardship or community violent crime

Table XI

MULTILEVEL LOGISTIC REGRESSION MODELS OF THE ASSOCIATION BETWEEN COMMUNITY-LEVEL CHARACTERISTICS AND INADEQUATE PRENATAL CARE UTILIZATION: CHICAGO, 2010–2014 (N=180,216)

Variables[a]	*Model 3a* *OR (95% CI)*	*Model 4a* *OR (95% CI)*	*Model 5a* *OR (95% CI)*	*Model 6a* *OR (95% CI)*	*Model 7a* *OR (95% CI)*	*Model 8a* *OR (95% CI)*	*Model 9a* *OR (95% CI)*
Individual-level variables							
Maternal race							
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.32 (1.19–1.47)	1.33 (1.20–1.48)	1.32 (1.19–1.47)	1.32 (1.19–1.46)	1.32 (1.19–1.46)	1.32 (1.19–1.47)	1.32 (1.19–1.47)
Hispanic	0.94 (0.84–1.05)	0.96 (0.86–1.07)	0.96 (0.86–1.07)	0.94 (0.84–1.05)	0.95 (0.85–1.06)	0.96 (0.86–1.07)	0.95 (0.85–1.06)
Other race/ethnicity	1.04 (0.88–1.22)	1.05 (0.89–1.23)	1.04 (0.89–1.23)	1.04 (0.88–1.22)	1.04 (0.89–1.22)	1.05 (0.89–1.23)	1.04 (0.88–1.22)
Maternal age							
Less than 19 years	1.69 (1.35–2.11)	1.69 (1.35–2.12)	1.69 (1.35–2.11)	1.69 (1.35–2.11)	1.69 (1.35–2.11)	1.69 (1.35–2.11)	1.69 (1.35–2.11)
20–34 years	Reference	Reference	Reference	Reference	Reference	Reference	Reference
35 years and above	0.83 (0.76–0.90)	0.83 (0.76–0.90)	0.83 (0.76–0.90)	0.83 (0.76–0.90)	0.83 (0.76–0.90)	0.83 (0.76–0.91)	0.83 (0.75–0.90)
Maternal education							
Less than 12 years	1.72 (1.53–1.93)	1.72 (1.53–1.93)	1.72 (1.53–1.93)	1.72 (1.53–1.93)	1.71 (1.52–1.92)	1.72 (1.53–1.93)	1.71 (1.52–1.92)
12 years	1.58 (1.43–1.73)	1.58 (1.44–1.74)	1.58 (1.44–1.74)	1.58 (1.43–1.73)	1.58 (1.43–1.74)	1.58 (1.44–1.74)	1.58 (1.43–1.73)
More than 12 years	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Marital status							
Married	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Not married	1.31 (1.19–1.44)	1.33 (1.21–1.47)	1.33 (1.21–1.47)	1.31 (1.19–1.44)	1.33 (1.20–1.46)	1.33 (1.21–1.47)	1.33 (1.20–1.46)
Parity							
No prior live birth	Reference	Reference	Reference	Reference	Reference	Reference	Reference
1 or 2 live births	1.18 (1.09–1.28)	1.18 (1.09–1.28)	1.18 (1.09–1.28)	1.18 (1.09–1.28)	1.18 (1.09–1.28)	1.18 (1.09–1.28)	1.18 (1.09–1.28)
≥3 prior live births	1.47 (1.19–1.82)	1.47 (1.19–1.82)	1.47 (1.19–1.82)	1.47 (1.19–1.82)	1.47 (1.19–1.81)	1.47 (1.19–1.82)	1.47 (1.19–1.81)
Plurality							
Singleton gestation	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Multiple gestations	0.56 (0.51–0.60)	0.56 (0.51–0.60)	0.56 (0.51–0.60)	0.56 (0.52–0.60)	0.56 (0.52–0.60)	0.56 (0.51–0.60)	0.56 (0.52–0.60)
Med/reproductive risk							
No	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Yes	0.90 (0.84–0.97)	0.91 (0.84–0.98)	0.91 (0.84–0.98)	0.90 (0.84–0.97)	0.91 (0.84–0.98)	0.91 (0.84–0.98)	0.91 (0.84–0.98)
Smoking in pregnancy							
No	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Yes	1.58 (1.49–1.68)	1.58 (1.49–1.68)	1.58 (1.49–1.68)	1.58 (1.49–1.68)	1.58 (1.49–1.67)	1.58 (1.49–1.68)	1.58 (1.49–1.68)
Alcohol use in pregnancy							
No	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Yes	1.32 (1.16–1.51)	1.33 (1.16–1.52)	1.33 (1.16–1.52)	1.32 (1.16–1.51)	1.33 (1.16–1.52)	1.33 (1.16–1.52)	1.33 (1.16–1.52)
Health insurance status							
Private Insurance	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Medicaid	1.43 (1.34–1.53)	1.44 (1.35–1.54)	1.44 (1.35–1.54)	1.43 (1.34–1.53)	1.44 (1.35–1.54)	1.44 (1.35–1.54)	1.44 (1.35–1.54)
Uninsured/Self-pay	3.55 (2.89–4.37)	3.63 (2.95–4.46)	3.63 (2.94–4.46)	3.56 (2.89–4.37)	3.62 (2.94–4.45)	3.63 (2.94–4.46)	3.61 (2.93–4.44)
Others	1.70 (1.49–1.94)	1.69 (1.48–1.93)	1.69 (1.48–1.93)	1.70 (1.49–1.94)	1.69 (1.48–1.92)	1.69 (1.48–1.93)	1.69 (1.48–1.92)

Table XI (continued)

MULTILEVEL LOGISTIC REGRESSION MODELS OF THE ASSOCIATION BETWEEN COMMUNITY-LEVEL CHARACTERISTICS AND INADEQUATE PRENATAL CARE UTILIZATION: CHICAGO, 2010–2014 (N=180,216)

Variables[a]	*Model 3a* *OR (95% CI)*	*Model 4a* *OR (95% CI)*	*Model 5a* *OR (95% CI)*	*Model 6a* *OR (95% CI)*	*Model 7a* *OR (95% CI)*	*Model 8a* *OR (95% CI)*	*Model 9a* *OR (95% CI)*
Community-level variables							
Neighborhood hardship	1.09 (1.06–1.12)*			1.08 (1.05–1.12)*	1.07 (1.04–1.10)*		1.08 (1.05–1.12)*
Violent crime rate		1.11 (1.05–1.17)*		1.02 (0.96–1.08)		1.03 (0.95–1.12)	0.94 (0.86–1.02)
NH-Black isolation			1.03 (1.02–1.04)*		1.02 (1.00–1.03)	1.02 (1.00–1.05)	1.03 (1.01–1.04)*
Error variance							
Level-2 intercept (τ_{00})	0.030 (0.005)	0.040 (0.007)	0.038 (0.007)	0.030 (0.005)	0.028 (0.005)	0.037 (0.007)	0.027 (0.005)
Model fit (-2LL)	180066.3	180083.4	180079.2	180065.9	180058.5	180078.7	180056.3

[a] Neighborhood hardship, violent crime rate and NH-Black isolation were scaled to unit increase of 10%, 0.1 and 1 per 100 residents, respectively.

* Significant at α=0.05, not indicated for the individual-level variables.

rate. A formal mediation analysis of the relationships between the three community-level variables is beyond the scope of this study's objectives and will be considered for future analyses.

In the full model (Table XI, Model 9a), an increase in neighborhood hardship by 10%, on a relative scale of 0–100, increased the odds of inadequate prenatal care utilization for Chicago mothers by 8%, holding random variability across Chicago community areas constant (OR=1.08, 95% CI: 1.05–1.12). The central 80% range of the distribution of odds ratios (the interval odds ratio [IOR]) between two mothers with the same individual-level covariates randomly selected from two community areas that differed only in neighborhood hardship by 10 on the Hardship Index was 0.80–1.45. The interval contains 1, meaning that the association was in the opposite direction for some neighborhoods that differed by 10 on the index. The proportion of opposed odds ratio (POOR), that is, the percentage of community areas in the opposite direction of the of the overall odds ratio was 36%. However, the odds of inadequate PNCU for Chicago mothers living in Riverdale, South Lawndale and Gage Park where the neighborhood hardship index was above 70 were about twice the odds of mothers living in Lake View, Loop and Near North Side where neighborhood hardship was less than 10 (OR= 1.62, 95% CI: 1.35–1.94; IOR= 1.12–2.17; POOR= 2%).

There was no significant association between community violent crime rate and inadequate prenatal care utilization in the model that adjusted for both neighborhood hardship and NH-Black isolation (Table XI, Model 9a). Nevertheless, additional multilevel regression analysis was conducted to examine the effect of community violent crime rate on inadequate PNCU for Chicago mothers in the three southern (South, Southwest, and Far South) regions of Chicago. This was informed by the findings from the geographically weighted analysis (Study 1) that showed that the effect of violent crime was more profound in these regions than any other regions in Chicago. After adjusting for neighborhood hardship and NH-Black isolation, an increase in community violent crime rate by 1 per 100 residents

increased the odds of inadequate prenatal care utilization by 6% for Chicago mothers living in the three southern regions of Chicago, holding the random variability at the community level constant (OR= 1.06, 95% CI: 1.01–1.12; IOR= 0.78–1.43; POOR= 40%) (Table XXII, Appendix B). Regional differences in the associations of neighborhood hardship and NH-Black isolation with inadequate prenatal care utilization are also shown in Table XXII, Appendix B.

After adjusting for neighborhood hardship and violent crime (Model 9a), living in a community area with a NH-Black isolation of 10 percentage points (i.e., 0.1 on the *Isolation Index*) above the average increased the odds of inadequate PNCU by 3% for Chicago mothers (OR= 1.03, 95% CI: 1.01–1.04 IOR= 0.74–1.35; POOR= 49%). The odds increased by 34% (OR= 1.34, 95% CI: 1.17–1.52; IOR= 1.00–1.80; POOR= 10%) for mothers living in community areas such as Roseland, Washington Park and Riverdale with high levels of NH-Black isolation above 0.9 relative to those living in community areas such as Edison Park, Forest Glen and Norwood Park where NH-Black isolation is negligible.

Table XII shows the results of the multilevel regression analysis of the association between the community-level variables and inadequate prenatal care utilization by racial/ethnic group. As obtained for all racial/ethnic groups combined (Table XI Model 3a–5a), each of the three community-level variables was associated with inadequate prenatal care utilization above the influence of individual-level variables and their significant interactions, not adjusting for other community-level variables (Table XII, Model 3b–5b). However, the strength of the associations between the community-level variables and inadequate prenatal care utilization differed by race/ethnicity.

In the regression model with neighborhood hardship as the only community-level variable (Table XII, Model 3b), the increase in the odds of inadequate prenatal care with a unit increase in neighborhood hardship was highest for NH-white and lowest for NH-Black mothers, holding random effects constant. The odds increased by 13% for NH-white mothers, 4% for NH-Black mothers, and 9%

Table XII

MULTILEVEL LOGISTIC REGRESSION MODELS OF THE ASSOCIATION BETWEEN COMMUNITY-LEVEL CHARACTERISTICS AND INADEQUATE PRENATAL CARE UTILIZATION BY RACE/ETHNICITY: CHICAGO, 2010–2014 (N=180,216)

Community-level variables[b]	*Model 3b*[a] *OR (95% CI)*	*Model 4b OR (95% CI)*	*Model 5b OR (95% CI)*	*Model 6b OR (95% CI)*	*Model 7b OR (95% CI)*	*Model 8b OR (95% CI)*	*Model 9b OR (95% CI)*
	Non-Hispanic White						
Neighborhood hardship	1.13 (1.09–1.16)*			1.11 (1.07–1.15)*	1.11 (1.07–1.15)*		1.11 (1.07–1.15)*
Violent crime rate		1.26 (1.15–1.38)*		1.11 (1.01–1.22)*		1.25 (1.08–1.44)*	1.08 (0.93–1.24)
NH-Black isolation			1.04 (1.02–1.06)*		1.02 (1.00–1.04)	1.01 (0.97–1.04)	1.01 (0.98–1.04)
	Non-Hispanic Black						
Neighborhood hardship	1.04 (1.01–1.07)*			1.05 (1.01–1.08)*	1.04 (1.01–1.07)*		1.05 (1.01–1.09)*
Violent crime rate		1.05 (1.01–1.12)*		1.00 (0.94–1.07)		1.01 (0.93–1.11)	0.95 (0.87–1.04)
NH-Black isolation			1.01 (1.00–1.03)		1.01 (0.99–1.02)	1.01 (0.97–1.04)	1.02 (0.99–1.04)
	Hispanic						
Neighborhood hardship	1.09 (1.06–1.13)*			1.07 (1.03–1.11)*	1.07 (1.04–1.11)*		1.07 (1.04–1.11)*
Violent crime rate		1.24 (1.16–1.34)*		1.14 (1.05–1.23)*		1.14 (1.01–1.29)*	1.03 (0.92–1.17)
NH-Black isolation			1.05 (1.03–1.07)*		1.03 (1.01–1.05)*	1.02 (1.00–1.05)	1.03 (1.00–1.05)
Error variance							
Level-2 intercept (τ_{00})	0.029 (0.005)	0.040 (0.007)	0.039 (0.007)	0.028 (0.005)	0.026 (0.005)	0.039 (0.007)	0.027 (0.005)
Model fit (-2LL)	180031.6	180044.7	180056.0	180012.40	180015.0	180041.0	180007.80

[a] Models 3b-9b are the same as Model 3a-9a, respectively, with interaction terms between the community level variables and race/ethnicity included.

[b] Neighborhood hardship, violent crime rate and NH-Black isolation were scaled to unit increase of 10%, 0.1 and 1 per 100 residents, respectively

* Significant at α=0.05

for Hispanic mothers for every 10% increase in neighborhood hardship (OR= 1.13 [1.09–1.16], OR=1.04 [1.01–1.07], and OR= 1.09 [1.06–1.13], respectively). Similarly, in the model that included community violent crime rate as the only community-level variable (Model 4b), the percentage increase in the odds of inadequate prenatal care utilization with an increase in violent crime by 1 per 100 residents was higher for NH-white (OR=1.26, 95% CI: 1.15–1.38) and Hispanic (OR=1.24, 95% CI: 1.16–1.34) mothers than for NH-Black mothers (OR=1.05, 95% CI: 1.01–1.12). A similar difference by race/ethnic group was found in the association between NH-Black isolation and inadequate prenatal care utilization (Table XII, Model 5b). The reason for the differential effects of the three community-level variables on prenatal care utilization may be partly explained by the racial/ethnic distribution in Chicago; most NH-Black mothers live in community areas where the levels of the exposure to the three community-level variables examined in this study are high (Table VII).

In the model that includes only neighborhood hardship and violent crime, there was no considerable change in the association between neighborhood hardship and inadequate prenatal care utilization; however, the association between violent crime and inadequate prenatal care utilization was reduced among NH-white and Hispanic mothers and was no longer significant among NH-Black mothers (Table XII, Model 3b vs. 6b). Separate model that includes neighborhood hardship and violent crime in addition to NH-Black isolation was used to determine if their effects on prenatal care utilization are independent of racial residential segregation (Table XII, Model 7b and 8b). For all the three race/ethnic groups, adjusting for NH-Black isolation did not affect the association between neighborhood hardship and inadequate PNCU (Table XII, Model 3b vs. 7b). However, after adjusting for NH-Black isolation, the strength of association between violent crime and inadequate PNCU was about the same for NH-white mothers, reduced for Hispanic mothers and was no longer significant for NH-Black mothers (Table XII, Model 4b vs. 8b).

In the full model that included all three community-level variables (Table XII, Model 9b), only neighborhood hardship was associated with inadequate prenatal care utilization. The odds increased by 11% for NH-white mothers, 5% for NH-Black mothers, and 7% for Hispanic mother for every 10% increase in neighborhood hardship (OR= 1.11 [1.07–1.15], OR=1.05 [1.01–1.09], and OR= 1.07 [1.04–1.11], respectively). The interval odds ratios (IOR) and the proportion of opposed odds ratio (POOR) for the association between neighborhood hardship and inadequate prenatal care utilization for NH-white, Hispanic, and NH-Black mothers were as follows: IOR= 0.82–1.49, POOR= 32%; IOR= 0.78–1.41, POOR= 41%; and 0.80–1.44, POOR= 38%, respectively. For all the three racial/ethnic groups, the effects of NH-Black isolation appeared to be mediated through neighborhood hardship and the community violent crime rate (Model 5b vs. Models 7b–9b).

To further understand the relationship between violent crime and NH-Black isolation with respect to prenatal care utilization, the regional differences in the association between violent crime and inadequate prenatal care utilization were examined for the three racial/ethnic groups with and without adjusting for NH-Black isolation. For NH-white and Hispanic mothers, the association between violent crime and inadequate prenatal care utilization was found in all Chicago regions; however, it was significant only in the three southern regions after adjusting for neighborhood hardship and/or NH-Black isolation. For NH-Black mothers, significant associations between violent crime and inadequate PNCU were found only in the three southern regions of Chicago; however, they were no longer significant after adjusting for neighborhood hardship and/or NH-Black isolation. The associations of neighborhood hardship, violent crime and NH-Black isolation with inadequate prenatal care utilization stratified by Chicago regions and by race/ethnicity are shown in Tables XXIII-XXV, Appendix B.

In sum, there was a significant amount of variability in the probability of having inadequate prenatal care utilization at the neighborhood level in Chicago. For all race/ethnic groups combined, each

of the three community-level variables (neighborhood hardship and community violent crime rate and NH-Black isolation) that were examined was associated with inadequate prenatal care utilization above the influence of individual-level variables and their significant interactions, not adjusting for other community-level variables. Neighborhood hardship has some effects on prenatal care utilization beyond individual-level compositional effects, independent of community violent crime rate and Non-Hispanic Black isolation. However, the effects of violent crime on prenatal care utilization is dependent on both neighborhood hardship and Non-Hispanic Black isolation. The association between each of the three community-level variables and inadequate prenatal utilization differed by race/ethnicity. The strength of the association was highest among NH-white mothers and lowest among NH-Black mothers. For all the three racial/ethnic groups examined, only neighborhood hardship was associated with inadequate prenatal care utilization in the full model that includes all the three community-level variables.

Additional analyses show that there are regional differences in the association between the community-level variables and inadequate prenatal care utilization. In the full model that include all the three community-level variables, the association between neighborhood hardship and inadequate prenatal care utilization was significant only in the North, the Northwest, the West and the Central regions while the association between violent crime and inadequate prenatal care utilization was significant only in the three southern (Southwest, South and Far South) regions. For NH-white and Hispanic mothers, the association between violent crime and inadequate prenatal care utilization was significant only in the three southern regions after adjusting for neighborhood hardship and/or NH-Black isolation. For NH-Black mothers, the significant association between violent crime and inadequate prenatal care utilization found only in the three southern regions of Chicago was no longer significant after adjusting for neighborhood hardship and/or NH-Black isolation.

5.4 Racial/Ethnic Disparities in Prenatal Care Utilization: Individual-level Characteristics and Place of Residence

Table XIII shows the estimates obtained from a series of logistic regression models created in sequence to examine the relative role of individual-level characteristics and community racial/ethnic composition in racial/ethnic disparities in prenatal care utilization among Chicago mothers. Before adjusting for any covariates, Non-Hispanic Black mothers were about three times more likely to have late/no PNC and about four times more likely to receive inadequate prenatal care than NH-white mothers (OR=2.94, 95%CI: 2.85–3.03 and OR=4.47, 95%CI: 4.33–4.61, respectively). Also, Hispanic mothers were about two times more likely to have late/no prenatal care or receive inadequate prenatal care than NH-white mothers, not adjusting for any covariates (OR=1.89, 95%CI: 1.83–1.95 and OR=2.43, 95%CI: 2.35–2.51, respectively). Maternal age, maternal level of education, marital status and health insurance status played a role in the disparities in prenatal care utilization between NH-Black and NH-white mothers, and between Hispanic and NH-white mothers (Table XIII).

Of the four individual-level variables, health insurance status appeared to play the most important role in explaining the disparities in prenatal care utilization between NH Black and NH-white mothers (NH Black-White disparities), and Hispanic and NH-white mothers (Hispanic-White disparities). After adjusting for only health insurance status, the relative NH Black-White disparities in late/no PNC and in inadequate PNCU were reduced by 65% and 61% respectively, while the relative Hispanic-White disparities in late/no PNC and in inadequate PNCU were reduced by 89% and 79% respectively (Table XIII, Model 6). Marital status had more influence on NH Black-White disparities than maternal level of education. In contrast, maternal level of education had more influence on Hispanic-White disparities than marital status. In a model that adjusted for only maternal age, maternal level of education, marital status, and health insurance status, Hispanic-White disparities in late/no PNC and in inadequate PNCU

Table XIII

ROLE[a] OF INDIVIDUAL-LEVEL CHARACTERISTICS AND COMMUNITY RACIAL/ETHNIC COMPOSITION IN RACIAL DISPARITIES[b] IN LATE/NO PRENATAL CARE (PNC) AND INADEQUATE PRENATAL CARE UTILIZATION (PNCU): CHICAGO, 2010–2014 (N= 180,216)

	Late/No PNC		*Inadequate PNCU*	
Variables	*NH-Black vs. NH-White*	*Hispanic vs. NH-White*	*NH-Black vs. NH-White*	*Hispanic vs. NH-White*
Individual-level variables				
Model 1[b]				
Race/ethnicity only	2.94 (2.85–3.03)	1.89 (1.83–1.95)	4.47 (4.33–4.61)	2.43 (2.35–2.51)
Model 2				
Race/ethnicity + Maternal age	2.52 (2.44–2.60)	1.70 (1.65–1.76)	3.80 (3.68–3.92)	2.17 (2.10–2.24)
Model 3				
Race/ethnicity + Maternal level of education	2.22 (2.15–2.29)	1.29 (1.25–1.34)	3.16 (3.05–3.26)	1.50 (1.45–1.55)
Model 4				
Race/ethnicity + Marital status	1.89 (1.83–1.96)	1.43 (1.38–1.48)	2.76 (2.66–2.86)	1.79 (1.73–1.85)
Model 5				
Race/ethnicity + Sociodemographic variables	1.61 (1.55–1.67)	1.11 (1.07–1.16)	2.25 (2.17–2.33)	1.27 (1.22–1.32)
Model 6				
Race/ethnicity + Health insurance status	1.68 (1.62–1.74)	1.10 (1.06–1.14)	2.35 (2.27–2.44)	1.30 (1.25–1.35)
Model 7				
Model 5 + Health insurance status	1.30 (1.25–1.35)	0.90 (0.87–0.94)	1.77 (1.70–1.84)	1.00 (0.96–1.04)
Model 8				
Model 7 + Obstetric characteristics	1.24 (1.20–1.29)	0.88 (0.85–0.91)	1.70 (1.63–1.77)	0.96 (0.92–1.00)
Model 9				
Model 8 + Maternal health behaviors	1.24 (1.19–1.29)	0.90 (0.87–0.94)	1.69 (1.62–1.76)	0.99 (0.95–1.03)
Model 10				
Model 9 + Individual-level interactions	1.20 (1.08–1.34)	1.01 (0.90–1.14)	1.67 (1.49–1.87)	1.06 (0.94–1.19)
Individual and community-level variables				
Model 11				
Model 10 + Community racial/ethnic comp	1.25 (1.07–1.46)	1.03 (0.94–1.14)	1.51 (1.20–1.90)	1.00 (0.87–1.16)
Model 12				
Full model[c, d]	1.25 (1.11–1.41)	1.03 (0.91–1.17)	1.45 (1.23–1.72)	0.98 (0.84–1.13)

[a] The estimates were obtained from a series of logistic regression models used to sequentially examine the effect of adjusting for the individual-level variables and community racial/ethnic composition on racial disparities in late/no PNC and in inadequate PNCU.

[b] Racial/ethnic disparities between NH-White and other racial/ethnic groups are not shown.

[c] Full model adjusted for all individual-level variables and community racial/ethnic composition including significant interactions at both levels.

[d] Signiant interactions include race/ethnicity with maternal age, education, parity, insurance status, and racial/ethnic composition; insurance status with maternal age, education, marital status, and parity; and marital status with parity- additional interactions were found for late/no PNC (race/ethnicity with marital status and med/reproductive risk; maternal age with parity; and education with parity; and marital status with gestation); and for inadequate PNCU (gestation with med/reproductive risk).

were eliminated, and the relative NH Black-White disparities in late/no PNC and inadequate PNCU were reduced by 85% and 78%, respectively (Table XIII, Model 7). In a full model that adjusted for all individual-level variables and community racial/ethnic composition including their significant interactions, the NH Black-White disparities in inadequate PNCU were reduced by additional 10% (OR=1.45, 95%CI: 1.23–1.72).

To further understand racial/ethnic disparities among Chicago mothers, racial/ethnic disparities in prenatal care utilization were examined within the strata of each individual-level variable (Table XIV). In general, racial/ethnic disparities in prenatal care utilization between NH-Black and NH-white mothers were greater than the disparities between Hispanic and NH-white mothers in all the strata of each individual-level variable (Table XIV). NH Black-White disparities in late/no PNC and in inadequate PNCU were found within almost all of the levels of each individual-level characteristic, especially maternal age, maternal level of education, parity and health insurance status. NH Black-White disparities were highest among mothers who were less than 20 years, had less than 12 years of education, or used private health insurance as their principal method of payment for their prenatal care.

Of public health importance at the policy level is the difference in NH Black-White disparities in prenatal care utilization by health insurance status during pregnancy. Among those with private health insurance in pregnancy, NH-Black mothers were more likely to have late/no PNC or inadequate PNCU than NH-White mothers (OR=1.69, 95%CI: 1.51–1.90 and OR=1.64, 95%CI: 1.54–1.75, respectively). Also, among those who had no health insurance, the odds of late/no PNC and inadequate PNCU were higher for NH-Black relative to the odds for NH-white mothers (OR=1.54, 95%CI: 1.01–2.32 and OR=1.93, 95%CI: 1.05–3.35, respectively). However, the disparities in late/no PNC and in inadequate PNCU were not as high among mothers who used Medicaid as their principal method of payment for prenatal care (OR=1.15, 95%CI: 1.05–1.26 and OR=1.25, 95%CI: 1.18–1.33, respectively).

Table XIV

RACIAL DISPARITIES[a] IN LATE/NO PRENATAL CARE (PNC) AND INADEQUATE PRENATAL CARE UTILIZATION (PNCU) ACROSS THE STRATA OF INDIVIDUAL-LEVEL SOCIODEMOGRAPHIC AND OBSTETRIC CHARACTERISTICS: CHICAGO, 2010–2014 (N= 180,216)

	Late/No PNC		*Inadequate PNCU*	
Individual-level variables[b]	*NH-Black vs. NH-White*	*Hispanic vs. NH-White*	*NH-Black vs. NH-White*	*Hispanic vs. NH-White*
Maternal age				
Less than 20 years	1.60 (1.31–1.95)	1.31 (1.07–1.60)	1.70 (1.38–2.09)	1.15 (0.97–1.35)
20–34 years	1.21 (1.11–1.32)	0.98 (0.88–1.08)	1.35 (1.12–1.62)	0.90 (0.78–1.05)
35 years and above	1.11 (0.95–1.30)	0.93 (0.80–1.09)	1.34 (1.15–1.55)	0.90 (0.77–1.05)
Maternal level of education				
Less than 12 years	1.42 (1.20–1.67)	0.99 (0.82–1.20)	1.52 (1.35–1.71)	0.85 (0.76–0.95)
12 years	1.25 (1.07–1.45)	1.03 (0.91–1.18)	1.48 (1.19–1.84)	0.98 (0.81–1.20)
More than 12 years	1.22 (1.06–1.40)	1.16 (1.06–1.27)	1.36 (1.11–1.67)	1.11 (0.97–1.28)
Marital status				
Married	1.38 (1.18–1.63)	1.03 (0.91–1.17)	1.47 (1.29–1.69)	0.96 (0.87–1.06)
Unmarried	1.21 (1.05–1.38)	1.09 (0.93–1.28)	1.45 (1.17–1.78)	0.99 (0.80–1.21)
Parity				
No prior live birth	1.16 (1.00–1.35)	1.07 (0.91–1.27)	1.38 (1.20–1.59)	1.05 (0.94–1.16)
1 or 2 live births	1.34 (1.14–1.59)	1.08 (0.96–1.20)	1.62 (1.39–1.89)	1.05 (0.94–1.19)
>=3 prior live births	1.38 (1.23–1.54)	1.03 (0.90–1.18)	1.37 (1.11–1.70)	0.84 (0.67–1.06)
Plurality				
Singleton gestation	1.30 (1.14–1.48)	1.07 (0.94–1.22)	1.46 (1.24–1.71)	0.98 (0.85–1.13)
Multiple gestations	1.13 (0.82–1.55)	0.85 (0.57–1.27)	1.29 (0.85–1.95)	0.83 (0.56–1.24)
Medical/reproductive risk				
No	1.26 (1.10–1.43)	0.98 (0.87–1.10)	1.46 (1.26–1.70)	0.97 (0.87–1.09)
Yes	1.33 (1.14–1.55)	1.15 (0.98–1.35)	1.43 (1.13–1.80)	1.14 (0.96–1.34)
Smoking during pregnancy				
No	1.30 (1.14–1.49)	1.06 (0.92–1.22)	1.45 (1.24–1.70)	0.97 (0.85–1.12)
Yes	1.16 (0.92–1.46)	1.23 (1.06–1.44)	1.46 (1.06–2.00)	1.12 (0.80–1.57)
Alcohol use during pregnancy				
No	1.25 (1.10–1.41)	1.03 (0.91–1.18)	1.46 (1.23–1.72)	0.98 (0.84–1.13)
Yes	1.28 (0.99–1.66)	0.92 (0.67–1.25)	1.27 (1.06–1.53)	0.76 (0.59–0.97)
Health insurance status				
Private Insurance	1.69 (1.51–1.90)	1.40 (1.21–1.62)	1.64 (1.54–1.75)	1.10 (1.06–1.14)
Medicaid	1.15 (1.05–1.26)	0.77 (0.71–0.83)	1.25 (1.18–1.33)	0.74 (0.70–0.78)
Uninsured/Self-pay	1.54 (1.01–2.32)	1.27 (0.99–1.64)	1.93 (1.05–3.55)	1.23 (0.73–2.07)

[a] Racial disparities between NH-White and other racial/ethnic groups are not shown.

[b] Racial disparities (NH-Black-White disparities and Hispanic-NH-White disparities) across the levels of each individual-level variable were estimated from a logistic regression model that adjusted for other individual-level variables, community racial/ethnic composition and their significant interactions (See Table XIII footnotes for the list).

The racial/ethnic disparities between Hispanic and NH-white mothers also varied by maternal age, maternal level of education, and health insurance status (Table XIV). However, the disparities were found in only a few strata of individual-level characteristics. Hispanic-White disparities were found among mothers who were less than 20 years, had more than 12 years of education, or used private health insurance as their principal method of payment for prenatal care. Some Hispanic mothers even had lower odds of late/no prenatal care and inadequate prenatal care utilization than NH-white mothers, especially with respect to health insurance status. Among mothers who used private health insurance as the principal method of payment for prenatal care, the odds of late/no prenatal care and inadequate prenatal care utilization were higher for Hispanic than NH-white mothers (OR=1.40, 95%CI: 1.21–1.62; OR=1.10, 95%CI: 1.06–1.14, respectively). However, among mothers who were covered by Medicaid during pregnancy, the odds of late/no prenatal care and inadequate prenatal care utilization were lower for Hispanic mothers relative to NH-white mothers (OR=0.77, 95%CI: 0.71–0.83; OR=0.74, 95%CI: 0.70–0.78, respectively).

Tables XV and XVI show the results of additional analyses conducted to examine the relative role of maternal sociodemographic characteristics and health insurance status in racial/ethnic disparities in late/no prenatal care and in prenatal care utilization in Chicago. Different combinations of maternal characteristics (maternal age, maternal level of education, parity, and health insurance status) were examined to identify the characteristics of Non-Hispanic Black and Hispanic mothers with the highest odds of late/no prenatal care and inadequate prenatal care utilization relative to Non-Hispanic white mothers. The odds of late/no prenatal care and inadequate prenatal care utilization appeared to be consistently high among adolescent NH-Black mothers who had no health insurance or used private health insurance as the principal method of payment for prenatal care.

Table XV

RELATIVE ROLE[a] OF MATERNAL CHARACTERISTICS IN RACIAL DISPARITIES IN LATE/NO PRENATAL CARE AND INADEQUATE PRENATAL CARE UTILIZATION BETWEEN NON-HISPANIC BLACK AND NON-HISPANIC WHITE MOTHERS: CHICAGO, 2010–2014

Maternal characteristics				
Age	*Level of education*	*Parity*	*Health insurance status*	*Odds Ratio (95% CI)*
		Late/No PNC		
Less than 20 years	Less than 12 years	1 or 2 live births	Private insurance	2.36 (1.92–2.90)
Less than 20 years	Less than12 years	1 or 2 live births	Private insurance	2.30 (1.81–2.91)
Less than 20 years	Less than 12 years	>=3 prior live births	Uninsured/Self-pay	2.08 (1.21–3.56)
Less than 20 years	12 years	>=3 prior live births	Private insurance	2.09 (1.81–2.42)
Less than 20 years	More than 12 years	>=3 prior live births	Private insurance	2.09 (1.86–2.34)
.....[b]				
.....				
.....				
35 years and above	Less than 12 years	No prior live birth	Medicaid	1.16 (0.95–1.41)
20–34 years	12 years	No prior live birth	Medicaid	0.86 (0.80–0.92)
20–34 years	More than 12 years	No prior live birth	Medicaid	0.86 (0.81–0.91)
35 years and above	12 years	No prior live birth	Medicaid	0.82 (0.72–0.93)
35 years and above	More than 12 years	No prior live birth	Medicaid	0.81 (0.73–0.91)
		Inadequate PNCU		
Less than 20 years	Less than 12 years	1 or 2 prior live births	Uninsured/Self-pay	2.71 (1.40–5.25)
Less than 20 years	12 years	1 or 2 prior live births	Uninsured/Self-pay	2.64 (1.19–5.84)
Less than 20 years	More than 12 years	1 or 2 prior live births	Uninsured/Self-pay	2.43 (1.09–5.43)
Less than 20 years	Less than 12 years	No prior live birth	Uninsured/Self-pay	2.32 (1.24–4.35)
Less than 20 years	Less than 12 years	1 or 2 prior live births	Private insurance	2.30 (1.92–2.75)
.....[b]				
.....				
.....				
35 years and above	12 years	>=3 prior live births	Medicaid	1.16 (1.04–1.28)
20–34 years	More than 12 years	No prior live birth	Medicaid	1.09 (0.95–1.24)
35 years and above	More than 12 years	No prior live birth	Medicaid	1.08 (1.01–1.16)
20–34 years	More than 12 years	>=3 prior live births	Medicaid	1.07 (0.90–1.26)
35 years and above	More than 12 years	No prior live birth	Medicaid	1.07 (0.98–1.17)

[a] Different combinations of maternal age, maternal-level of education, parity and health insurance status (n-=81) were examined using a logistic regression model that adjusted for all individual-level variables, community racial/ethnic composition, and their significant interactions (See Table XIII footnotes for the list).

[b] Only the combinations of maternal characteristics and health insurance status with the highest and lowest magnitude (odds ratio) of racial/ethnic disparities are shown.

Table XVI

RELATIVE ROLE[a] OF MATERNAL CHARACTERISTICS IN RACIAL DISPARITIES IN LATE/NO PRENATAL CARE AND INADEQUATE PRENATAL CARE UTILIZATION BETWEEN HISPANIC AND NON-HISPANIC WHITE MOTHERS: CHICAGO, 2010–2014

Maternal characteristics				
Age	*Level of education*	*Parity*	*Health insurance status*	*Odds Ratio (95% CI)*
		Late/No PNC		
Less than 20 years	More than 12 years	1 or 2 live births	Private insurance	1.88 (1.58–2.23)
Less than 20 years	More than 12 years	No prior live birth	Private insurance	1.83 (1.51–2.23)
Less than 20 years	More than 12 years	>=3 prior live births	Private insurance	1.80 (1.52–2.13)
Less than 20 years	More than 12 years	1 or 2 live births	Uninsured/Self-pay	1.74 (1.42–2.12)
Less than 20 years	More than 12 years	No prior live birth	Uninsured/Self-pay	1.70 (1.38–2.08)
.....[b]				
.....				
.....				
35 years and above	12 years	>=3 prior live births	Medicaid	0.63 (0.59–0.66)
35 years and above	Less than 12 years	1 or 2 live births	Medicaid	0.62 (0.57–0.68)
20–34 years	Less than 12 years	>=3 prior live births	Medicaid	0.61 (0.59–0.64)
35 years and above	Less than 12 years	No prior live birth	Medicaid	0.61 (0.53–0.70)
35 years and above	Less than 12 years	>=3 prior live births	Medicaid	0.60 (0.54–0.66)
		Inadequate PNCU		
Less than 20 years	More than 12 years	1 or 2 live births	Uninsured/Self-pay	2.24 (1.77–2.84)
Less than 20 years	More than 12 years	No prior live birth	Uninsured/Self-pay	1.97 (1.54–2.52)
Less than 20 years	More than 12 years	1 or 2 live births	Private insurance	1.91 (1.58–2.32)
Less than 20 years	More than 12 years	No prior live birth	Private insurance	1.91 (1.38–2.66)
Less than 20 years	12 years	1 or 2 live births	Uninsured/Self-pay	1.77 (1.63–1.92)
.....[b]				
.....				
.....				
Less than 20 years	Less than 12 years	>=3 prior live births	Medicaid	0.60 (0.53–0.67)
20–34 years	12 years	>=3 prior live births	Medicaid	0.56 (0.52–0.61)
35 years and above	12 years	>=3 prior live births	Medicaid	0.55 (0.50–0.59)
20–34 years	Less than 12 years	>=3 prior live births	Medicaid	0.51 (0.48–0.53)
35 years and above	Less than 12 years	>=3 prior live births	Medicaid	0.49 (0.46–0.53)

[a] Different combinations of maternal age, maternal-level of education, parity and health insurance status (n-=81) were examined using a logistic regression model that adjusted for all individual-level variables, community racial/ethnic composition, and their significant interactions (See Table XIII footnotes for the list).

[b] Only the combinations of maternal characteristics and health insurance status with the highest and lowest magnitude (odds ratio) of racial/ethnic disparities are shown.

The disparities between Non-Hispanic Black and white mothers were highest among teenage mothers with less than 12 years of education and one or two existing children who paid for their prenatal care with private health insurance or had no health insurance (uninsured/self-pay). Compared to NH-white mothers with similar characteristics, they were about twice as likely to have late/no PNC and almost three times as likely to have inadequate PNCU (OR=2.36, 95% CI:1.92–2.90 and OR=2.71, 95% CI:1.40–5.25, respectively). In contrast, the odds of late/no PNC and inadequate PNCU were comparatively low among older NH-Black mothers with Medicaid coverage in pregnancy, especially those who had at least 12 years of education and no existing children (Table XV).

Hispanic mothers with similar maternal characteristics also had higher odds of late/no PNC and inadequate PNCU relative to NH-white mothers (Table XVI). However, the direction of the influence of maternal level of education was different for Hispanic mothers. Hispanic-White disparities in late/no PNC and in inadequate PNCU were highest among adolescent mothers with more than 12 years of education and one or two existing children who paid for their prenatal care with private health insurance or had no health insurance. Their odds of late/no PNC and inadequate PNCU were about twice the odds for NH-white mothers with similar characteristics (OR=1.88, 95% CI: 1.58–2.23 and OR=2.24, 95% CI: 1.77–2.84, respectively). The odds of both late/no PNC and inadequate PNCU were lower for Hispanic than NH-white mothers who used Medicaid to pay for their prenatal care, especially for those who were 20 years or older with less than 12 years of education and three or more existing children.

The reason for the difference in the effect of maternal level of education between NH-Black and Hispanic mothers with respect to prenatal care utilization may be explained by the pattern of their health insurance status during pregnancy. Among Hispanic mothers with more than 12 years of education, 55% had Medicaid coverage and 42% used private health insurance to pay for their prenatal care. In contrast, among NH-Black mothers with similar level of education, 68% were covered by

Medicaid and 29% used private health insurance to pay for their prenatal care. However, about 73% of Hispanic mothers with less than 12 years of education, especially those with at least one existing child had Medicaid coverage during pregnancy compared to 57% of NH-Black mothers with similar characteristics. Given that racial/ethnic disparities are higher among mothers who used private health insurance, it should not be surprising that Hispanic-White disparities were higher among mothers with more than 12 years of education and lower among those with less than 12 years of education relative to NH Black-White disparities.

Table XVII shows the variation in racial/ethnic disparities in late/no PNC and inadequate PNCU across four groups of community areas categorized by majority racial/ethnic group. The list of the community areas in each of the four groups is shown in Table XXVI, Appendix B. In all communities combined, NH-Black mothers were more likely to have late/no prenatal care (OR= 1.25; 95% CI: 1.11–1.41) or receive inadequate prenatal care (OR= 1.45; 95% CI: 1.23–1.72) than NH-white mothers. However, there were no disparities in the odds of late/no PNC and inadequate PNCU between Hispanic and NH-white mothers. Moreover, racial/ethnic disparities in prenatal care utilization varied by community racial/ethnic composition, especially the disparities between NH-Black and NH-white mothers.

In NH-White communities, NH-Black mothers were about 34% more likely to have late/no prenatal care and 64% more likely to receive inadequate prenatal care than NH-white mothers (OR=1.34, 95% CI:1.16–1.54 and OR=1.64, 95% CI:1.39–1.93, respectively). However, in NH-Black communities, there were no racial disparities in late/no PNC and in inadequate PNCU between NH-Black and NH-white mothers (OR=1.15, 95% CI:1.00–1.31 and OR=1.15, 95% CI: 0.98–1.36, respectively). In Hispanic and Mixed communities, NH Black-White disparities in late/no care and in inadequate PNCU were about the same as in NH-white communities. In all the four groups of communities, there were no

racial disparities in late/no PNC between Hispanic and NH-white mothers. The odds of inadequate PNCU were even lower for Hispanic mothers than the odds for NH-White mothers in NH-Black communities (OR=0.86, 95% CI:0.74–0.99).

Table XVII
RACIAL DISPARITIES IN INADEQUATE PRENATAL CARE UTILIZATION BY TYPE OF COMMUNITY RACIAL/ETHNIC COMPOSITION, CHICAGO 2010–2014 (N= 180,216)

		Community racial/ethnic composition[a]			
Race/ethnicity	*All community areas*	*NH-White community*	*NH-Black community*	*Hispanic community*	*Mixed community*
	Late/No PNC				
Maternal race/ethnicity					
Non-Hispanic White	Reference	Reference	Reference	Reference	
Non-Hispanic Black	1.25 (1.11–1.41) *	1.34 (1.16–1.54) *	1.15 (1.00–1.31)	1.38 (1.20–1.58) *	1.32 (1.13–1.54) *
Hispanic	1.03 (0.91–1.17)	1.15 (1.00–1.33)	1.06 (0.93–1.20)	0.98 (0.86–1.11)	1.06 (0.90–1.24)
	Inadequate PNCU				
Maternal race/ethnicity					
Non-Hispanic White	Reference	Reference	Reference	Reference	
Non-Hispanic Black	1.45 (1.23–1.72) *	1.64 (1.39–1.93) *	1.15 (0.98–1.36)	1.50 (1.27–1.77) *	1.58 (1.33–1.88) *
Hispanic	0.98 (0.84–1.13)	0.99 (0.85–1.16)	0.86 (0.74–0.99) *	1.07 (0.93–1.24)	1.00 (0.87–1.16)

[a] Community racial/ethnic composition: a four-level variable (NH-White, NH-Black, Hispanic, and *Mixed* communities) based on the majority racial/ethnic group greater than or equal to 60% of the residents in the community-area.
* Significant at α=0.05.

Table XVIII shows the association between community racial/ethnic composition and prenatal care utilization by race/ethnicity. In general, Chicago mothers living in Hispanic communities had lower odds of late/no PNC than those living in NH-white communities (OR= 0.87, 95% CI: 0.82–0.93); there was no significant difference in the odds of late/no PNC between mothers living in Mixed communities and those living in NH-white communities. In contrast, the odds of receiving inadequate prenatal care were higher for Chicago mothers living in NH-Black, Hispanic or Mixed communities than for those living in

NH-White communities (OR= 1.48, 95% CI:1.46–1.51, OR= 1.21, 95% CI: 1.19–1.23, and OR= 1.23, 95% CI: 1.22–1.25, respectively).

The effect of place of residence with respect to its racial/ethnic composition on prenatal care utilization was not the same for mothers of different racial/ethnic groups. For NH-white mothers, those living in NH-Black or Mixed communities had higher odds of late/no PNC than those living in NH-White communities (OR= 1.08, 95% CI: 1.03–1.13, and OR= 1.05, 95% CI: 1.03–1.07, respectively). However, the odds of late/no PNC for NH-white mothers living in NH-White communities were not significantly different from the odds for NH-white mothers living in Hispanic communities. Nevertheless, the odds of inadequate PNCU were higher for NH-white mothers who were resident in NH-Black, Hispanic or Mixed communities relative to other NH-white mothers living in NH-White communities (OR= 1.75, 95% CI:1.69–1.82, OR= 1.23, 95% CI: 1.18–1.29, and OR= 1.23, 95% CI: 1.21–1.25, respectively). The risk of receiving inadequate prenatal care was highest for those who were resident in NH-Black communities.

Table XVIII
ASSOCIATION BETWEEN COMMUNITY RACIAL/ETHNIC COMPOSITION AND PRENATAL CARE UTILIZATION BY RACE/ETHNICITY, CHICAGO 2010–2014 (N= 180,216)

Community-level variable	*All racial/ethnic groups*	*Race/ethnicity*		
		Non-Hispanic White	*Non-Hispanic Black*	*Hispanic*
	Late/No PNC			
Racial/ethnic composition				
NH-White community	Reference	Reference	Reference	Reference
NH-Black community	0.95 (0.92–1.00)	1.08 (1.03–1.13) *	0.93 (0.89–0.96) *	0.99 (0.94–1.04)
Hispanics community	0.87 (0.82–0.93) *	1.01 (0.95–1.07)	1.04 (1.00–1.08)	0.86 (0.81–0.92) *
Mixed community	1.02 (0.99–1.06)	1.05 (1.03–1.07) *	1.04 (1.01–1.06) *	0.96 (0.91–1.01)
	Inadequate PNCU			
Racial/ethnic composition				
NH-White community	Reference	Reference	Reference	Reference
NH-Black community	1.48 (1.46–1.51) *	1.75 (1.69–1.82) *	1.23 (1.22–1.25) *	1.52 (1.47–1.57) *
Hispanics community	1.21 (1.19–1.23) *	1.23 (1.18–1.29) *	1.13 (1.11–1.14) *	1.33 (1.28–1.39) *
Mixed community	1.23 (1.22–1.25) *	1.23 (1.21–1.25) *	1.19 (1.18–1.20) *	1.25 (1.20–1.29) *

* Significant at α=0.05.

For NH-Black mothers, living in NH-Black communities lowered the odds of late/no prenatal care relative to living in NH-White communities (Table XVIII). The odds of late/no prenatal care were 7% lower for NH-Black mothers living in NH-Black communities relative to NH-Black mothers resident in NH-White communities (OR= 0.93, 95% CI: 0.89–0.96). However, living in NH-Black communities did not positively influence the adequacy of prenatal care received. The odds of inadequate prenatal care among NH-Black mothers were 23% higher for those living in NH-Black communities than the odds for those living in NH-White communities (OR =1.23, 95% CI: 1.22–1.25). Similarly, the odds of inadequate PNCU for NH-Black mothers living in NH-Black communities were higher than the odds for NH-Black mothers resident in Hispanic or *Mixed* communities (OR=1.13, 95% CI: 1.11–1.14 and OR=1.19, 95% CI:1.18–1.20, respectively).

Similar to the advantage that the NH-Black mothers living in NH-Black communities had with respect to early initiation of prenatal care, Hispanic mothers living in Hispanic communities had lower odds of late/no prenatal care than Hispanic mothers living in NH-White communities. The odds were 14% lower for Hispanic mothers living in Hispanic communities relative to the odds for Hispanic mothers in NH-White communities (OR= 0.86, 95% CI: 0.81–0.92). However, the odds of having inadequate prenatal care were 33% higher for Hispanic mothers living in Hispanic communities relative to the odds for Hispanic mothers in NH-White communities (OR= 1.33, 95% CI: 1.28–1.39). Also, for Hispanic mothers, living in NH-Black or *Mixed* communities increased the odds of receiving inadequate prenatal care relative to living in NH-White communities (OR=1.52, 95% CI: 1.47–1.57 and OR=1.25, 95% CI:1.20–1.29, respectively), with the highest odds among those living in NH-Black communities.

The results of sensitivity analysis to assess the effect of regression coefficients obtained from using 60% as the percentage cut-off point for grouping community areas by racial/ethnic composition showed that the same conclusions would be made if the percentage cut-off was changed to values in

the range of 50 and 70% (Tables XXVII and XXVIII, Appendix B). The upper limit of the percentage cut-off point for the sensitivity analysis was set to 70% based on the distribution of the racial/ethnic composition of Chicago community areas and to minimize off-support inferences.

In sum, living in a community area where one's race/ethnic group was the majority positively influenced only the time prenatal care was initiated, and not the adequacy of prenatal care received. For NH-white mothers, the odds of late/no prenatal care and inadequate prenatal care utilization were highest among those living in NH-Black communities and lowest among those living in NH-White communities. For NH-Black mothers, the odds of late/no PNC were lowest among those living in NH-Black communities. Similarly, among Hispanic mothers, those living in Hispanic communities had the lowest odds of late/no PNC. However, for both NH-Black and Hispanic mothers, the odds of inadequate PNCU were lowest among those living in NH-White communities and highest among those living in NH-Black communities. In NH-White communities, NH-Black mothers had higher odds of inadequate PNCU than Hispanic mothers (OR=1.66, 95% CI: 1.56–1.76).

6. DISCUSSION

This dissertation contains three studies: 1) mapping and Geographical Information Systems (GIS) analysis of inadequate prenatal care utilization (PNCU); 2) multilevel regression analysis of the effect of neighborhood characteristics on inadequate PNCU; and 3) assessment of the role of individual-level characteristics and community racial/ethnic composition in racial/ethnic disparities in late/no prenatal care (PNC) and inadequate PNCU. The interpretation and public health importance of the study findings, and the specific limitations and strengths of each study are discussed in the above order.

The first study was designed to identify Chicago community areas with relatively high levels of inadequate use of prenatal care and to examine the spatial associations of neighborhood socioeconomic indicators, community violent crime rate, and racial residential segregation with inadequate prenatal care utilization across Chicago community areas. In general, with a few exceptions, the community areas in the North, the Northwest, and the Central regions had lower percentages of inadequate prenatal care utilization (PNCU) than the community areas in the West and the three southern (South, Southwest, and Far South) regions of Chicago. The spatial pattern of inadequate PNCU closely follows the spatial distributions of neighborhood hardship, community violent crime rate, and Non-Hispanic Black isolation across Chicago community areas. In addition, the locations of the *Low-Low* cluster of percent inadequate PNCU in the North and the Northwest, and the *High-High* cluster of percent inadequate PNCU in the three southern regions of Chicago reflected the spatial cluster patterns of each of the three community-level characteristics to a considerable extent.

These findings suggest that there are mechanisms operating at the community-level that influence adequate utilization of prenatal care for Chicago mothers. A formal analysis using both ordinary least squares regression (OLS) and geographically weighted regression (GWR) conducted at the community level confirmed the associations between the three community-level characteristics and

inadequate PNCU. The results from the ordinary least squares regression (*global*) analysis show that the higher the neighborhood hardship on a relative scale of 0-100, the higher the percentage of residents who received inadequate prenatal care. Similar positive associations with inadequate PNCU were also found for the community violent crime rate and Non-Hispanic Black isolation.

Geographically weighted regression provided additional information beyond the findings obtained from the OLS regression analysis. It allowed the examination of the *local* variability in the strength of the association between the community-level characteristics and inadequate PNCU across Chicago community areas. The coefficients of the association between neighborhood hardship and inadequate PNCU were high for most of the community areas in the three southern regions of Chicago where the levels of neighborhood hardship were generally high. However, after adjusting for community violent crime, they became lower than the coefficients for the community areas in the North, the Northwest, and the Central regions of Chicago. This is because in these regions, levels of violent crime were generally low; thus, its confounding effect on the association between neighborhood hardship and inadequate PNCU were minimal. The intricate relationships between neighborhood hardship and community violent crime also explain why regional differences in the effects of violent crime on prenatal care utilization were masked without adjustment for neighborhood hardship. After adjusting for neighborhood hardship, the coefficient of the association between violent crime and inadequate PNCU was high in the three southern regions compared to other Chicago regions (Figure 8, see also Figure 10, Appendix B).

Adjusting for Non-Hispanic Black isolation had a minimal effect on the association between neighborhood hardship and inadequate PNCU but a considerable effect on the association between community violent crime and inadequate PNCU. Although the coefficients of the association between violent crime and inadequate PNCU were reduced across all Chicago community areas after adjusting for

Non-Hispanic Black isolation, they were still high in the three southern regions compared to other Chicago regions. In some community areas in the North and the Northwest regions, the direction of the association was even reversed—prenatal care utilization increased with an increase in the violent crime rate.

The reason for this reverse association is not very clear but may be related to: 1) the racial/ethnic composition of the residents in these regions because in Chicago, for a variety of historic reasons, violent crime tends to be clustered in communities where the majority racial/ethnic group is NH-Black; 2) differences in prenatal care utilization behavior when violent crime is subtle rather than intense; and 3) the complex causal relationships between violent crime, NH-Black isolation, and prenatal care utilization. Relatedly, violent crime appears to mediate the association between NH-Black isolation and prenatal care utilization to a greater extent than neighborhood hardship.

The findings in this study are in line with those few ecological studies that examined the relationship between similar community-level characteristics and prenatal care. Charreire and Combier (2009) found significant spatial association between the neighborhood deprivation index and poor prenatal care utilization in a highly urbanized French district (Seine-Saint-Denis). However, the study is limited in its methodology because the researchers used only bivariate *Moran I* statistic for spatial autocorrelation to examine the association. In another related study, Shoff, Yang and Mathews (2012) examined the local variations in the effects of county-level measures of female socioeconomic disadvantage on late/no prenatal care in the United States. Using geographically weighted regression analysis, they found that in many counties in the US, the more socially disadvantaged the female population is, the higher the percentage of mothers receiving late/no prenatal care. However, the results they obtained from OLS did not show a significant association between female socioeconomic

disadvantage and late/no prenatal care. This may be due to the difference between using OLS rather than GWR methods.

The importance of area of residence or neighborhood as a major contributor to health outcomes, health behaviors, and healthcare utilization has been well emphasized (Macintyre, Ellaway & Cummins, 2002; Diez-Roux & Mair, 2010). Understanding the determinants of prenatal care utilization requires not only understanding individual-level risk factors but also the social and the environmental contexts in which individuals live. The findings in this study show that there are spatial disparities in prenatal care utilization in the city of Chicago. In addition, they provide useful information that is essential for the identification of community areas that are most in need of public health interventions with respect to inadequate use of prenatal care. The findings also provide support for further research on the contextual effects of neighborhood on prenatal care utilization above the compositional influences of the characteristics of the residents.

In general, public health efforts to reduce inadequate prenatal care utilization in Chicago should target the community areas in the South, the Southwest, and the Far South regions, especially Fuller Park, Englewood, West Englewood, Washington Park and Riverdale that have high levels of percent inadequate prenatal care utilization, neighborhood hardship, community violent crime rate and NH-Black isolation. Given the regional differences in the effects of neighborhood hardship and community violent crime rate in the city of Chicago, public health efforts to reduce inadequate prenatal care utilization in the North, the Northwest, the Central regions of Chicago should focus more on addressing the socioeconomic hardship within the community areas in these regions. However, reducing inadequate prenatal care utilization in the Southwest, South and Far South regions of Chicago requires concerted public health efforts that address both the socioeconomic hardship and the violent crime rate of the community areas in these regions. Using prevalence data of the community-level variables can

facilitate the identification of the community areas that are most in need of public health interventions. In addition, the effects of racial residential segregation (NH-Black isolation) need to be carefully considered when addressing the community violent crime rate.

The first study has some limitations. First, it is an ecological study; therefore, causal inferences about individual behaviors cannot be made from the study findings without ecological fallacy. Second, it is possible that the boundaries of Chicago community areas used in this study to define neighborhoods may not accurately reflect the different subjective definitions of neighborhood held by Chicago residents, a general methodological problem in neighborhood studies (Coulton, Korbin, Chan & Su, 2001). Third, the study methodology allowed for the examination of only spatial disparities but not racial/ethnic disparities in prenatal care utilization. Nevertheless, the study findings provide support for further research on the contextual effects of neighborhood factors on prenatal care utilization independent of the compositional influences of the characteristics of the residents, in addition to providing valuable information for specific interventions at the regional and community-level. The second and third studies were designed to address some of the limitations of the first study.

The main objective of the second study was to examine the contextual effects of the three community-level characteristics on prenatal care utilization above the compositional influences of the characteristics of the residents. In addition, racial/ethnic differences in the effects of community-level characteristics on prenatal care utilization among Chicago mothers were examined. This study showed a significant amount of variability in the probability of having inadequate prenatal care utilization that could be explained at the community level. The probability of inadequate PNCU ranged between 0.06 and 0.50 across Chicago community areas, with an estimated population (marginal) average of 0.27. Neighborhood hardship, community-level violent crime rate, and NH-Black isolation accounted for a

considerable proportion of variability in inadequate PNCU across Chicago community areas after adjusting for the individual-level compositional influences.

These findings substantiate those of the first study and provide evidence that there are mechanisms operating at the community-level that influence adequate utilization of prenatal care beyond the individual level for Chicago mothers. For all race/ethnic groups combined, each of the three community-level variables examined was found to be associated with inadequate prenatal care utilization above the influence of individual-level characteristics and their significant interactions, not adjusting for other community-level variables. The effects of neighborhood hardship on prenatal care utilization were independent of Non-Hispanic Black isolation and community violent crime in Chicago to a large extent. However, the effects of violent crime on prenatal care utilization among Chicago mothers were dependent on both neighborhood hardship and Non-Hispanic Black isolation.

There are regional differences in the association between the community-level variables and inadequate prenatal care utilization. In the full model that include all the three community-level variables, the association between neighborhood hardship and inadequate prenatal care utilization was significant only in the North, the Northwest, the West and the Central regions while the association between violent crime and inadequate prenatal care utilization was significant only in the three southern (Southwest, South and Far South) regions. The regional differences found from the multilevel regression analyses are in line with those obtained from the geographically weighted regression conducted in the first study that showed that the coefficients of the association between neighborhood hardship and inadequate prenatal care utilization were high in the North, Northwest and Central regions while the coefficients of the association between violent crime and inadequate PNCU were high in the three southern regions compared to other Chicago regions.

Clearly, the relationships between neighborhood hardship, community violent crime rate and NH-Black isolation with respect to inadequate prenatal care utilization is complex in the city of Chicago. Understanding the effect of each of the three community-level variables on prenatal care utilization requires careful consideration of their intertwined relationships. This is particularly true for the association between violent crime and inadequate prenatal care utilization especially in the South, Southwest and the Far South regions where the levels of neighborhood hardship and NH-Black isolation are also high. Thus, understanding regional differences in the effect of violent crime on prenatal care utilization requires considering neighborhood socioeconomic hardship, which has almost ubiquitous effects on adequate use of prenatal care across Chicago community areas.

For all the three racial/ethnic groups examined in this study, each of the three community-level variables examined were found to be associated with inadequate prenatal care utilization, not adjusting for other community-level variables. However, the strength of the associations between the community-level variables and inadequate prenatal care utilization differed by race/ethnicity. The effects of neighborhood hardship, violent crime and NH-Black isolation were higher for NH-white and Hispanic mothers than for NH-Black mothers. A plausible explanation for the differential effects of the three community-level variables on prenatal care utilization by race/ethnicity is that most of the NH-Black mothers were residents in community areas where the levels of the variables are high. Therefore, using the same unit change in the level of exposure for all the three racial/ethnic groups for comparison may not be adequate. The differential effects of the three community-level variables on prenatal care utilization by racial/ethnicity would be smaller than observed if the three racial/ethnic groups were more uniformly distributed across Chicago community areas.

Nevertheless, adjusting for violent crime and/or NH-Black isolation had minimal effects on the association between neighborhood hardship and inadequate prenatal care utilization for all the three

racial/ethnic groups. However, the association between violent crime and inadequate PNCU was more intricately linked with neighborhood hardship and NH-Black isolation for NH-Black mothers than for NH-white and Hispanic mothers. In addition, there were regional variations in the association between violent crime and inadequate PNCU that differ by race/ethnicity. For NH-white and Hispanic mothers, there was a significant association between violent crime and inadequate PNCU in all Chicago regions; however, the association was significant only in the three southern regions after adjusting for neighborhood hardship and/or NH-Black isolation. For NH-Black mothers, the association between violent crime and inadequate PNCU was found significant only in the three southern regions of Chicago, not adjusting for neighborhood hardship or NH-Black isolation

These findings suggest that addressing neighborhood socioeconomic hardship has the potential to improve prenatal care utilization for all Chicago mothers, especially those living in the community areas in the North, the Northwest, the West and the Central regions of Chicago. Chicago mothers living in the three southern (South, Southwest and Far South) regions of Chicago will also benefit from controlling their community-level violent crime rate. Moreover, public efforts to reduce inadequate use of prenatal care among NH-Black mothers should focus more on the three southern (South, Southwest and Far South) regions of Chicago to address the high levels of neighborhood socioeconomic hardship and community violent crime rate in these regions. Importantly, designing public health interventions to achieve these aims needs thorough consideration of the complex, inextricable relationships between neighborhood hardship, violent crime and NH-Black isolation, especially in the southern regions of Chicago.

Comparing the findings in this study with those of other studies on the contextual effects of neighborhood on prenatal care utilization is not straightforward. This is because most of the few related studies in the literature have been limited to one measure of neighborhood context, usually a measure

of neighborhood poverty (Braveman, Egerter, Cubbin & Marchi, 2004; Daoud et al., 2015), did not use the appropriate statistical techniques to account for multiple levels of influence- individual and neighborhood level (Braveman, Egerter, Cubbin & Marchi, 2004; Cubbin et al., 2008; Daoud et al., 2015; Perloff & Jaffee, 1999), or have a large gap between the time that the neighborhood-level factors and prenatal care utilization were measured (Braveman, Egerter, Cubbin & Marchi, 2004; Cubbin et al., 2008; Kieffer, Alexander & Mor, 1992). Moreover, no published studies have examined the relationship between violent crime and prenatal care utilization or used a formal measure of racial residential segregation to examine its association with adequate use of prenatal care.

Nevertheless, the findings in this study are in line with those found by previous researchers. Kieffer, Alexander and More (1992) examined area-level predictors of variations in the use of prenatal care services in Hawaii using census tract as the unit of analysis. Their study showed that area-level socioeconomic indicators predicted 61% of the variation in the percent of inadequate use of prenatal care across census tracts. Perloff and Jaffee (1999) examined individual and neighborhood factors associated with late entry into prenatal care in New York City between 1991 and 1992 and found that residence in a neighborhood with a limited economic or health care opportunity structure significantly increased the risk of late initiation of prenatal care. Braveman, Egerter, Cubbin and Marchi (2004) found that women in California who lived in poor neighborhoods were more likely to have delayed or no prenatal care than those who lived in neighborhoods that were not poor. Likewise, Cubbin and colleagues (2008) found that living in a high-deprivation neighborhood was associated with increased odds of late/no prenatal care among whites in Washington.

This study has some limitations. First, it is a cross-sectional study; therefore, causal inferences cannot be drawn from the study findings. Second, given the unbalanced distribution of the three racial/ethnic groups across Chicago community areas, extrapolation of the observed data may result in

making off-support inferences. Third, although many neighborhood variables were examined, due to limited available data, there are other important neighborhood characteristics that were not examined, especially those related to the distribution and organization of healthcare resources. Fourth, there is a possibility of over-adjustment by including many individual-level variables in the multilevel analysis. However, this would only underestimate the contextual effects of neighborhood on prenatal care utilization. Thus, finding significant associations between the neighborhood characteristics that were examined and prenatal care utilization is very reassuring. Fifth, generalizability of the study findings is potentially limited since the study was conducted only in Chicago. However, the findings are applicable to other large urban centers with a high degree of racial/ethnic segregation.

Nevertheless, this study has some important strengths. First, the study used multiple sources of information to simultaneously examine the associations of both individual and neighborhood-level factors with prenatal care utilization to distinguish between those that are compositional from those that are contextual using the appropriate statistical techniques for analyzing multi-level data. Second, the sample size was large enough to include many individual-level variables and to also examine the differences in the contextual effects of neighborhood on prenatal care utilization for different racial/ethnic groups. Third, the study made use of information obtained from geographically weighted regression (Study 1) to highlight regional differences in the contextual effects of neighborhood on prenatal care utilization by race/ethnicity in order to enhance the practical usefulness of the study findings. Fourth, the study minimized the time lag between neighborhood exposure and the outcome by using 5-year estimates collected between January 1, 2009 and December 31, 2013 to reflect the neighborhood experience of Chicago residents who had a live birth between January 1, 2010 and December 31, 2014. Last, this study contributes to the literature on prenatal care utilization; its findings can inform health policy change and public health interventions aimed at reducing inadequate use of prenatal care, in Chicago and beyond. By design, the second study focused on the contextual effects of

neighborhood on prenatal care utilization. As such, the third study was designed to examine the associations between individual-level characteristics and inadequate prenatal care utilization and their role in racial/ethnic disparities in prenatal care utilization.

The main objectives of the third study were to identify maternal characteristics, including health insurance status, that explain racial/ethnic disparities in prenatal care utilization and to also assess the effect of living in a community area where one's race/ethnic group is the majority on prenatal care utilization among Chicago residents. This study clearly identified evidence of racial/ethnic disparities in prenatal care utilization among Chicago mothers. Not adjusting for differences in individual-level characteristics or place of residence, Non-Hispanic Black mothers were about three times more likely to have late/no PNC and four times more likely to receive inadequate prenatal care than Non-Hispanic white mothers. Also, Hispanic mothers were about two times more likely to have late/no prenatal care or receive inadequate prenatal care than Non-Hispanic white mothers.

However, adjusting for only health insurance status reduced the relative disparities in late/no PNC and in inadequate PNCU between Non-Hispanic Black and Non-Hispanic white mothers by 65% and 61% respectively, and the relative disparities between Hispanic and Non-Hispanic white disparities by 89% and 79% respectively. The differences in the racial/ethnic distribution by maternal age, maternal level of education and marital status also played a role in the racial/ethnic disparities in prenatal care utilization. Adjusting for health insurance status and maternal sociodemographic characteristics eliminated the relative disparities between Hispanic and Non-Hispanic white mothers and reduced the relative disparities in late/no PNC and in inadequate PNCU between Non-Hispanic Black and Non-Hispanic white mothers by 85% and 78%, respectively. There was an additional 10% reduction in the relative disparities in inadequate PNCU between Non-Hispanic Black and Non-Hispanic white mothers after controlling for the racial/ethnic composition of their place of residence.

To further understand the intersectionality of the individual-level characteristics in racial/ethnic disparities in late/no PNC and inadequate PNCU, different combinations of maternal characteristics with respect to maternal age, maternal level of education, parity and health insurance status were examined. The racial/ethnic disparities between Non-Hispanic Black and Non-Hispanic white mothers were highest among adolescent mothers with less than 12 years of education and one or two existing children who paid for their prenatal care with private health insurance or had no health insurance (*uninsured/self-pay*). Similarly, except for maternal level of education, the disparities between Hispanic and Non-Hispanic white mothers were highest among adolescent mothers with more than 12 years of education and one or two existing children who paid for their prenatal care with private health insurance or had no health insurance. The reason for the dissimilarity in the effect of maternal level of education on disparities is likely related to the difference in the pattern of health insurance status during pregnancy with respect to level of education.

These findings suggest that private health insurance, unlike Medicaid, does not provide uniform coverage for prenatal care for Chicago mothers. The extent of healthcare coverage varies by type of private health insurance. Some women with private health insurance may still need to pay for uncovered healthcare expenses that may hinder their adequate utilization of prenatal care services. Paying for uncovered prenatal care expenses may be more difficult for Non-Hispanic Black and Hispanic mothers than for Non-Hispanic white mothers. It is also plausible that NH-white mothers have more extensive coverage than NH-Black and Hispanic mothers. Thus, providing more uniform health insurance coverage such as Medicaid during pregnancy has the potential to reduce racial/ethnic disparities in prenatal care utilization. Moreover, a closer look at the Medicaid application and approval process may shed light on understanding the dissimilarities in the percentage of Non-Hispanic Black and Hispanic mothers with Medicaid coverage. Furthermore, addressing teenage pregnancy, providing public information and education about the nature and value of prenatal care, and ensuring that child care

services are affordable and easily accessible for pregnant women with existing children may also reduce racial/ethnic disparities in prenatal care utilization.

Racial/ethnic disparities in prenatal care utilization also varied by community racial/ethnic composition, especially the disparities between NH-Black and NH-white mothers. After adjusting for individual-level characteristics, there were no disparities in late/no PNC and in inadequate PNCU between Non-Hispanic Black and Non-Hispanic white mothers in NH-Black communities. However, NH-Black mothers were about 34% more likely to have late/no prenatal care and 64% more likely to receive inadequate prenatal care than NH-white mothers in NH-white communities. Similar disparities were found in Hispanic and Mixed communities. Given that individual-level characteristics completely explained the disparities in late/no PNC and in inadequate PNCU between Hispanic and NH-white mothers, as discussed above, it was not surprising that there were no residual racial disparities in late/no PNC and in inadequate PNCU that could be explained by community racial/ethnic composition of their place of residence.

The reasons for the dissimilarities in racial/ethnic disparities in prenatal care utilization in NH-White and NH-Black communities cannot be fully be explained by the (residual) differences in individual-level characteristics of NH-Black and white mothers, or the unequal distribution of the healthcare infrastructure in Chicago. This is because, given the same healthcare infrastructure, one would expect the racial/ethnic disparities between Non-Hispanic Black and Non-Hispanic white mothers to be about the same in NH-White and NH-Black communities if the differences in their individual-level characteristics explain the findings. Also, the fact that there were no disparities between NH-Black and NH-white mothers in NH-Black communities while disparities exist in NH-White communities suggest that some factors beyond the provision of healthcare infrastructure may be responsible. Some of these factors include racial discrimination and implicit bias against minority racial/ethnic groups in NH-White

communities based on their skin color or type of health insurance (Baumeister & Vohs, 2007; Zestcot, Blair & Stone, 2016). The implicit bias held by prenatal care providers towards pregnant women from minority racial/ethnic groups may lead to unfavorable patient-provider interactions that discourage their adequate use of prenatal care (Hall et al., 2015).

Living in a community area where one's race/ethnic group was the majority positively influenced only the time prenatal care was initiated, and not the adequacy of prenatal care received. For NH-Black mothers, the odds of late/no PNC were lowest among those living in NH-Black communities. Similarly, among Hispanic mothers, those living in Hispanic communities had the lowest odds of late/no PNC. Nevertheless, for both NH-Black and Hispanic mothers, the odds of inadequate PNCU were lowest among those living in NH-White communities and highest among those living in NH-Black communities.

The advantage of living in communities where one's race/ethnic group is the majority with respect to the initiation of prenatal care for NH-Black and Hispanic mothers may be related to peer or other positive social interactions with other members of the same racial/ethnic group. Through social interactions, injunctive and descriptive norms may be imparted by other members of the same ethnic group (Kasprzyk, Montaño, & Fishbein, 1998). Injunctive norms are related to the expectations of significant others in one's personal or social networks with respect to performing a particular behavior while descriptive norms are related to whether most of the significant others perform the behavior.

While injunctive and descriptive norms may be sufficient to support women's entry into prenatal care, other factors, especially at the contextual level, may be more important with respect to the receipt of adequate prenatal care services. Therefore, it is possible that the advantage of living in NH-white communities with respect to receiving adequate prenatal care for NH-Black and Hispanic mothers may be related to the uneven distribution of health care resources favoring NH-White communities. Another plausible explanation is that NH-Black or Hispanic mothers living in NH-White

communities are better able to navigate the healthcare system because they are more likely to have higher levels of education than those living in NH-Black communities.

In sum, this study findings suggest that the propensity to initiate prenatal care may actually be about the same for all racial/ethnic groups and can even be reinforced by the social interactions between a pregnant woman and other members of her racial/ethnic group. However, the difference in the observed higher prevalence of late/no PNC and inadequate PNCU among Non-Hispanic Black and Hispanic mothers than among Non-Hispanic white mothers may, in fact, be explained by individual-level predisposing (maternal age, marital status, maternal level of education, and social networks, interactions and affiliations), enabling (health insurance status) and need (e.g., medical/reproductive risks) factors, as well as contextual level predisposing (community racial/ethnic composition) and the enabling (the number, distribution, and organization of healthcare services, including patient-provider interactions) factors. Although the enabling factors at the contextual level were not directly measured in this study, their effects on prenatal care utilization can be inferred from the study findings.

There are very few studies that have critically examined the role of individual-level characteristics, or factors beyond the individual level to explain racial/ethnic disparities in prenatal care utilization (Bengiamin, Capitman & Ruwe, 2010; Bromley, Nunes & Phipps, 2012; LaVeist, Keith, & Gutierrez, 1995). A study by Bengiamin, Capitman and Ruwe (2010) focused only on health insurance status while a study by Bromley, Nunes and Phipps (2012) examined a limited number of individual-level characteristics. Nevertheless, the findings in this study are in line with those obtained from these three studies. The methodology and findings in the study conducted by Laviest, Keith and Gutierrez (1995) are somewhat similar to those used in this study. However, the researchers did not explicitly assess the role of place of residence in racial/ethnic disparities in late/no PNC and in adequate PNCU.

The third study also has some limitations. First, it is a cross-sectional study; therefore, cause and effect inferences cannot be made. Second, the study did not include variables related to the number, distribution, and organization of healthcare services, including patient-provider interactions. The main strengths of the study include: 1) its use of the principle of intersectionality to identify the combinations of individual-level variables that may explain racial/ethnic disparities in prenatal care utilization; 2) the determinants of racial/ethnic disparities in prenatal care utilization for two major minority racial/ethnic groups relative to Non-Hispanic whites were examined in one study; and 3) it is the first study in the literature to explicitly examine the role of place of residence in racial/ethnic disparities in prenatal care utilization.

The findings of the third study have important implications for public health interventions, especially for Chicago mothers. They provide evidence that racial/ethnic disparities in prenatal care utilization are due to factors that can be measured, assessed and addressed at both the individual and neighborhood levels. Providing more uniform health insurance such as expanding Medicaid eligibility for all uninsured pregnant women may considerably reduce the racial/ethnic disparities in prenatal care utilization in Chicago. Ensuring that all those eligible for Medicaid coverage during pregnancy are enrolled would be a good starting point. In addition, some women who are eligible for Medicaid coverage only during pregnancy may not be aware of this fact; therefore, more education needs to be done prior to pregnancy, during prenatal care, and at other sites where pregnant women may be receiving any types of services.

Although there are multiple ongoing efforts to address teenage pregnancy, it is important to reiterate that pregnant adolescents need adequate financial and social support during pregnancy and regular educational sessions during prenatal care. This can be achieved using specially designed programs linked to the delivery of their prenatal care. Providing public information and education about

the nature and value of prenatal care to all women is also essential. A full-scale campaign to support prenatal care that reaches across communities may be warranted. In addition, simplifying the prenatal care delivery system to improve patient navigation can also address inadequate prenatal care utilization, especially among pregnant women with limited health literacy. The provision of adequate child care services that are affordable and easily accessible for pregnant women with existing children are also important in reducing racial/ethnic disparities in adequate use of prenatal care services.

Furthermore, it appears there are some community-level factors that make living in NH-white communities a more opportune environment to facilitate the receipt of adequate prenatal care services for Chicago mothers. As such, identifying and implementing community-level factors that favor adequate utilization of prenatal care services evenly across all the community areas irrespective of community racial/ethnic composition are both essential to addressing the racial/ethnic disparities in inadequate PNCU in Chicago. Assessing the distribution of the healthcare facilities that provide quality prenatal care services across Chicago community areas may be a promising starting point.

The findings from the third study also have important research implications. They provide support for further research to examine how the number, distribution, and organization of healthcare services, including patient-provider interactions differentially affect adequate utilization of use prenatal care services for all racial/ethnic groups. In addition, this study highlights the importance of the use of an intersectional approach in understanding racial/ethnic disparities in health outcomes and behaviors.

7. CONCLUSION

The three studies in this dissertation clearly show that place of residence has a role in the use of prenatal care services and in racial/ethnic disparities in prenatal care utilization. There is evidence of spatial disparities in prenatal care utilization in the city of Chicago. The spatial pattern of inadequate prenatal care utilization closely follows the spatial distributions of neighborhood hardship, community violent crime rate, and Non-Hispanic Black isolation across Chicago community areas. The community areas in the South, the Southwest and the Far South regions have the highest levels of inadequate prenatal care utilization. Importantly, some community areas in these regions form a high-value cluster of inadequate prenatal care utilization, neighborhood hardship, community violent crime rate and Non-Hispanic-Black isolation.

Therefore, public health efforts to reduce inadequate prenatal care utilization in the city of Chicago should target community areas in the South, the Southwest and the Far South regions. Reducing inadequate prenatal care utilization among Chicago mothers living in these regions requires concerted public health efforts that address both their neighborhood socioeconomic hardship and the violent crime rate while giving attention to the racial residential segregation that characterize these communities. Public health efforts to reduce inadequate prenatal care utilization in the North, the Northwest, the West and the Central regions of Chicago will also need to focus more on addressing socioeconomic hardship that is often hidden in some community areas in these regions.

There are mechanisms operating at the community-level that influence adequate utilization of prenatal care beyond the individual level for Chicago mothers. Neighborhood hardship, community violent crime rate, and Non-Hispanic Black isolation explain some of the variability in inadequate prenatal care utilization at the community area level in Chicago. While the relationships between neighborhood hardship, community violent crime rate and Non-Hispanic Black isolation with respect to

prenatal care utilization are inextricably complex, neighborhood hardship has some effects on inadequate prenatal care utilization that are independent of both community violent crime rate and NH-Black isolation for all Chicago mothers. Thus, addressing neighborhood hardship across all Chicago community areas has the potential to improve adequate utilization of prenatal care for all Chicago mothers.

The effects of neighborhood hardship and community violent crime rate, and Non-Hispanic Black isolation on inadequate prenatal care utilization vary by race/ethnicity and across Chicago regions. Although their effects appear to be greater for Non-Hispanic white and Hispanic mothers, the association between violent crime and inadequate PNCU was more intricately linked with neighborhood hardship and NH-Black isolation for NH-Black mothers. While addressing neighborhood hardship may be more beneficial to Chicago mothers living in the community areas in the North, the Northwest, West and the Central regions of Chicago, addressing the community violent crime rate may be more beneficial for the community areas in the South, Southwest and the Far South of Chicago.

Racial/ethnic disparities in prenatal care utilization in Chicago appear to be due to factors that can be measured, assessed, and addressed at both the individual and neighborhood levels. Thus, reducing racial/ethnic disparities may require: 1) providing more uniform health insurance such as expanding Medicaid coverage for all uninsured pregnant women; 2) providing adequate social support and regular educational sessions during prenatal care for pregnant adolescents through specially designed programs linked to the delivery of their prenatal care; 3) providing public information and education about the nature and value of prenatal care for all women; and, 4) providing adequate child care services that are affordable and easily accessible for pregnant women with existing children. Increasing accessibility may also require efforts to ensure adequate transportation is available.

The propensity to initiate prenatal care may actually be about the same for all racial/ethnic groups and can even be reinforced by the positive social interactions between a pregnant woman and other members of her racial/ethnic group. However, there are some community-level factors that make living in Non-Hispanic white communities an advantage with respect to receiving adequate prenatal care services for Chicago mothers. Identifying and implementing community-level factors that favor adequate utilization of prenatal care services evenly across all the community areas irrespective of community racial/ethnic composition is essential to addressing the racial/ethnic disparities in inadequate prenatal care utilization in Chicago. Assessing the distribution of the healthcare facilities that provide quality prenatal care services across Chicago community areas may be a promising starting point.

The findings in this dissertation also have research implications. The importance of using information obtained from geographically weighted regression to understand regional differences in the contextual effects of neighborhood on prenatal care utilization by race/ethnicity and to enhance the practical usefulness of the study findings was demonstrated. In addition, this dissertation highlights the importance of the use of intersectionality approach in understanding racial/ethnic disparities in health outcomes and behaviors. Moreover, the study findings provide support for further research to examine how the number, distribution, and organization of healthcare services, including patient-provider interaction differentially affect adequate utilization of use prenatal care services for all racial/ethnic groups.

CITED LITERATURE

Acevedo-Garcia, D. (2001). Zip code-level risk factors for tuberculosis: neighborhood environment and residential segregation in New Jersey, 1985-1992. *American Journal of Public Health, 91*(5), 734.

Acevedo-Garcia, D., & Lochner, K. A. (2003). Residential segregation and health. In I. Kawachi, & I. F. Berkman (Eds.), *Neighborhoods and Health* (pp. 265–287). New York, NY: Oxford University Press Inc.

Akaike, H. (1974). A new look at the statistical model identification. *IEEE transactions on automatic control*, *19*(6), 716-723.

Alexander, G. R., & Cornely, D. A. (1987). Prenatal care utilization: its measurement and relationship to pregnancy outcome. *American Journal of Preventive Medicine*, *3*(5), 243-253.

Alexander, G. R., & Kotelchuck, M. (1996). Quantifying the adequacy of prenatal care: a comparison of indices. *Public Health Reports*, *111*(5), 408.

Alexander, G. R., & Kotelchuck, M. (2001). Assessing the role and effectiveness of prenatal care: history, challenges, and directions for future research. *Public Health Reports*, *116*(4), 306-316.

Alexander, G. R., Kogan, M. D., & Nabukera, S. (2002). Racial differences in prenatal care use in the United States: Are disparities decreasing? *American Journal of Public Health, 92*(12), 1970-1975.

American Academy of Pediatrics & American College of Obstetricians and Gynecologists. (2012). *Guidelines for perinatal care*. Washington, DC: The American College of Obstetricians and Gynecologists.

Andersen, R. M. (1968). *Behavioral Model of Families' Use of Health Services*. Research Series No. 25. Chicago, IL: Center for Health Administration Studies, University of Chicago.

Andersen, R. M. (1995). Revisiting the behavioral model and access to medical care: does it matter? *Journal of Health and Social Behavior, 36*(1), 1-10.

Andersen, R. M. (2008). National health surveys and the behavioral model of health services use. *Medical Care*, *46*(7), 647-653.

Andersen, R. M., & Davidson, P. L. (2007). Improving access to care in America: Individual and contextual indicators. In R. Andersen, T. Rice, & G. F. Kominski (Eds.), *Changing the U.S. Health Care System: Key Issues in Health Services Policy and Management* (pp. 3–32). San Francisco, CA: Jossey-Bass.

Andersen, R. M., Davidson, P. L., & Baumeister, S. E. (2014). Improving access to care in America. In G. F. Kominski (Ed.), *Changing the U.S. Health Care System: Key Issues in Health Services Policy and Management* (pp. 33–68). San Francisco, CA: Jossey-Bass.

Anselin, L., & Getis, A. (2010). Spatial statistical analysis and geographic information systems. In L. Anselin & S. J. Rey (Eds), *Perspectives on Spatial Data Analysis* (pp. 35-47). Berlin Heidelberg: Springer.

Anthopolos, R., James, S. A., Gelfand, A. E., & Miranda, M. L. (2011). A spatial measure of neighborhood level racial isolation applied to low birthweight, preterm birth, and birthweight in North Carolina. *Spatial and Spatio-temporal Epidemiology, 2*(4), 235-246.

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

Bach, P. B., Pham, H. H., Schrag, D., Tate, R. C., & Hargraves, J. L. (2004). Primary care physicians who treat blacks and whites. *New England Journal of Medicine, 351*(6), 575-584.

Bagheri, N., Holt, A., & Benwell, G. L. (2009). Using geographically weighted regression to validate approaches for modelling accessibility to primary health care. *Applied Spatial Analysis and Policy*, *2*(3), 177.

Baldwin, L. M., Larson, E. H., Connell, F. A., Nordlund, D., Cain, K. C., Cawthon, M. L., ... & Rosenblatt, R. A. (1998). The effect of expanding Medicaid prenatal services on birth outcomes. *American Journal of Public Health*, *88*(11), 1623-1629.

Ballantyne, J. W. (1901). A plea for a pro-maternity hospital. *British Medical Journal*, *1*(2101), 813.

Bancroft, C., Joshi, S., Rundle, A., Hutson, M., Chong, C., Weiss, C. C., ... & Lovasi, G. (2015). Association of proximity and density of parks and objectively measured physical activity in the United States: A systematic review. *Social Science & Medicine, 138*, 22-30.

Baumeister, R. F., & Vohs, K. D. (2007). *Encyclopedia of Social Psychology* (Vol. 1). Thousand Oaks, CA: Sage.

Bécares, L., Nazroo, J., & Stafford, M. (2009). The buffering effects of ethnic density on experienced racism and health. *Health & Place, 15*(3), 700-708.

Beck, L. F., Morrow, B., Lipscomb, L. E., Johnson, C. H., Gaffield, M. E., Rogers, M., & Gilbert, B. C. (2002). Prevalence of selected maternal behaviors and experiences, Pregnancy Risk Assessment Monitoring System (PRAMS), 1999. *Morbidity and Mortality Weekly Report CDC Surveillance Summaries*, *51*(2).

Behrman, R. E. & Butler, A. S. (2007). *Preterm Birth: Causes, Consequences, and Prevention*. Washington, DC: National Academic Press.

Bell, J. F., & Zimmerman, F. J. (2003). Selection bias in prenatal care use by Medicaid recipients. *Maternal and Child Health Journal*, *7*(4), 239-252.

Bengiamin, M. I., Capitman, J. A., & Ruwe, M. B. (2010). Disparities in initiation and adherence to prenatal care: impact of insurance, race-ethnicity and nativity. *Maternal and Child Health Journal, 14*(4), 618-624.

Benkert, R., Peters, R. M., Clark, R., & Keves-Foster, K. (2006). Effects of perceived racism, cultural mistrust and trust in providers on satisfaction with care. *Journal of National Medical Association, 98*(9), 1532-1540.

Berk, M. L., & Schur, C. L. (2001). The effect of fear on access to care among undocumented Latino immigrants. *Journal of Immigrant Health*, *3*(3), 151-156.

Bernardes, A.C., Antonio da Silva, R., Coimbra, L. C., Britto-Alves, M. T., Sousa-Queiroz, R. C., Batista, R. F., Bettiol, H., Barbieri, M. A., & Moura da Silva, A. A. (2014). Inadequate prenatal care utilization and associated factors in São Luís, Brazil. *BMC Pregnancy and Childbirth, 14*, 266. doi: 10.1186/1471-2393-14-266

Blalock, H. M. (1984). Contextual-effects models: theoretical and methodological issues. *Annual Review of Sociology*, *10*(1), 353-372.

Brady, T. M., Visscher, W., Feder, M., & Burns, A. M. (2003). Maternal drug use and the timing of prenatal care. *Journal of Health Care for the Poor and Underserved*, *14*(4), 588-607.

Braveman, P. A., Egerter, S. A., Cubbin, C., & Marchi, K. S. (2004). An approach to studying social disparities in health and health care. *American Journal of Public Health*, *94*(12), 2139-2148.

Braveman, P., Marchi, K., Egerter, S., Pearl, M., & Neuhaus, J. (2000). Barriers to timely prenatal care among women with insurance: the importance of prepregnancy factors. *Obstetrics & Gynecology*, *95*(6), 874-880.

Bromley, E., Nunes, A., & Phipps, M. G. (2012). Disparities in pregnancy healthcare utilization between Hispanic and non-Hispanic White women in Rhode Island. *Maternal and Child Health Journal, 16*(8), 1576-1582.

Brown, S. S. (Ed.). (1988). *Prenatal Care: Reaching Mothers, Reaching Infants* (Vol. 926). Washington, DC: National Academy Press.

Brunsdon, C., Fotheringham, A. S., & Charlton, M. E. (1996). Geographically weighted regression: a method for exploring spatial nonstationarity. *Geographical Analysis*, *28*(4), 281-298.

Buka, S. L., Brennan, R. T., Rich-Edwards, J. W., Raudenbush, S. W., & Earls, F. (2003). Neighborhood support and the birth weight of urban infants. *American Journal of Epidemiology, 157*(1), 1-8.

Byrd, T. L., Mullen, P. D., Selwyn, B. J., & Lorimor, R. (1996). Initiation of prenatal care by low-income Hispanic women in Houston. *Public Health Reports*, *111*(6), 536.

Byrnes, J., Mahoney, R., Quaintance, C., Gould, J. B., Carmichael, S., Shaw, G. M., ... & Wise, P. H. (2015). Spatial and temporal patterns in preterm birth in the United States. *Pediatric Research, 77*(6), 836-844.

Caldas de Castro, M., & Singer, B. H. (2006). Controlling the false discovery rate: a new application to account for multiple and dependent tests in local statistics of spatial association. *Geographical Analysis*, *38*(2), 180-208.

Carstairs, V. & Morris, R. (1990). Deprivation and health in Scotland. *Health Bulletin (Edinburg), 48*,162 – 75.

Casagrande, S. S., Whitt-Glover, M. C., Lancaster, K. J., Odoms-Young, A. M., & Gary, T. L. (2009). Built environment and health behaviors among African Americans: a systematic review. *American Journal of Preventive Medicine*, *36*(2), 174-181.

Chaix, B., Merlo, J., & Chauvin, P. (2005). Comparison of a spatial approach with the multilevel approach for investigating place effects on health: the example of healthcare utilisation in France. *Journal of Epidemiology & Community Health*, *59*(6), 517-526.

Champion, V. L., & Skinner, C. S. (2008). The Health Belief Model. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health Behavior and Health Education: Theory, Research, and Practice* (pp. 67-96). San Francisco, CA: Jossey-Bass.

Chan, E., & Quigley, M. A. (2014). School performance at age 7 years in late preterm and early term birth: a cohort study. *Archives of Disease in Childhood-Fetal and Neonatal Edition*, 99(6), F451–F457.

Charreire, H., & Combier, E. (2009). Poor prenatal care in an urban area: a geographic analysis. *Health & Place, 15*(2), 412-419.

Chen, D. R., & Truong, K. (2012). Using multilevel modeling and geographically weighted regression to identify spatial variations in the relationship between place-level disadvantages and obesity in Taiwan. *Applied Geography*, *32*(2), 737-745.

Chen, X. K., Wen, S. W., Fleming, N., Demissie, K., Rhoads, G. G., & Walker, M. (2007). Teenage pregnancy and adverse birth outcomes: a large population based retrospective cohort study. *International Journal of Epidemiology*, *36*(2), 368-373.

Cheng, D., Schwarz, E. B., Douglas, E., & Horon, I. (2009). Unintended pregnancy and associated maternal preconception, prenatal and postpartum behaviors. *Contraception*, *79*(3), 194-198.

Chicago Police Department (2017). *Crime Type Categories: Definition & Description*. Retrieved from http://gis.chicagopolice.org/clearmap_crime_sums/crime_types.html

Clark, K., Fu, C. M., & Burnett, C. (1997). Accuracy of birth certificate data regarding the amount, timing, and adequacy of prenatal care using prenatal clinic medical records as referents. *American Journal of Epidemiology*, *145*(1), 68-71.

Clark, R., Anderson, N. B., Clark, V. R., & Williams, D. R. (1999). Racism as a stressor for African Americans: A biopsychosocial model. *American Psychologist*, *54*(10), 805.

Clarke, L. L., Miller, M. K., Albrecht, S. L., Frentzen, B., & Cruz, A. (1999). The role of medical problems and behavioral risks in explaining patterns of prenatal care use among high-risk women. *Health Services Research*, *34*(1 Pt 1), 145.

Cogan, L. W., Josberger, R. E., Gesten, F. C., & Roohan, P. J. (2012). Can prenatal care impact future well-child visits? The experience of a low income population in New York State Medicaid managed care. *Maternal and Child Health Journal*, *16*(1), 92-99.

Cohen, D., & Coco, A. (2009). Declining trends in the provision of prenatal care visits by family physicians. *The Annals of Family Medicine*, *7*(2), 128-133.

Collins, J. W., & David, R. J. (1996). Urban violence and African-American pregnancy outcome: an ecologic study. *Ethnicity & Disease*, *7*(3), 184-190.

Collins, J. W., David, R. J., Handler, A., Wall, S., & Andes, S. (2004). Very low birth weight in African American infants: The role of maternal exposure to interpersonal racial discrimination. *American Journal of Public Health, 94*(12), 2132-2138.

Collins, J. W., David, R. J., Rankin, K. M., & Desireddi, J. R. (2009). Transgenerational effect of neighborhood poverty on low birth weight among African Americans in Cook County, Illinois. *American Journal of Epidemiology, 169*(6), 712-717.

Collins, J. W., David, R. J., Symons, R., Handler, A., Wall, S. N., & Dwyer, L. (2000). Low-income African American mothers' perception of exposure to racial discrimination and infant birth weight. *Epidemiology, 11*(3), 337-339.

Collins, J. W., Simon, D. M., Tara A., Jackson, T. A., Drolet, A. (2006). Advancing maternal age and infant birth weight among urban African Americans: the effect of neighborhood poverty. *Ethnicity & Disease, 16*, 181.

Comber, A. J., Brunsdon, C., & Radburn, R. (2011). A spatial analysis of variations in health access: linking geography, socio-economic status and access perceptions. *International Journal of Health Geographics*, *10*(1), 44.

Conway, K. S., & Kutinova, A. (2006). Maternal health: does prenatal care make a difference? *Health Economics*, *15*(5), 461-488.

Cooper, L. A., Roter, D. L., Carson, K. A., Beach, M. C., Sabin, J. A., Greenwald, A. G., & Inui, T. S. (2012). The associations of clinicians' implicit attitudes about race with medical visit communication and patient ratings of interpersonal care. *American Journal of Public Health, 102*(5), 979-987.

Coulton, C. J., Korbin, J., Chan, T., & Su, M. (2001). Mapping residents' perceptions of neighborhood boundaries: a methodological note. *American Journal of Community Psychology*, *29*(2), 371-383.

Cox, R. G., Zhang, L., Zotti, M. E., & Graham, J. (2011). Prenatal care utilization in Mississippi: racial disparities and implications for unfavorable birth outcomes. *Maternal and Child Health Journal, 15*(7), 931-942.

Cromley, E. K., & McLafferty, S. L. (2012). *GIS and public health* [Second Edition]. New York, NY: Guilford Press.

Cubbin, C., Marchi, K., Lin, M., Bell, T., Marshall, H., Miller, C., & Braveman, P. (2008). Is neighborhood deprivation independently associated with maternal and infant health? Evidence from Florida and Washington. *Maternal and Child Health Journal, 12*(1), 61-74.

Dai, D. (2010). Black residential segregation, disparities in spatial access to health care facilities, and late-stage breast cancer diagnosis in metropolitan Detroit. *Health & Place, 16*(5), 1038-1052.

Damgaard, A. L., Hansen, B. M., Mathiasen, R., Buchvald, F., Lange, T., & Greisen, G. (2015). Prematurity and prescription asthma medication from childhood to young adulthood: A Danish national cohort study. *PloS One, 10*(2), e0117253.

D'Angelo, D., Le, B., O'Neil, M. A., Williams, L., Ahluwalia, I. B., Leslie L., … Centers for Disease Control and Prevention (CDC). (2016). Patterns of health insurance coverage around the time of pregnancy among women with live-born infants-Pregnancy Risk Assessment Monitoring System, 29 States, 2009. *MMWR Surveillance Summaries, 64*(4): 1–19.

Daoud, N., O'Campo, P., Minh, A., Urquia, M. L., Dzakpasu, S., Heaman, M., ... & Chalmers, B. (2015). Patterns of social inequalities across pregnancy and birth outcomes: a comparison of individual and neighborhood socioeconomic measures. *BMC Pregnancy and Childbirth, 14*(1), 393.

D'Ascoli, P. T., Alexander, G. R., Petersen, D. J., & Kogan, M. D. (1996). Parental factors influencing patterns of prenatal care utilization. *Journal of Perinatology: Official Journal of the California Perinatal Association, 17*(4), 283-287.

Diez-Roux, A. V. (1998). Bringing context back into epidemiology: variables and fallacies in multilevel analysis. *American Journal of Public Health*, *88*(2), 216-222.

Diez-Roux, A. V. (2000). Multilevel analysis in public health research. *Annual Review of Public Health*, *21*(1), 171-192.

Diez-Roux, A. V. (2001). Investigating neighborhood and area effects on health. *American Journal of Public Health*, *91*(11), 1783-1789.

Diez-Roux, A. V. (2004). Estimating neighborhood health effects: the challenges of causal inference in a complex world. *Social Science & Medicine, 58*(10), 1953–1960.

Diez-Roux, A. V., & Mair, C. (2010). Neighborhoods and health. *Annals of the New York Academy of Sciences*, *1186*(1), 125-145.

Dobie, S. A., Baldwin, L. M., Rosenblatt, R. A., Fordyce, M. A., Andrilla, C. H. A., & Hart, L. G. (1998). How well do birth certificates describe the pregnancies they report? The Washington State experience with low-risk pregnancies. *Maternal and Child Health Journal*, *2*(3), 145-154.

Dong, G., & Harris, R. (2015). Spatial autoregressive models for geographically hierarchical data structures. *Geographical Analysis*, *47*(2), 173-191.

Dubay, L., Joyce, T., Kaestner, R., & Kenney, G. M. (2001). Changes in prenatal care timing and low birth weight by race and socioeconomic status: implications for the Medicaid expansions for pregnant women. *Health Services Research*, *36*(2), 373.

Dunkel-Schetter, C., Sagrestano, L. M., Feldman, P., & Killingsworth, C. (1996). Social support and pregnancy. In G. R. Pierce, I.G. Sarason (Eds.), *Handbook of social support and the family* (pp. 375-412). New York, NY: Springer Science.

Dunstan, F., Weaver, N., Araya, R., Bell, T., Lannon, S., Lewis, G., ... & Palmer, S. (2005). An observation tool to assist with the assessment of urban residential environments. *Journal of Environmental Psychology*, *25*(3), 293-305.

Elo, I. T., Culhane, J. F., Kohler, I. V., O'campo, P., Burke, J. G., Messer, L. C., ... & Holzman, C. (2009). Neighbourhood deprivation and small-for-gestational-age term births in the United States. *Paediatric and Perinatal Epidemiology*, *23*(1), 87-96.

Farkas, G. (1974). Specification, residuals and contextual effects. *Sociological Methods & Research*, *2*(3), 333-363.

Feng, J., Glass, T. A., Curriero, F. C., Stewart, W. F., & Schwartz, B. S. (2010). The built environment and obesity: a systematic review of the epidemiologic evidence. *Health & Place*, *16*(2), 175-190.

Ferré, C. (2016). Effects of Maternal Age and Age-Specific Preterm Birth Rates on Overall Preterm Birth Rates—United States, 2007 and 2014. *Morbidity and Mortality Weekly Report*, *65*, 1181–1184.

Fick, A. C., & Thomas, S. M. (1995). Growing up in a violent environment: Relationship to health-related beliefs and behaviors. *Youth & Society*, *27*(2), 136-147.

Finer, L. B., & Henshaw, S. K. (2006). Disparities in rates of unintended pregnancy in the United States, 1994 and 2001. *Perspectives on Sexual and Reproductive Health*, *38*(2), 90-96.

Finer, L. B., & Zolna, M. R. (2016). Declines in unintended pregnancy in the United States, 2008–2011. *New England Journal of Medicine*, *374*(9), 843-852.

Fiscella, K. (1995). Does prenatal care improve birth outcomes? A critical review. *Obstetrics and Gynecology, 85*(3), 468–479.

Fishbein, M. (2000). The role of theory in HIV prevention. *AIDS Care, 12*, 273–278.

Fishbein, M., & Cappella, J. N. (2006). The role of theory in developing effective health communications. *Journal of Communication*, *56,* s1–s17.

Floyd, R. L., Johnson, K. A., Owens, J. R., Verbiest, S., Moore, C. A., & Boyle, C. (2013). A national action plan for promoting preconception health and health care in the United States (2012–2014). *Journal of Women's Health*, *22*(10), 797-802.

Forrest, J. D., & Singh, S. (1987). Timing of prenatal care in the United States: how accurate are our measurements? *Health Services Research*, *22*(2), 235.

Fotheringham, A. S., Brunsdon, C., & Charlton, M. E. (2002). *Geographically weighted regression: The analysis of spatially varying relationships*. Chichester, UK: John Wiley & Sons.

Frayne, D. J., Verbiest, S., Chelmow, D., Clarke, H., Dunlop, A., Hosmer, J., ... & Zephyrin, L. (2016). Health care system measures to advance preconception wellness: consensus recommendations of the Clinical Workgroup of the National Preconception Health and Health Care Initiative. *Obstetrics & Gynecology*, *127*(5), 863-872.

Frick, K. D., & Lantz, P. M. (1996). Selection bias in prenatal care utilization: an interdisciplinary framework and review of the literature. *Medical Care Research and Review*, *53*(4), 371-396.

Frisbie, W. P., Echevarria, S., & Hummer, R. A. (2001). Prenatal care utilization among non-Hispanic whites, African Americans, and Mexican Americans. *Maternal and Child Health Journal*, *5*(1), 21-33.

Funai, E. F., White, J., Lee, M. J., Allen, M., & Kuczynski, E. (2003). Compliance with prenatal care visits in substance abusers. *The Journal of Maternal-Fetal & Neonatal Medicine*, *14*(5), 329-332.

Funkhouser, A. W., Butz, A. M., Feng, T. I., McCaul, M. E., & Rosenstein, B. J. (1993). Prenatal care and drug use in pregnant women. *Drug and Alcohol Dependence*, *33*(1), 1-9.

Galea, S., Riddle, M., & Kaplan, G. A. (2010). Causal thinking and complex system approaches in epidemiology. *International Journal of Epidemiology*, *39*(1), 97-106.

Gaskin, D. J., Dinwiddie, G. Y., Chan, K. S., & McCleary, R. (2012). Residential segregation and disparities in health care services utilization. *Medical Care Research and Review, 69*(2), 158-175.

Getis, A., & Ord, J. K. (1992). The analysis of spatial association by use of distance statistics. *Geographical Analysis*, *24*(3), 189-206.

Giblin, P. T., Poland, M. L., & Ager, J. W. (1990). Effects of social supports on attitudes, health behaviors and obtaining prenatal care. *Journal of Community Health*, *15*(6), 357-368.

Gifford, B. (1997). Obstetricians' receptiveness to teen prenatal patients who are Medicaid recipients. *Health Services Research*, *32*(3), 265.

Giscombé, C. L., & Lobel, M. (2005). Explaining disproportionately high rates of adverse birth outcomes among African Americans: the impact of stress, racism, and related factors in pregnancy. *Psychological Bulletin*, *131*(5), 662.

Giurgescu, C., Zenk, S. N., Templin, T. N., Engeland, C. G., Kavanaugh, K., & Misra, D. P. (2017). The Impact of Neighborhood Conditions and Psychological Distress on Preterm Birth in African-American Women. *Public Health Nursing*, *34*(3), 256-266.

Glass, T. A., & McAtee, M. J. (2006). Behavioral science at the crossroads in public health: extending horizons, envisioning the future. *Social Science & Medicine*, *62*(7), 1650-1671.

Goodchild, M. F. (1992). Geographical information science. *International Journal of Geographical Information Systems*, *6*(1), 31-45.

Goodchild, M., Haining, R., & Wise, S. (1992). Integrating GIS and spatial data analysis: problems and possibilities. *International Journal of Geographical Information Systems*, *6*(5), 407-423.

Grady, S. C. (2006). Racial disparities in low birthweight and the contribution of residential segregation: a multilevel analysis. *Social Science & Medicine, 63*(12), 3013-3029.

Greenland, S. (2000). When should epidemiologic regressions use random coefficients? *Biometrics*, 56(3), 915-921.

Guest, A. M., Almgren, G., & Hussey, J. M. (1998). The ecology of race and socioeconomic distress: infant and working-age mortality in Chicago. *Demography, 35*(1), 23-34.

Hall, W. J., Chapman, M. V., Lee, K. M., Merino, Y. M., Thomas, T. W., Payne, B. K., ... & Coyne-Beasley, T. (2015). Implicit racial/ethnic bias among health care professionals and its influence on health care outcomes: a systematic review. *American Journal of Public Health, 105*(12), e60-e76.

Hamilton, B. E., & Mathews, T. J. (2016). Continued declines in teen births in the United States, 2015. *NCHS data brief*, *259*, 1-8.

Hamilton, B. E., Martin, J. A., & Osterman, M. J. (2016). Births: Preliminary Data for 2015. *National Vital Statistics Reports, 65*(3), 1-14.

Handler, A., & Johnson, K. (2016). A Call to Revisit the Prenatal Period as a Focus for Action Within the Reproductive and Perinatal Care Continuum. *Maternal and Child Health Journal, 20*(11), 2217-2227.

Handler, A., Rosenberg, D., Raube, K., & Kelley, M. A. (1998). Health care characteristics associated with women's satisfaction with prenatal care. *Medical care*, 679-694.

Handler, A., Rosenberg, D., Raube, K., & Lyons, S. (2003). Satisfaction and Use of Prenatal Care: Their Relationship Among African-American Women in a Large Managed Care Organization. *Birth, 30*(1), 23-30.

Hankin, J., McCaul, M. E., & Heussner, J. (2000). Pregnant, alcohol-abusing women. *Alcoholism: Clinical and Experimental Research*, *24*(8), 1276-1286.

Harrell, S. P. (2000). A multidimensional conceptualization of racism-related stress: Implications for the well-being of people of color. *American Journal of Orthopsychiatry, 70*(1), 42-57.

Hauser, R. M. (1974). Contextual analysis revisited. *Sociological Methods & Research*, *2*(3), 365-375.

Heagerty, P. J., & Zeger, S. L. (2000). Marginalized multilevel models and likelihood inference (with comments and a rejoinder by the authors). *Statistical Science*, *15*(1), 1-26.

Herbst, M. A., Mercer, B. M., Beazley, D., Meyer, N., & Carr, T. (2003). Relationship of prenatal care and perinatal morbidity in low-birth-weight infants. *American Journal of Obstetrics and Gynecology, 189*(4), 930-933.

Hessol, N. A., Vittinghoff, E., & Fuentes-Afflick, E. (2004). Reduced risk of inadequate prenatal care in the era after Medicaid expansions in California. *Medical Care*, *42*(5), 416-422.

Higgins, P., Murray, M. L., & Williams, E. M. (1994). Self-esteem, social support, and satisfaction differences in women with adequate and inadequate prenatal care. *Birth*, *21*(1), 26-33.

Hill, I. T. (1992). The role of Medicaid and other government programs in providing medical care for children and pregnant women. *The Future of Children*, 134-153.

Hogan, V. K., Amamoo, A., Anderson, A. D., Webb, D., Mathews, L., Rowley, D., & Culhane, J. F. (2014). Barriers to women's participation in inter-conceptional care: a cross-sectional analysis. *BMC Public Health, 12*, 93. doi: 10.1186/1471-2458-12-93

Howell, E. M. (2001). The impact of the Medicaid expansions for pregnant women: a synthesis of the evidence. *Medical Care Research and Review*, *58*(1), 3-30.

Hu, F. B., Goldberg, J., Hedeker, D., Flay, B. R., & Pentz, M. A. (1998). Comparison of population-averaged and subject-specific approaches for analyzing repeated binary outcomes. *American Journal of Epidemiology*, *147*(7), 694-703.

Huddy, C. L. J., Johnson, A., & Hope, P. L. (2001). Educational and behavioural problems in babies of 32–35 weeks gestation. *Archives of Disease in Childhood-Fetal and Neonatal Edition*, *85*(1), F23-F28.

Hueston, W. J., Geesey, M. E., & Diaz, V. (2008). Prenatal care initiation among pregnant teens in the United States: An analysis over 25 years. *Journal of Adolescent Health, 42*, 243-248.

Hunt, M. O., Wise, L. A., Jipguep, M. C., Cozier, Y. C., & Rosenberg, L. (2007). Neighborhood racial composition and perceptions of racial discrimination: Evidence from the Black Women's Health Study. *Social Psychology Quarterly, 70*(3), 272-289.

Hussein, M., Roux, A. V. D., & Field, R. I. (2016). Neighborhood Socioeconomic Status and Primary Health Care: Usual Points of Access and Temporal Trends in a Major US Urban Area. *Journal of Urban Health*, *93*(6), 1027-1045.

Hutchinson, R. N., Putt, M. A., Dean, L. T., Long, J. A., Montagnet, C. A., & Armstrong, K. (2009). Neighborhood racial composition, social capital and black all-cause mortality in Philadelphia. *Social Science & Medicine, 68*(10), 1859-1865.

Illinois Department of Public Health. (2015). *Illinois maternal and child health databook*. Retrieved from http://www.dph.illinois.gov/sites/default/files/publications/publications-owh-il-title-v2015-databook-042816.pdf

Illinois Department of Public Health. (2017). *Infant Mortality Statistics*. Retrieved from http://www.dph.illinois.gov/data-statistics/vital-statistics/infant-mortality-statistics

Illinois Department of Public Health, Perinatal Advisory Committee (2012). *Preterm Birth in Illinois: Understanding the Problem, Forging a Solution*. Retrieved from https://www.dailyherald.com/assets/PDF/DA1223281126.pdf

Inagami, S., Borrell, L. N., Wong, M. D., Fang, J., Shapiro, M. F., & Asch, S. M. (2006). Residential segregation and Latino, black and white mortality in New York City. *Journal of Urban Health, 83*(3), 406-420.

Ingram, D. D., Makuc, D., & Kleinman, J. C. (1986). National and state trends in use of prenatal care, 1970-83. *American Journal of Public Health*, *76*(4), 415-423.

Institute of Medicine. Committee to Study the Prevention of Low Birth Weight. (1985). *Preventing low birth weight*. Washington, DC: National Academy Press.

Jarman, B. (1983). Identification of underprivileged areas. *British Medical Journal (Clinical Research Edition)*, *287*(6385), 130-131.

Johnson, A. A., Hatcher, B. J., El-Khorazaty, M. N., Milligan, R. A., Bhaskar, B., Rodan, M. F., ... & Laryea, H. A. (2007). Determinants of inadequate prenatal care utilization by African American women. *Journal of Health Care for the Poor and Underserved*, *18*(3), 620-636.

Johnson, K., Posner, S. F., Biermann, J., Cordero, J. F., Atrash, H. K., Parker, C. S., ... & Curtis, M. G. (2006). Recommendations to improve preconception health and health care—United States. *Morbidity and Mortality Weekly Report*, *55*(4), 1-23.

Johnson, S., Hennessy, E., Smith, R., Trikic, R., Wolke, D., & Marlow, N. (2009). Academic attainment and special educational needs in extremely preterm children at 11 years of age: The EPICure study. *Archives of Disease in Childhood-Fetal and Neonatal Edition*, *94*(4), F283-F289.

Joyce, T., Kaestner, R., & Korenman, S. (2000). The stability of pregnancy intentions and pregnancy-related maternal behaviors. *Maternal and Child Health Journal*, *4*(3), 171-178.

Kasprzyk, D., Montaño, D. E., & Fishbein, M. (1998). Application of an Integrated Behavioral Model to Predict Condom Use: A Prospective Study Among High HIV Risk Groups. *Journal of Applied Social Psychology, 28*(17), 1557-1583.

Kessner, D. M., Singer, J., Kalk, C. E., & Schlesinger, E. R. (1973). Infant Death: An Analysis by Maternal Risk and Health Care. In D. Kessner (Ed.), *Contrasts in Health Status* (Vol. I). Washington, DC: Institute of Medicine and National Academy of Sciences.

Kieffer, E., Alexander, G. R., & Mor, J. (1992). Area-level predictors of use of prenatal care in diverse populations. *Public Health Reports, 107*(6), 653.

Kim, D. (2008). Blues from the neighborhood? Neighborhood characteristics and depression. *Epidemiologic Reviews, 30*(1), 101-117.

Kirby, J. B., & Kaneda, T. (2005). Neighborhood socioeconomic disadvantage and access to health care. *Journal of Health and Social Behavior*, *46*(1), 15-31.

Kogan, M. D., Alexander, G. R., Jack, B. W., & Allen, M. C. (1998). The association between adequacy of prenatal care utilization and subsequent pediatric care utilization in the United States. *Pediatrics*, *102*(1), 25-30.

Korenman, S., Kaestner, R., & Joyce, T. (2002). Consequences for infants of parental disagreement in pregnancy intention. *Perspectives on Sexual and Reproductive Health*, 198-205.

Koroukian, S. M., & Rimm, A. A. (2002). The "adequacy of prenatal care utilization" (APNCU) index to study low birth weight: is the index biased? *Journal of Clinical Epidemiology*, *55*(3), 296-305.

Kost, K., & Lindberg, L. (2015). Pregnancy intentions, maternal behaviors, and infant health: investigating relationships with new measures and propensity score analysis. *Demography*, *52*(1), 83-111.

Kotelchuck, M. (1994). 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.

Kotelchuck, M. (2003). Is the APNCU Index to study LBW biased or only the article by Koroukian and Rimm?. *Journal of Clinical Epidemiology*, *56*(3), 286-288.

Kramer, M. R., & Hogue, C. R. (2009). Is segregation bad for your health? *Epidemiologic Reviews, 31*(1), 178-194.

Krans, E. E., & Davis, M. M. (2012). Preventing low birthweight: 25 years, prenatal risk, and the failure to reinvent prenatal care. *American Journal of Obstetrics and Gynecology*, *206*(5), 398-403.

Krans, E. E., Davis, M. M., & Palladino, C. L. (2013). Disparate patterns of prenatal care utilization stratified by medical and psychosocial risk. *Maternal and Child Health Journal*, *17*(4), 639-645.

Krans, E. E., Moloci, N. M., Housey, M. T., & Davis, M. M. (2014). Impact of psychosocial risk factors on prenatal care delivery: a national provider survey. *Maternal and Child Health Journal, 18*(10), 2362-2370.

Krieger, N. (2014). Got theory? On the 21st c. CE rise of explicit use of epidemiologic theories of disease distribution: A review and ecosocial analysis. *Current Epidemiology Reports*, *1*(1), 45-56.

Krysan, M., & Farley, R. (2002). The residential preferences of blacks: Do they explain persistent segregation? *Social Forces, 80*(3), 937-980.

Kurtzman, J. H., Wasserman, E. B., Suter, B. J., Glantz, J. C., & Dozier, A. M. (2014). Measuring adequacy of prenatal care: does missing visit information matter? *Birth*, *41*(3), 254-261.

Lapinski, M. K., Anderson, J., Cruz, S., & Lapine, P. (2015). Social Networks and the Communication of Norms About Prenatal Care in Rural Mexico. *Journal of Health Communication*, *20*(1), 112-120.

Laraia, B. A., Messer, L., Kaufman, J. S., Dole, N., Caughy, M., O'Campo, P., & Savitz, D. A. (2006). Direct observation of neighborhood attributes in an urban area of the US south: characterizing the social context of pregnancy. *International Journal of Health Geographics*, *5*(1), 11.

Larsen, K., & Merlo, J. (2005). Appropriate assessment of neighborhood effects on individual health: integrating random and fixed effects in multilevel logistic regression. *American Journal of Epidemiology*, *161*(1), 81-88.

Larsen, K., Petersen, J. H., Budtz-Jørgensen, E., & Endahl, L. (2000). Interpreting parameters in the logistic regression model with random effects. *Biometrics*, *56*(3), 909-914.

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

LaVeist, T. A., Keith, V. M., & Gutierrez, M. L. (1995). Black/White differences in prenatal care utilization: An assessment of predisposing and enabling factors. *Health Services Research, 30*(1), 43-58.

Leatherman, J., Blackburn, D., & Davidhizar, R. (1990). How postpartum women explain their lack of obtaining adequate prenatal care. *Journal of Advanced Nursing*, *15*(3), 256-267.

Lee, S. H., & Grubbs, L. M. (1995). Pregnant teenagers' reasons for seeking or delaying prenatal care. *Clinical Nursing Research*, *4*(1), 38-49.

Lekic, T., Klebe, D., Poblete, R., R Krafft, P., B Rolland, W., Tang, J., & H Zhang, J. (2015). Neonatal brain hemorrhage (NBH) of prematurity: translational mechanisms of the vascular-neural network. *Current Medicinal Chemistry*, *22*(10), 1214-1238.

Leventhal, T., & Brooks-Gunn, J. (2000). The neighborhoods they live in: the effects of neighborhood residence on child and adolescent outcomes. *Psychological Bulletin*, *126*(2), 309.

Lewis, C. T., Heuser, R. L., & Mathews, T. J. (1996). Prenatal care in the United States, 1980-94. *Vital and Health Statistics, 21*(54), 1-17.

Lia-Hoagberg, B., Rode, P., Skovholt, C. J., Oberg, C. N., Berg, C., Mullett, S., & Choi, T. (1990). Barriers and motivators to prenatal care among low-income women. *Social Science & Medicine*, *30*(4), 487-494.

Liang, K. Y., & Zeger, S. L. (1986). Longitudinal data analysis using generalized linear models. *Biometrika*, *73*(1), 13-22.

Liran, D., Vardi, I. S., Sergienko, R., & Sheiner, E. (2013). Adverse perinatal outcome in teenage pregnancies: is it all due to lack of prenatal care and ethnicity? *The Journal of Maternal-Fetal & Neonatal Medicine*, *26*(5), 469-472.

Little, R. J., & Rubin, D. B. (2000). Causal effects in clinical and epidemiological studies via potential outcomes: concepts and analytical approaches. *Annual Review of Public Health*, *21*(1), 121-145.

Long, J. S. (1997). Regression models for categorical and limited dependent variables. *Advanced quantitative techniques in the social sciences*. Thousand Oaks, CA: Sage Publications

Long, S. H., & Marquis, M. S. (1998). The effects of Florida's Medicaid eligibility expansion for pregnant women. *American Journal of Public Health*, *88*(3), 371-376.

Lorenc, T., Clayton, S., Neary, D., Whitehead, M., Petticrew, M., Thomson, H., ... & Renton, A. (2012). Crime, fear of crime, environment, and mental health and wellbeing: mapping review of theories and causal pathways. *Health & Place*, *18*(4), 757-765.

Lori, J. R., Yi, C. H., & Martyn, K. K. (2011). Provider characteristics desired by African American women in prenatal care. *Journal of Transcultural Nurse, 22*(1), 71-76.

Lu, M. C., Tache, V., Alexander, G. R., Kotelchuck, M., & Halfon, N. (2003). Preventing low birth weight: is prenatal care the answer? *The Journal of Maternal-Fetal & Neonatal Medicine*, *13*(6), 362-380.

Luke, D. A. (2004). *Multilevel modeling* (Vol. 143). Thousand Oaks, CA: Sage.

Ma, X., Fleischer, N. L., Liu, J., Hardin, J. W., Zhao, G., & Liese, A. D. (2015). Neighborhood deprivation and preterm birth: an application of propensity score matching. *Annals of Epidemiology*, *25*(2), 120-125.

Macintyre, S., Ellaway, A., & Cummins, S. (2002). Place effects on health: how can we conceptualise, operationalise and measure them? *Social Science & Medicine*, *55*(1), 125-139.

Mair, C. F., Roux, A. V. D., & Galea, S. (2008). Are neighborhood characteristics associated with depressive symptoms? A critical review. *Journal of Epidemiology and Community Health, 62*(11), 940–946.

Marín, H. A., Ramírez, R., Wise, P. H., Peña, M., Sánchez, Y., & Torres, R. (2009). The effect of Medicaid managed care on prenatal care: the case of Puerto Rico. *Maternal and Child Health Journal, 13*(2), 187.

Marlow, N., Wolke, D., Bracewell, M. A., & Samara, M. (2005). Neurologic and developmental disability at six years of age after extremely preterm birth. *New England Journal of Medicine, 352*(1), 9-19.

Martikainen, P., Bartley, M., & Lahelma, E. (2002). Psychosocial determinants of health in social epidemiology. *International Journal of Epidemiology, 31*(6), 1091–1093.

Martin, J. A., Hamilton, B. E., Osterman, M. J., Driscoll, A. K., & Mathews, T. J. (2017). Births: Final Data for 2015. *National Vital Statistics Reports, 66*(1), 1-69.

Martin, J. A., Hamilton, B. E., Sutton, P. D., Ventura, S. J., Menacker, F., Kirmeyer, S., (2005). Births: preliminary data for 2004. *National Vital Statistics Reports, 54*(8), 1-18.

Martin, J. A., Hamilton, B. E., Sutton, P. D., Ventura, S. J., Menacker, F., Kimeyer, S., & Mathews, M. S. (2009). Births: Final data for 2006. *National Vital Statistics Reports, 57*(7), 1-101.

Martin, J. A., Hamilton, B. E., Sutton, P. D., Ventura, S. J., Menacker, F., Kirmeyer, S., & Munson, M. L. (2007). Births: final data for 2005. *National Vital Statistics Reports, 56*(6), 1-103.

Martin, J. A., Hamilton, B. E., Sutton, P. D., Ventura, S. J., Menacker, F., & Munson, M. L. (2005). Births: final data for 2003. *National Vital Statistics Reports,* 54(2), 1-116.

Mason, S. M., Messer, L. C., Laraia, B. A., & Mendola, P. (2009). Segregation and preterm birth: the effects of neighborhood racial composition in North Carolina. *Health & Place, 15*(1), 1-9.

Massey, D. S. (2001). Residential segregation and neighborhood conditions in US metropolitan areas. America becoming. *Racial Trends and their Consequences, 1*(1), 391-434.

Massey, D.S. (2016). Segregation and the perpetuation of disadvantage. In: L. Burton, & D. Brady, D. (Eds.), *The Oxford handbook of social science of poverty* (pp. 369–393). Oxford: Oxford University Press.

Massey, D. S., & Denton, N. A. (1988). The dimensions of residential segregation. *Social Forces, 67*(2), 281-315.

Massey, D. S., & Fischer, M. J. (2000). How segregation concentrates poverty. *Ethnic and Racial Studies, 23*(4), 670-691.

Mayberry, R. M., Mili, F., & Ofili, E. (2000). Racial and ethnic differences in access to medical care. *Medical Care Research and Review, 57*(4 Suppl.), 108–145.

McCall-Hosenfeld, J. S., Carol S. Weisman, C. S., Camacho, F., Hillemeier, M. M., & Chuang, C. H. (2012). Multi-level analysis of the determinants of receipt of clinical preventive services among reproductive-age women. *Women's Health Issues, 22*(3), e243–e251. doi: 10.1016/j.whi.2011.11.005

McLafferty, S., & Grady, S. (2004). Prenatal care need and access: a GIS analysis. *Journal of Medical Systems, 28*(3), 321-333.

Mellor, J. M., & Milyo, J. D. (2004). Individual health status and racial minority concentration in US states and counties. *American Journal of Public Health, 94*(6), 1043-1048.

Mendez, D. D., Doebler, D. A., Kim, K. H., Amutah, N. N., Fabio, A., & Bodnar, L. M. (2014). Neighborhood socioeconomic disadvantage and gestational weight gain and loss. *Maternal and Child Health Journal*, *18*(5), 1095-1103.

Merlo, J., & Chaix, B. (2006). Neighbourhood effects and the real world beyond randomized community trials: a reply to Michael J Oakes. *International Journal of Epidemiology, 35*(5), 1361-1363.

Merlo, J., Chaix, B., Yang, M., Lynch, J., & Råstam, L. (2005). A brief conceptual tutorial of multilevel analysis in social epidemiology: linking the statistical concept of clustering to the idea of contextual phenomenon. *Journal of Epidemiology & Community Health*, *59*(6), 443-449.

Messer, L. C., Kaufman, J. S., Dole, N., Herring, A., & Laraia, B. A. (2006). Violent crime exposure classification and adverse birth outcomes: a geographically-defined cohort study. *International Journal of Health Geographics*, *5*(1), 22.

Messer, L. C., Kaufman, J. S., Dole, N., Savitz, D. A., & Laraia, B. A. (2006). Neighborhood crime, deprivation, and preterm birth. *Annals of Epidemiology*, *16*(6), 455-462.

Messer, L. C., Laraia, B. A., Kaufman, J. S., Eyster, J., Holzman, C., Culhane, J., ... & O'campo, P. (2006). The development of a standardized neighborhood deprivation index. *Journal of Urban Health*, *83*(6), 1041-1062.

Messer, L. C., Vinikoor, L. C., Laraia, B. A., Kaufman, J. S., Eyster, J., Holzman, C., ... & O'Campo, P. (2008). Socioeconomic domains and associations with preterm birth. *Social Science & Medicine*, *67*(8), 1247-1257.

Metcalfe, A., Lail, P., Ghali, W. A., & Sauve, R. S. (2011). The association between neighbourhoods and adverse birth outcomes: A systematic review and meta-analysis of multi-level studies. *Paediatric and Perinatal Epidemiology*, *25*(3), 236-245.

Meyer, E., Hennink, M., Rochat, R., Julian, Z., Pinto, M., Zertuche, A. D., ... & Cota, P. (2016). Working towards safe motherhood: Delays and barriers to prenatal care for women in rural and peri-urban areas of Georgia. *Maternal and Child Health Journal*, *20*(7), 1358-1365.

Mikhail, B. I., & Curry, M. A. (1999). Perceived impediments to prenatal care among low-income women. *Western Journal of Nursing Research*, *21*(3), 335-355.

Montiel, L. M., Nathan, R. P., & Wright, D. J. (2004). *An update on urban hardship*. Albany, NY: Nelson A. Rockefeller Institute of Government, State University of New York.

Moore, P., & Hepworth, J. T. (1994). Use of Perinatal and Infant Health Services by Mexican-American Medicaid Enrollees. *The Journal of the American Medical Association*, *272*(4), 297-304.

Moran, P. A. P. (1948). The interpretation of statistical maps. *Journal of the Royal Statistical Society. Series B (Methodological)*, *10*(2), 243-251.

Morenoff, J.D. (2003). Neighborhood mechanisms and the spatial dynamics of birth weight. *American Journal of Sociology, 108* (5), 976–1017.

Morris, P., & Halkitis, P. N. (2015). The influence of context on health. *Behavioral Medicine*, 41, 77–79.

Mustillo, S., Krieger, N., Gunderson, E. P., Sidney, S., McCreath, H., & Kiefe, C. I. (2004). Self-reported experiences of racial discrimination and Black-White differences in preterm and low-birthweight deliveries: the CARDIA Study. *American Journal of Public Health, 94*(12), 2125-2131.

Nathan, R. P., & Adams, C. (1976). Understanding central city hardship. *Political Science Quarterly, 91*(1), 47-62.

Nathan, R. P., & Adams, C. F. (1989). Four perspectives on urban hardship. *Political Science Quarterly*, *104*(3), 483-508.

National Committee to Prevent Infant Mortality. (1988). *Death before life: The tragedy of infant mortality*. Washington: The national committee to prevent infant mortality.

Ncube, C. N., Enquobahrie, D. A., Albert, S. M., Herrick, A. L., & Burke, J. G. (2016). Association of neighborhood context with offspring risk of preterm birth and low birthweight: A systematic review and meta-analysis of population-based studies. *Social Science & Medicine*, *153*, 156-164.

Nelson, A. (2002). Unequal treatment: confronting racial and ethnic disparities in health care. *Journal of the National Medical Association, 94*(8), 666.

Nepal, V. P., Banerjee, D., & Perry, M. (2011). Prenatal care barriers in an inner-city neighborhood of Houston, Texas. *Journal of Primary Care & Community Health, 2*(1), 33-36.

Neubauer, V., Junker, D., Griesmaier, E., Schocke, M., & Kiechl-Kohlendorfer, U. (2015). Bronchopulmonary dysplasia is associated with delayed structural brain maturation in preterm infants. *Neonatology, 107*(3), 179-184.

Noble, M., Wright, G., Dibben, C., Smith, G., McLennan, D., Anttila, C., ... & Gardner, J. (2004). *Indices of deprivation 2004. Report to the Office of the Deputy Prime Minister. London: Neighbourhood Renewal Unit*.

Oakes, J. M. (2004). The (mis) estimation of neighborhood effects: causal inference for a practicable social epidemiology. *Social Science & Medicine*, *58*(10), 1929-1952.

Oakes, J. M., Andrade, K. E., Biyoow, I. M., & Cowan, L. T. (2015). Twenty years of neighborhood effect research: an assessment. *Current Epidemiology Reports*, *2*(1), 80-87.

Oberg, C. N., Lia-Hoagberg, B., Skovholt, C., Hodkinson, E., & Vanman, R. (1991). Prenatal care use and health insurance status. *Journal of Health Care for the Poor and Underserved*, *2*(2), 270-292.

O'Campo, P., Burke, J. G., Culhane, J., Elo, I. T., Eyster, J., Holzman, C., ... & Laraia, B. A. (2008). Neighborhood deprivation and preterm birth among non-Hispanic Black and White women in eight geographic areas in the United States. *American Journal of Epidemiology*, *167*(2), 155-163.

O'Campo, P., Xue, X., Wang, M. C., & Caughy, M. (1997). Neighborhood risk factors for low birthweight in Baltimore: a multilevel analysis. *American Journal of Public Health*, *87*(7), 1113-1118.

Oliver, J., & Wong, J. (2003). Intergroup prejudice in multiethnic settings. *American Journal of Political Science, 47*(4), 567-582.

Osterman, M. J., Martin, J. A., Mathews, T. J., & Hamilton, B. E. (2011). Expanded data from the new birth certificate, 2008. *National Vital Statistics Reports*, *59*(7), 1-28.

Osypuk, T. L., & Acevedo-Garcia, D. (2010). Beyond individual neighborhoods: A geography of opportunity perspective for understanding racial/ethnic health disparities. *Health & Place, 16*(6), 1113-1123.

Papas, M. A., Alberg, A. J., Ewing, R., Helzlsouer, K. J., Gary, T. L., & Klassen, A. C. (2007). The built environment and obesity. *Epidemiologic Reviews*, *29*(1), 129-143.

Park, J. H., Vincent, D., & Hastings-Tolsma, M. (2007). Disparity in prenatal care among women of colour in the USA. *Midwifery, 23*(1), 28-37.

Partington, S. N., Steber, D. L., Blair, K. A., & Cisler, R. A. (2009). Second births to teenage mothers: risk factors for low birth weight and preterm birth. *Perspectives on Sexual and Reproductive Health*, *41*(2), 101-109.

Penchansky, R., & Thomas, J. W. (1981). The concept of access: definition and relationship to consumer satisfaction. *Medical Care*, *19*(2), 127-140.

Perloff, J. D., & Jaffee, K. D. (1999). Late entry into prenatal care: the neighborhood context. *Social work, 44*(2), 116-128.

Peterson, R. D., & Krivo, L. J. (2005). Macrostructural analyses of race, ethnicity, and violent crime: Recent lessons and new directions for research. *Annual Review of Sociology, 31*, 331-356.

Pickett, K. E., & Pearl, M. (2001). Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. *Journal of Epidemiology & Community Health*, *55*(2), 111-122.

Pickett, K. E., & Wilkinson, R. G. (2008). People like us: ethnic group density effects on health. *Ethnicity & Health, 13*(4), 321-334.

Piper, J. M., Mitchel, E. F., Snowden, M., Hall, C., Adams, M., & Taylor, P. (1993). Validation of 1989 Tennessee birth certificates using maternal and newborn hospital records. *American Journal of Epidemiology*, *137*(7), 758-768.

Prentice, J. C. (2006). Neighborhood effects on primary care access in Los Angeles. *Social Science & Medicine*, *62*(5), 1291-1303.

Quillian, L. (2012). Segregation and poverty concentration: The role of three segregations. *American Sociological Review, 77*(3), 354-379.

Rajaratnam, J. K., Burke, J. G., & O'campo, P. (2006). Maternal and child health and neighborhood context: the selection and construction of area-level variables. *Health & Place*, *12*(4), 547-556.

Raudenbush, S.W., & Bryk, A.S. (2002). *Hierarchical Linear Models: Applications and Data Analysis Methods* (2nd edition). Thousand Oaks, CA: Sage publications, Inc.

Ray, W. A., Mitchel Jr, E. F., & Piper, J. M. (1996). Effect of Medicaid expansions on preterm birth. *American Journal of Preventive Medicine*, *13*(4), 292-297.

Reichman, N. E., Corman, H., Noonan, K., & Schwartz-Soicher, O. (2010). Effects of prenatal care on maternal postpartum behaviors. *Review of Economics of the Household*, *8*(2), 171-197.

Rini, C., Schetter, C. D., Hobel, C. J., Glynn, L. M., & Sandman, C. A. (2006). Effective social support: Antecedents and consequences of partner support during pregnancy. *Personal Relationships*, *13*(2), 207-229.

Rittenhouse, D. R., Braveman, P., & Marchi, K. (2003). Improvements in prenatal insurance coverage and utilization of care in California: an unsung public health victory. *Maternal and Child Health Journal*, *7*(2), 75-86.

Roberts, R. O., Yawn, B. P., Wickes, S. L., Field, C. S., Garretson, M., & Jacobsen, S. J. (1998). Barriers to prenatal care: factors associated with initiation of care in a middle-class midwestern community. *Journal of Family Practice*, *47*(1), 53-62.

Robins, J. M., & Greenland, S. (1992). Identifiability and exchangeability for direct and indirect effects. *Epidemiology*, 143-155.

Rogers, C., & Schiff, M. (1996). Early versus late prenatal care in New Mexico: barriers and motivators. *Birth*, *23*(1), 26-30.

Roohan, P. J., Josberger, R. E., Acar, J., Dabir, P., Feder, H. M., & Gagliano, P. J. (2003). Validation of birth certificate data in New York State. *Journal of Community Health*, *28*(5), 335-346.

Rosenberg, D., Handler, A., Rankin, K. M., Zimbeck, M., & Adams, E. K. (2007). Prenatal care initiation among very low-income women in the aftermath of welfare reform: does pre-pregnancy Medicaid coverage make a difference? *Maternal and Child Health Journal*, *11*(1), 11-17.

Rosenstock, I. M. (1974). Historical origins of the Health Belief Model. *Health Education & Behavior, 2*(4), 328-335.

Rosenstock, I. M., Strecher, V. J., & Becker, M. H. (1988). Social Learning Theory and the Health Belief Model. *Health Education Quarterly, 15*(2), 175–183.

Salem, E. & Ferguson, R. (2005). *Casting Chicago's safety net: A 12-year review of Chicago's community-based primary care system*. Retrieved from https://www.cityofchicago.org/dam/city/depts/cdph/policy_planning/PP_ServingChicagosUnderserved.pdf

Salm-Ward, T. C., Mazul, M., Ngui, E. M., Bridgewater, F. D., & Harley, A. E. (2013). "You learn to go last": perceptions of prenatal care experiences among African-American women with limited incomes. *Maternal and Child Health Journal, 17*(10), 1753-1759.

Sampson, R. J., & Raudenbush, S. W. (2004). Seeing disorder: Neighborhood stigma and the social construction of "broken windows". *Social Psychology Quarterly*, *67*(4), 319-342.

Schaefer-McDaniel, N., Dunn, J. R., Minian, N., & Katz, D. (2010). Rethinking measurement of neighborhood in the context of health research. *Social Science & Medicine*, *71*(4), 651-656.

Schaffer, M. A., & Lia-Hoagberg, B. (1997). Effects of Social Support on Prenatal Care and Health Behaviors of Low-Income Women. *Journal of Obstetric, Gynecologic, & Neonatal Nursing*, *26*(4), 433-440.

Schappert, S. M., & Burt, C. W. (2006). Ambulatory care visits to physician offices, hospital outpatient departments, and emergency departments: United States, 2001-02. Vital and Health Statistics. Series 13, Data from the National Health Survey, (159), 1-66.

Schempf, A. H., & Strobino, D. M. (2009). Drug use and limited prenatal care: an examination of responsible barriers. *American Journal of Obstetrics and Gynecology*, *200*(4), 412e1–412e10.

Schempf, A., Strobino, D., & O'Campo, P. (2009). Neighborhood effects on birthweight: an exploration of psychosocial and behavioral pathways in Baltimore, 1995–1996. *Social Science & Medicine*, *68*(1), 100-110.

Shaffer, C. F. (2002). Factors influencing the access to prenatal care by Hispanic pregnant women. *Journal of the American Association of Nurse Practitioners*, *14*(2), 93-96.

Shah, T. I., & Bell, S. (2013). Exploring the intra-urban variations in the relationship among geographic accessibility to PHC services and socio-demographic factors. In *Proceedings of the Second ACM SIGSPATIAL International Workshop on the Use of GIS in Public Health* (pp. 68-76). ACM.

Shihadeh, E. S., & Flynn, N. (1996). Segregation and crime: The effect of black social isolation on the rates of black urban violence. *Social Forces, 74*(4), 1325-1352.

Shoff, C., Chen, V. Y. J., & Yang, T. C. (2014). When homogeneity meets heterogeneity: the geographically weighted regression with spatial lag approach to prenatal care utilization. *Geospatial Health, 8*(2), 557.

Shoff, C., Yang, T. C., & Matthews, S. A. (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.

Singh, S., Torres, A., & Forrest, J. D. (1985). The need for prenatal care in the United States: Evidence from the 1980 National Natality Survey. *Family Planning Perspectives*, 118-124.

Slaughter-Acey, J. C., Caldwell, C. H., & Misra, D. P. (2013). The influence of personal and group racism on entry into prenatal care among African American women. *Women's Health Issues, 23*(6), e381-387.

Smaje, C. (1995). Ethnic residential concentration and health: evidence for a positive effect? *Policy & Politics, 23*(3), 251-270.

South, A. P., Jones, D. E., Hall, E. S., Huo, S., Meinzen-Derr, J., Liu, L., & Greenberg, J. M. (2012). Spatial analysis of preterm birth demonstrates opportunities for targeted intervention. *Maternal and Child Health Journal, 16*(2), 470-478.

Sparks, P. J., & Sparks, C. S. (2010). An application of spatially autoregressive models to the study of US county mortality rates. *Population, Space and Place*, *16*(6), 465-481.

St Clair, P. A., Smeriglio, V. L., Alexander, C. S., & Celentano, D. D. (1989). Social network structure and prenatal care utilization. *Medical Care*, *27*(8), 823-832.

Stepanikova, I. (2006). *Inequality in Quality: Toward a Better Understanding of Micro-Mechanisms Underlying Racial/Ethnic Disparities in American Health Care* (Doctoral dissertation). Stanford University, USA.

Stevens-Simon, C., Roghmann, K. J., & McAnarney, E. R. (1991). Early vaginal bleeding, late prenatal care, and misdating in adolescent pregnancies. *Pediatrics*, *87*(6), 838-840.

Stiratelli, R., Laird, N., & Ware, J. H. (1984). Random-effects models for serial observations with binary response. *Biometrics*, 961-971.

Subramanian, S. V. (2004). The relevance of multilevel statistical methods for identifying causal neighborhood effects. *Social Science & Medicine, 58*(10), 1961-1967.

Sunil, T. S., Spears, W. D., Hook, L., Castillo, J., & Torres, C. (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.

Tandon, S. D., Parillo, K. M., & Keefer, M. (2005). Hispanic Women's Perceptions of Patient-Centeredness During Prenatal Care: A Mixed-Method Studya. *Birth*, *32*(4), 312-317.

Taylor, H. G., Klein, N., Minich, N. M., & Hack, M. (2001). Long-term family outcomes for children with very low birth weights. *Archives of Pediatrics and Adolescent Medicine, 155*(2), 155-161.

Teagle, S. E., & Brindis, C. D. (1998). Perceptions of motivators and barriers to public prenatal care among first-time and follow-up adolescent patients and their providers. *Maternal and Child Health Journal*, *2*(1), 15-24.

Terris, M., & Glasser, M. (1974). A life table analysis of the relation of prenatal care to prematurity. *American Journal of Public Health*, *64*(9), 869-875.

Thompson, J. E., Walsh, L. V., & Merkatz, I. R. (1990). The history of prenatal care: cultural, social, and medical contexts. *New perspectives on prenatal care, 9-30.* New York: Elsevier.

Tilghman, J., & Lovette, A. (2008). Prenatal care: The adolescent's perspective. *The Journal of Perinatal Education*, *17*(2), 50-53.

Torrieri, N. K. (Ed.). (2014). *American Community Survey: Design and Methodology (January 2014)*. Retrieved from https://www2.census.gov/programs-surveys/acs/methodology/design_and_methodology/acs_design_methodology_report_2014.pdf

Townsend, P., Phillimore, P., & Beattie, A. (1988). *Health and deprivation: inequality and the North*. London: Routledge.

Truong, K. D., & Ma, S. (2006). A systematic review of relations between neighborhoods and mental health. *Journal of Mental Health Policy and Economics, 9*, 137-154.

Uddin, S. G., Simon, A. E., & Myrick, K. (2014). *Routine Prenatal Care Visits by Provider Speciality in the United States, 2009-2010* (No. 145). United States Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics.

United Health Foundation. (2017). *America's Health Rankings: 2016 Annual Report*. Retrieved from https://assets.americashealthrankings.org/app/uploads/ahr16-complete-v2.pdf

United States Department of Health and Human Services. (2015). *The Affordable Care Act: Advancing the Health of Women and Children*. Retrieved from https://aspe.hhs.gov/system/files/pdf/77191/ib_mch.pdf

United States Department of Health and Human Services, CDC. (2017). *Natality public-use data 2007-2015, on CDC WONDER Online Database*. Retrieved from https://wonder.cdc.gov/natality-current.html

United States Department of Health and Human Services, Healthy People 2020. (2017). *HP2020 Objective Data Search*. Retrieved from https://www.healthypeople.gov/2020/data-search/Search-the-Data#objid=4834;

United States Department of Justice, Federal Bureau of Investigation. (2013). *National Incident-Based Reporting System (NIBRS) User Manual*. Retrieved from https://ucr.fbi.gov/nibrs/nibrs-user-manual

United States Public Health Service. (1989). *Caring for our future: The content of prenatal care. A report of the Public Health Service Expert Panel on the content of prenatal care*. USDHHS. Washington, DC: Public Health Service, NIH.

Vaughan-Sarrazin, M. S., Campbell, M. E., Richardson, K. K., & Rosenthal, G. E. (2009). Racial segregation and disparities in health care delivery: conceptual model and empirical assessment. *Health services Research, 44*(4), 1424-1444.

Vogt-Yuan, A. S. (2007). Racial composition of neighborhood and emotional well-being. *Sociological Spectrum, 28*(1), 105-129.

Vohr, B. R. (2014). Neurodevelopmental outcomes of extremely preterm infants. *Clinics in Perinatology, 41*(1), 241-255.

Vos, A. A., Posthumus, A. G., Bonsel, G. J., Steegers, E. A., & Denktaş, S. (2014). Deprived neighborhoods and adverse perinatal outcome: a systematic review and meta-analysis. *Acta Obstetricia et Gynecologica Scandinavica*, *93*(8), 727-740.

Walford, H. H., Sonya, T., Wiencrot, A., & Lu, M. C. (2011). What is the Role of Prenatal Care in Reducing Racial and Ethnic Disparities in Pregnancy Outcomes? In A. Handler, J. Kennelly, & N. Peacock, (Eds.), *Reducing Racial/Ethnic Disparities in Reproductive and Perinatal Outcomes: The Evidence from Population-Based Interventions* (pp. 151-179). Boston, MA: Springer

White, K., & Borrell, L. N. (2011). Racial/ethnic residential segregation: framing the context of health risk and health disparities. *Health & Place, 17*(2), 438-448.

White, K., Haas, J. S., & Williams, D. R. (2012). Elucidating the role of place in health care disparities: the example of racial/ethnic residential segregation. *Health Services Research, 47*(3pt2), 1278-1299.

White, M. J. (1986). Segregation and diversity measures in population distribution. *Population Index,* 198-221.

Wiemann, C. M., Berenson, A. B., Pino, L. G. D., & McCombs, S. L. (1997). Factors associated with adolescents' risk for late entry into prenatal care. *Family Planning Perspectives*, 273-276.

Williams, J. W. (1915). The limitations and possibilities of prenatal care: based on the study of 705 fetal deaths occurring in 10,000 consecutive admissions to the Obstetrical Department of the Johns Hopkins Hospital. *Journal of the American Medical Association*, *64*(2), 95-101.

Williams, D. R., & Collins, C. (2001). Racial residential segregation: a fundamental cause of racial disparities in health. *Public Health Reports, 116*(5), 404.

Wise, P. H. (2008). Transforming preconceptional, prenatal, and interconceptional care into a comprehensive commitment to women's health. *Women's Health Issues*, *18*(6), S13-S18.

Wong, G. Y., & Mason, W. M. (1985). The hierarchical logistic regression model for multilevel analysis. *Journal of the American Statistical Association*, *80*(391), 513-524.

Wu, M., LaGasse, L. L., Wouldes, T. A., Arria, A. M., Wilcox, T., Derauf, C., ... & Huestis, M. A. (2013). Predictors of inadequate prenatal care in methamphetamine-using mothers in New Zealand and the United States. *Maternal and Child Health Journal*, *17*(3), 566-575.

Yan, J. (2017). The effects of prenatal care utilization on maternal health and health behaviors. *Health Economics*, *26*(8), 1001-1018.

Young, C. L., Mcmahon, J., Bowman, V. M., & Thompson, D. (1989). Adolescent third-trimester enrollment in prenatal care. *Journal of Adolescent Health Care, 10*(5), 393-397.

Zambrana, R. E., Dunkel-Schetter, C., & Scrimshaw, S. (1991). Factors which influence use of prenatal care in low-income racialethnic women in Los Angeles County. *Journal of Community Health*, *16*(5), 283-295.

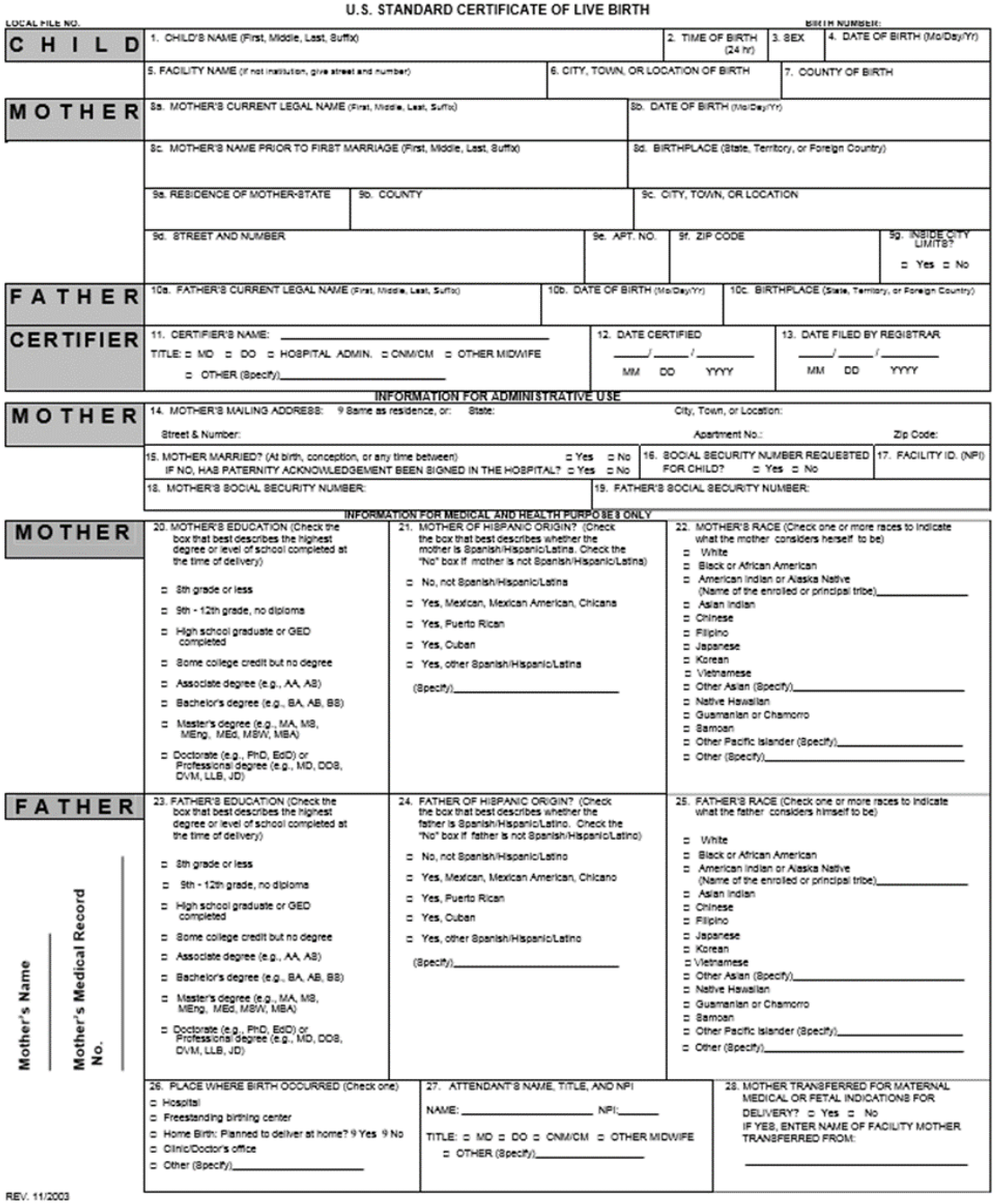
Zenk, S. N., Schulz, A. J., Mentz, G., House, J. S., Gravlee, C. C., Miranda, P. Y., ... & Kannan, S. (2007). Inter-rater and test–retest reliability: methods and results for the neighborhood observational checklist. *Health & Place*, *13*(2), 452-465.

Zestcott, C. A., Blair, I. V., & Stone, J. (2016). Examining the presence, consequences, and reduction of implicit bias in health care: a narrative review. *Group Processes & Intergroup Relations, 19*(4), 528-542.

Zweig, S., LeFevre, M., & Kruse, J. (1988). The health belief model and attendance for prenatal care. *Family Practice Research Journal, 8*(1), 32-41.

APPENDICES

Appendix A: US Birth Certificate



U.S. STANDARD CERTIFICATE OF LIVE BIRTH

LOCAL FILE NO. BIRTH NUMBER:

CHILD

1. CHILD'S NAME (First, Middle, Last, Suffix)
2. TIME OF BIRTH (24 hr)
3. SEX
4. DATE OF BIRTH (Mo/Day/Yr)
5. FACILITY NAME (If not institution, give street and number)
6. CITY, TOWN, OR LOCATION OF BIRTH
7. COUNTY OF BIRTH

MOTHER

8a. MOTHER'S CURRENT LEGAL NAME (First, Middle, Last, Suffix)
8b. DATE OF BIRTH (Mo/Day/Yr)
8c. MOTHER'S NAME PRIOR TO FIRST MARRIAGE (First, Middle, Last, Suffix)
8d. BIRTHPLACE (State, Territory, or Foreign Country)
9a. RESIDENCE OF MOTHER-STATE
9b. COUNTY
9c. CITY, TOWN, OR LOCATION
9d. STREET AND NUMBER
9e. APT. NO.
9f. ZIP CODE
9g. INSIDE CITY LIMITS? ☐ Yes ☐ No

FATHER

10a. FATHER'S CURRENT LEGAL NAME (First, Middle, Last, Suffix)
10b. DATE OF BIRTH (Mo/Day/Yr)
10c. BIRTHPLACE (State, Territory, or Foreign Country)

CERTIFIER

11. CERTIFIER'S NAME: _____
TITLE: ☐ MD ☐ DO ☐ HOSPITAL ADMIN. ☐ CNM/CM ☐ OTHER MIDWIFE
☐ OTHER (Specify)_____
12. DATE CERTIFIED ____/____/____ MM DD YYYY
13. DATE FILED BY REGISTRAR ____/____/____ MM DD YYYY

INFORMATION FOR ADMINISTRATIVE USE

MOTHER

14. MOTHER'S MAILING ADDRESS: 9 Same as residence, or: State: City, Town, or Location:
Street & Number: Apartment No.: Zip Code:
15. MOTHER MARRIED? (At birth, conception, or any time between) ☐ Yes ☐ No
IF NO, HAS PATERNITY ACKNOWLEDGEMENT BEEN SIGNED IN THE HOSPITAL? ☐ Yes ☐ No
16. SOCIAL SECURITY NUMBER REQUESTED FOR CHILD? ☐ Yes ☐ No
17. FACILITY ID. (NPI)
18. MOTHER'S SOCIAL SECURITY NUMBER:
19. FATHER'S SOCIAL SECURITY NUMBER:

INFORMATION FOR MEDICAL AND HEALTH PURPOSES ONLY

MOTHER

20. MOTHER'S EDUCATION (Check the box that best describes the highest degree or level of school completed at the time of delivery)
☐ 8th grade or less
☐ 9th - 12th grade, no diploma
☐ High school graduate or GED completed
☐ Some college credit but no degree
☐ Associate degree (e.g., AA, AS)
☐ Bachelor's degree (e.g., BA, AB, BS)
☐ Master's degree (e.g., MA, MS, MEng, MEd, MSW, MBA)
☐ Doctorate (e.g., PhD, EdD) or Professional degree (e.g., MD, DDS, DVM, LLB, JD)

21. MOTHER OF HISPANIC ORIGIN? (Check the box that best describes whether the mother is Spanish/Hispanic/Latina. Check the "No" box if mother is not Spanish/Hispanic/Latina)
☐ No, not Spanish/Hispanic/Latina
☐ Yes, Mexican, Mexican American, Chicana
☐ Yes, Puerto Rican
☐ Yes, Cuban
☐ Yes, other Spanish/Hispanic/Latina
(Specify)_____

22. MOTHER'S RACE (Check one or more races to indicate what the mother considers herself to be)
☐ White
☐ Black or African American
☐ American Indian or Alaska Native (Name of the enrolled or principal tribe)_____
☐ Asian Indian
☐ Chinese
☐ Filipino
☐ Japanese
☐ Korean
☐ Vietnamese
☐ Other Asian (Specify)_____
☐ Native Hawaiian
☐ Guamanian or Chamorro
☐ Samoan
☐ Other Pacific Islander (Specify)_____
☐ Other (Specify)_____

FATHER

23. FATHER'S EDUCATION (Check the box that best describes the highest degree or level of school completed at the time of delivery)
☐ 8th grade or less
☐ 9th - 12th grade, no diploma
☐ High school graduate or GED completed
☐ Some college credit but no degree
☐ Associate degree (e.g., AA, AS)
☐ Bachelor's degree (e.g., BA, AB, BS)
☐ Master's degree (e.g., MA, MS, MEng, MEd, MSW, MBA)
☐ Doctorate (e.g., PhD, EdD) or Professional degree (e.g., MD, DDS, DVM, LLB, JD)

24. FATHER OF HISPANIC ORIGIN? (Check the box that best describes whether the father is Spanish/Hispanic/Latino. Check the "No" box if father is not Spanish/Hispanic/Latino)
☐ No, not Spanish/Hispanic/Latino
☐ Yes, Mexican, Mexican American, Chicano
☐ Yes, Puerto Rican
☐ Yes, Cuban
☐ Yes, other Spanish/Hispanic/Latino
(Specify)_____

25. FATHER'S RACE (Check one or more races to indicate what the father considers himself to be)
☐ White
☐ Black or African American
☐ American Indian or Alaska Native (Name of the enrolled or principal tribe)_____
☐ Asian Indian
☐ Chinese
☐ Filipino
☐ Japanese
☐ Korean
☐ Vietnamese
☐ Other Asian (Specify)_____
☐ Native Hawaiian
☐ Guamanian or Chamorro
☐ Samoan
☐ Other Pacific Islander (Specify)_____
☐ Other (Specify)_____

Mother's Name

Mother's Medical Record No.

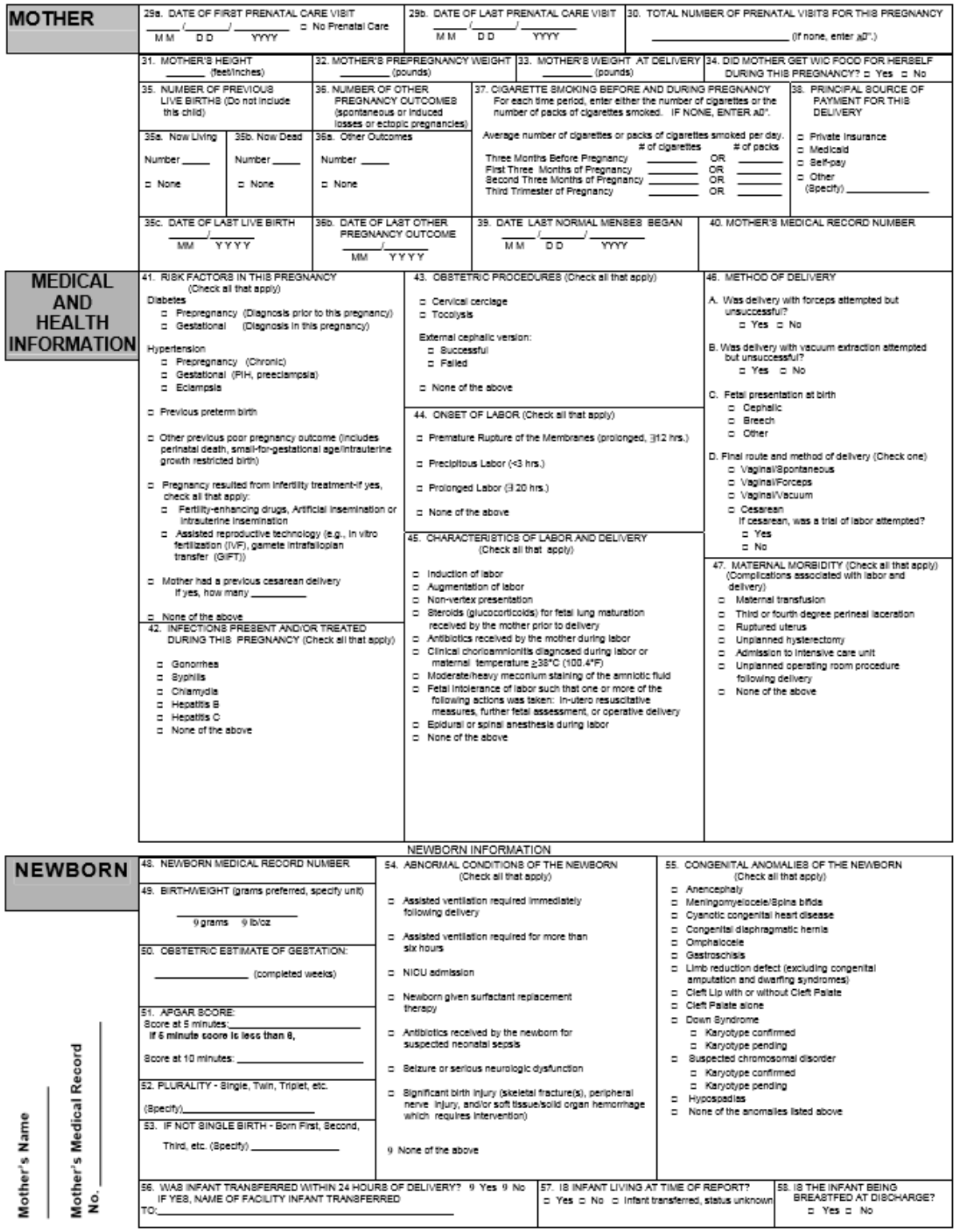
26. PLACE WHERE BIRTH OCCURRED (Check one)
☐ Hospital
☐ Freestanding birthing center
☐ Home Birth: Planned to deliver at home? 9 Yes 9 No
☐ Clinic/Doctor's office
☐ Other (Specify)_____

27. ATTENDANT'S NAME, TITLE, AND NPI
NAME: _____ NPI:_____
TITLE: ☐ MD ☐ DO ☐ CNM/CM ☐ OTHER MIDWIFE
☐ OTHER (Specify)_____

28. MOTHER TRANSFERRED FOR MATERNAL MEDICAL OR FETAL INDICATIONS FOR DELIVERY? ☐ Yes ☐ No
IF YES, ENTER NAME OF FACILITY MOTHER TRANSFERRED FROM:
_____

REV. 11/2003

Appendix A: US Birth Certificate (continued)



MOTHER

29a. DATE OF FIRST PRENATAL CARE VISIT ____/____/____ (MM DD YYYY) ☐ No Prenatal Care

29b. DATE OF LAST PRENATAL CARE VISIT ____/____/____ (MM DD YYYY)

30. TOTAL NUMBER OF PRENATAL VISITS FOR THIS PREGNANCY _____ (If none, enter "0".)

31. MOTHER'S HEIGHT _____ (feet/inches)

32. MOTHER'S PREPREGNANCY WEIGHT _____ (pounds)

33. MOTHER'S WEIGHT AT DELIVERY _____ (pounds)

34. DID MOTHER GET WIC FOOD FOR HERSELF DURING THIS PREGNANCY? ☐ Yes ☐ No

35. NUMBER OF PREVIOUS LIVE BIRTHS (Do not include this child)

35a. Now Living Number ____ ☐ None

35b. Now Dead Number ____ ☐ None

36. NUMBER OF OTHER PREGNANCY OUTCOMES (spontaneous or induced losses or ectopic pregnancies)

36a. Other Outcomes Number ____ ☐ None

37. CIGARETTE SMOKING BEFORE AND DURING PREGNANCY
For each time period, enter either the number of cigarettes or the number of packs of cigarettes smoked. IF NONE, ENTER "0".

Average number of cigarettes or packs of cigarettes smoked per day.

	# of cigarettes	OR	# of packs
Three Months Before Pregnancy		OR	
First Three Months of Pregnancy		OR	
Second Three Months of Pregnancy		OR	
Third Trimester of Pregnancy		OR	

38. PRINCIPAL SOURCE OF PAYMENT FOR THIS DELIVERY
☐ Private Insurance
☐ Medicaid
☐ Self-pay
☐ Other (Specify) _____

35c. DATE OF LAST LIVE BIRTH ____/____ (MM YYYY)

36b. DATE OF LAST OTHER PREGNANCY OUTCOME ____/____ (MM YYYY)

39. DATE LAST NORMAL MENSES BEGAN ____/____/____ (MM DD YYYY)

40. MOTHER'S MEDICAL RECORD NUMBER

MEDICAL AND HEALTH INFORMATION

41. RISK FACTORS IN THIS PREGNANCY (Check all that apply)

Diabetes
☐ Prepregnancy (Diagnosis prior to this pregnancy)
☐ Gestational (Diagnosis in this pregnancy)

Hypertension
☐ Prepregnancy (Chronic)
☐ Gestational (PIH, preeclampsia)
☐ Eclampsia

☐ Previous preterm birth

☐ Other previous poor pregnancy outcome (Includes perinatal death, small-for-gestational age/intrauterine growth restricted birth)

☐ Pregnancy resulted from infertility treatment-If yes, check all that apply:
☐ Fertility-enhancing drugs, Artificial insemination or intrauterine insemination
☐ Assisted reproductive technology (e.g., In vitro fertilization (IVF), gamete intrafallopian transfer (GIFT))

☐ Mother had a previous cesarean delivery
If yes, how many _____

☐ None of the above

42. INFECTIONS PRESENT AND/OR TREATED DURING THIS PREGNANCY (Check all that apply)
☐ Gonorrhea
☐ Syphilis
☐ Chlamydia
☐ Hepatitis B
☐ Hepatitis C
☐ None of the above

43. OBSTETRIC PROCEDURES (Check all that apply)
☐ Cervical cerclage
☐ Tocolysis

External cephalic version:
☐ Successful
☐ Failed

☐ None of the above

44. ONSET OF LABOR (Check all that apply)
☐ Premature Rupture of the Membranes (prolonged, ≥12 hrs.)
☐ Precipitous Labor (<3 hrs.)
☐ Prolonged Labor (≥ 20 hrs.)
☐ None of the above

45. CHARACTERISTICS OF LABOR AND DELIVERY (Check all that apply)
☐ Induction of labor
☐ Augmentation of labor
☐ Non-vertex presentation
☐ Steroids (glucocorticoids) for fetal lung maturation received by the mother prior to delivery
☐ Antibiotics received by the mother during labor
☐ Clinical chorioamnionitis diagnosed during labor or maternal temperature ≥38°C (100.4°F)
☐ Moderate/heavy meconium staining of the amniotic fluid
☐ Fetal intolerance of labor such that one or more of the following actions was taken: In-utero resuscitative measures, further fetal assessment, or operative delivery
☐ Epidural or spinal anesthesia during labor
☐ None of the above

46. METHOD OF DELIVERY

A. Was delivery with forceps attempted but unsuccessful?
☐ Yes ☐ No

B. Was delivery with vacuum extraction attempted but unsuccessful?
☐ Yes ☐ No

C. Fetal presentation at birth
☐ Cephalic
☐ Breech
☐ Other

D. Final route and method of delivery (Check one)
☐ Vaginal/Spontaneous
☐ Vaginal/Forceps
☐ Vaginal/Vacuum
☐ Cesarean
If cesarean, was a trial of labor attempted?
☐ Yes
☐ No

47. MATERNAL MORBIDITY (Check all that apply)
(Complications associated with labor and delivery)
☐ Maternal transfusion
☐ Third or fourth degree perineal laceration
☐ Ruptured uterus
☐ Unplanned hysterectomy
☐ Admission to intensive care unit
☐ Unplanned operating room procedure following delivery
☐ None of the above

NEWBORN INFORMATION

NEWBORN

48. NEWBORN MEDICAL RECORD NUMBER

49. BIRTHWEIGHT (grams preferred, specify unit)
_____ 9 grams 9 lb/oz

50. OBSTETRIC ESTIMATE OF GESTATION:
_____ (completed weeks)

51. APGAR SCORE:
Score at 5 minutes:_____
If 5 minute score is less than 8,
Score at 10 minutes: _____

52. PLURALITY - Single, Twin, Triplet, etc.
(Specify)_____

53. IF NOT SINGLE BIRTH - Born First, Second, Third, etc. (Specify) _____

54. ABNORMAL CONDITIONS OF THE NEWBORN (Check all that apply)
☐ Assisted ventilation required immediately following delivery
☐ Assisted ventilation required for more than six hours
☐ NICU admission
☐ Newborn given surfactant replacement therapy
☐ Antibiotics received by the newborn for suspected neonatal sepsis
☐ Seizure or serious neurologic dysfunction
☐ Significant birth injury (skeletal fracture(s), peripheral nerve injury, and/or soft tissue/solid organ hemorrhage which requires intervention)
9 None of the above

55. CONGENITAL ANOMALIES OF THE NEWBORN (Check all that apply)
☐ Anencephaly
☐ Meningomyelocele/Spina bifida
☐ Cyanotic congenital heart disease
☐ Congenital diaphragmatic hernia
☐ Omphalocele
☐ Gastroschisis
☐ Limb reduction defect (excluding congenital amputation and dwarfing syndromes)
☐ Cleft Lip with or without Cleft Palate
☐ Cleft Palate alone
☐ Down Syndrome
☐ Karyotype confirmed
☐ Karyotype pending
☐ Suspected chromosomal disorder
☐ Karyotype confirmed
☐ Karyotype pending
☐ Hypospadias
☐ None of the anomalies listed above

56. WAS INFANT TRANSFERRED WITHIN 24 HOURS OF DELIVERY? 9 Yes 9 No
IF YES, NAME OF FACILITY INFANT TRANSFERRED TO:_____

57. IS INFANT LIVING AT TIME OF REPORT? ☐ Yes ☐ No ☐ Infant transferred, status unknown

58. IS THE INFANT BEING BREASTFED AT DISCHARGE? ☐ Yes ☐ No

Mother's Name _____ Mother's Medical Record No. _____

Appendix B: Supplemental Tables and Figures

Table XIX
DISTRIBUTION OF THE STUDY POPULATION AND TIME OF ENTRY INTO PRENATAL CARE: CHICAGO, 2010–2014

		Trimester of prenatal care initiation			
Characteristics	*N= 180,216 n (%)*	*First (%)*	*Second (%)*	*Third (%)*	*No PNC (%)*
Maternal race					
Non-Hispanic White	53284 (29.6)	86.4	0.5	10.9	2.2
Non-Hispanic Black	55939 (31.1)	68.4	4.1	22.2	5.4
Hispanic	59259 (32.9)	77.1	1.5	17.7	3.8
Other race/ethnicity	11644 (6.5)	80.3	0.5	15.4	3.8
Maternal age					
Less than 20 years	16933 (9.4)	59.8	4.1	28.7	7.4
20–34 years	130019 (72.2)	78.0	1.9	16.5	3.7
35 years and above	33174 (18.4)	83.6	1.1	12.8	2.5
Maternal level of education					
Less than 12 years	38140 (21.2)	67.7	4.4	22.4	5.6
12 years	39918 (22.2)	71.4	2.7	21.1	4.8
More than 12 years	102068 (56.7)	83.3	0.7	13.3	2.8
Marital status					
Married	91063 (50.6)	84.8	0.6	12.0	2.6
Not married	89063 (49.4)	69.7	3.3	22.0	5.1
Parity					
No prior live birth	78370 (43.5)	78.7	1.2	16.4	3.7
1 or 2 live births	80299 (44.6)	78.3	1.8	16.4	3.5
3 or more prior live births	21457 (11.9)	68.6	4.9	21.2	5.3
Plurality					
Singleton gestation	173617 (96.4)	77.2	1.9	17.0	3.9
Multiple gestations	6509 (3.6)	79.8	1.7	16.1	2.4
Medical/reproductive risk					
No	135329 (75.1)	77.2	2.0	17.0	3.8
Yes	44797 (24.9)	77.7	1.7	16.7	3.8
Smoking during pregnancy					
No	174676 (97.0)	77.9	1.7	16.7	3.7
Yes	5450 (3.0)	58.7	9.9	24.2	7.3
Alcohol use during pregnancy					
No	179080 (99.4)	77.4	1.9	16.9	3.8
Yes	1046 (0.6)	66.1	6.4	20.9	6.6
Health insurance status					
Private Insurance	69492 (38.6)	88.1	0.4	9.8	1.7
Medicaid	104012 (57.7)	70.9	2.6	21.4	5.1
Uninsured/Self-pay	1518 (0.8)	55.3	12.1	19.0	13.6
Others	5104 (2.8)	67.2	6.0	22.2	4.6
Community racial/ethnic composition[a]					
NH-White community	32726 (18.2)	86.5	0.3	11.0	2.2
NH-Black community	43189 (24.0)	69.2	4.2	21.7	5.0
Hispanic community	33226 (18.4)	77.4	1.7	17.2	3.8
Mixed community	70985 (39.4)	78.1	1.4	16.7	3.9

[a] Community racial/ethnic composition: a four-level variable (NH-White, NH-Black, Hispanic, and *Mixed* communities) based on the majority racial/ethnic group greater than or equal to 60% of the residents in the community-area.

Table XX
ADEQUACY OF PRENATAL CARE UTILIZATION BY CHARACTERISTICS OF THE STUDY POPULATION: CHICAGO, 2010–2014

	Adequacy of prenatal care utilization[a] *(N= 180,126)*			
Characteristics	*Inadequate (%)*	*Intermediate (%)*	*Adequate (%)*	*Adequate Plus (%)*
Maternal race				
Non-Hispanic White	7.3	5.0	45.3	42.4
Non-Hispanic Black	24.6	14.0	29.3	32.2
Hispanic	14.6	10.9	36.7	37.9
Other race/ethnicity	12.0	7.2	40.4	40.4
Maternal age				
Less than 20 years	30.7	14.5	28.4	26.4
20–34 years	14.9	10.2	37.7	37.3
35 years and above	9.6	6.2	39.6	44.7
Maternal level of education				
Less than 12 years	24.8	13.6	30.1	31.5
12 years	20.4	13.3	32.7	33.6
More than 12 years	9.9	7.1	41.6	41.5
Marital status				
Married	8.7	6.6	42.6	42.2
Not married	22.3	13.2	31.7	32.9
Parity				
No prior live birth	13.9	8.7	38.8	38.6
1 or 2 live births	14.5	10.3	37.7	37.5
3 or more prior live births	24.1	12.5	29.4	34.1
Plurality				
Singleton gestation	15.5	10.1	38.1	36.2
Multiple gestations	11.9	2.5	11.6	73.9
Medical/reproductive risk				
No	15.7	10.9	39.0	34.5
Yes	14.5	6.7	31.7	47.1
Smoking during pregnancy				
No	14.7	9.7	37.6	38.0
Yes	36.0	14.8	23.5	25.7
Alcohol use during pregnancy				
No	15.3	9.8	37.2	37.6
Yes	27.1	11.1	30.1	31.7
Health insurance status				
Private Insurance	6.2	4.7	44.8	44.2
Medicaid	20.7	13.1	32.4	33.8
Uninsured/Self-pay	41.4	13.4	25.6	19.6
Others	23.2	11.9	34.9	30.1
Community racial/ethnic composition[b]				
NH-White community	7.0	4.0	45.1	43.9
NH-Black community	24.2	14.5	29.6	31.7
Hispanic community	14.8	12.2	36.8	36.3
Mixed community	14.2	8.6	38.3	38.9

[a] Inadequate prenatal care utilization (PNCU) was defined as having inadequate or intermediate prenatal care utilization based on Kotelchuck's Index

[b] Community racial/ethnic composition: a four-level variable (NH-White, NH-Black, Hispanic, and *Mixed* communities) based on the majority racial/ethnic group greater than or equal to 60% of the residents in the community-area.

Table XXI
PREVALENCE OF INADEQUATE PRENATAL CARE UTILIZATION (PNCU) AND THE PRIMARY EXPOSURE VARIABLES BY CHICAGO COMMUNITY AREA, 2010–2014

Community area	*Inadequate PNCU (%)*	*Hardship Index*	*Violent crime*	*Isolation Index*
Rogers Park	28.02	40.12	0.55	0.33
West Ridge	28.53	44.92	0.32	0.17
Uptown	16.56	29.98	0.47	0.29
Lincoln Square	13.83	24.27	0.25	0.07
North Center	6.20	14.47	0.18	0.03
Lake View	7.14	10.90	0.49	0.08
Lincoln Park	6.59	11.94	0.27	0.07
Near North Side	11.64	9.33	0.47	0.29
Edison Park	12.71	24.65	0.04	0.00
Norwood Park	13.47	29.51	0.09	0.02
Jefferson Park	17.98	34.43	0.18	0.02
Forest Glen	14.78	24.84	0.06	0.02
North Park	24.69	36.46	0.27	0.03
Albany Park	21.47	49.25	0.42	0.06
Portage Park	19.12	37.81	0.31	0.03
Irving Park	17.55	38.70	0.43	0.08
Dunning	16.85	34.04	0.18	0.03
Montclaire	21.95	43.59	0.30	0.07
Belmont Cragin	22.69	56.50	0.49	0.07
Hermosa	21.70	54.86	0.59	0.03
Avondale	19.18	40.12	0.50	0.03
Logan Square	15.10	29.21	0.55	0.08
Humboldt park	28.79	62.58	1.63	0.61
West Town	10.70	22.59	0.65	0.15
Austin	32.65	55.29	1.70	0.90
West Garfield Park	38.38	67.52	2.95	0.90
East Garfield Park	36.62	58.33	2.51	0.87
Near West Side	15.40	27.01	0.98	0.55
North Lawndale	38.90	65.50	2.55	0.80
South Lawndale	30.32	71.17	0.80	0.52
Lower West Side	26.20	56.28	0.60	0.06
Loop	11.91	9.42	0.97	0.15
Near South Side	9.60	14.07	0.35	0.33
Armour Square	33.43	55.75	0.71	0.64
Douglas	34.01	41.15	1.20	0.84
Oakland	35.73	57.17	0.72	0.91
Fuller Park	51.78	67.49	3.97	0.89
Grand Boulevard	34.41	49.02	1.84	0.91
Kenwood	26.51	36.47	0.55	0.81
Washington Park	45.34	68.98	3.52	0.96
Hyde Park	19.70	25.78	0.45	0.48
Woodlawn	37.49	49.23	1.99	0.90
South Shore	40.34	48.41	2.10	0.95

Table XXI (continued)
PREVALENCE OF INADEQUATE PRENATAL CARE UTILIZATION[a] (PNCU) AND THE PRIMARY EXPOSURE VARIABLES[b] BY CHICAGO COMMUNITY AREA, 2010–2014

Community area	*Inadequate PNCU (%)*	*Hardship Index*	*Violent crime*	*Isolation Index*
Chatham	38.14	48.27	2.35	0.95
Avalon Park	36.15	39.99	1.53	0.92
South Chicago	42.80	55.98	1.94	0.70
Burnside	41.89	58.61	1.16	0.75
Calumet Heights	36.93	39.25	1.20	0.92
Roseland	39.95	47.62	1.94	0.96
Pullman	29.11	44.14	1.20	0.89
South Deering	37.20	52.65	1.26	0.84
East Side	30.57	51.68	0.34	0.08
West Pullman	41.97	53.07	1.66	0.95
Riverdale	46.17	82.17	2.03	0.95
Hegewisch	29.75	39.34	0.35	0.09
Garfield Ridge	23.43	36.42	0.30	0.58
Archer Heights	29.76	54.39	0.58	0.07
Brighton Park	30.11	63.88	0.45	0.03
McKinley Park	27.01	51.06	0.50	0.05
Bridgeport	27.00	43.98	0.30	0.11
New City	37.07	67.15	1.25	0.65
West Elsdon	27.36	55.03	0.33	0.02
Gage Park	29.79	71.11	0.60	0.12
Clearing	20.96	35.14	0.22	0.04
West Lawn	29.38	50.04	0.47	0.05
Chicago Lawn	33.90	58.52	1.32	0.63
West Englewood	47.37	63.64	2.76	0.81
Englewood	47.00	67.58	3.22	0.77
Greater Grand Crossing	44.35	53.22	2.58	0.82
Ashburn	26.16	37.04	0.55	0.65
Auburn Gresham	38.82	54.34	1.91	0.86
Beverly	13.10	24.23	0.37	0.45
Washington Height	33.38	42.35	1.60	0.78
Mount Greenwood	10.09	25.78	0.13	0.09
Morgan Park	25.69	34.64	0.69	0.65
O'Hare	23.56	34.82	0.17	0.02
Edgewater	19.24	28.95	0.31	0.17

[a] Inadequate prenatal care utilization is defined as having *inadequate* or *intermediate* prenatal care utilization based on Kotelchuck's Index
[b] *Hardship index* was measured on a scale of 0–100, while NH-Black *Isolation Index* was measured on a scale of 0–1. Violent crime rate was measured per 100 residents.

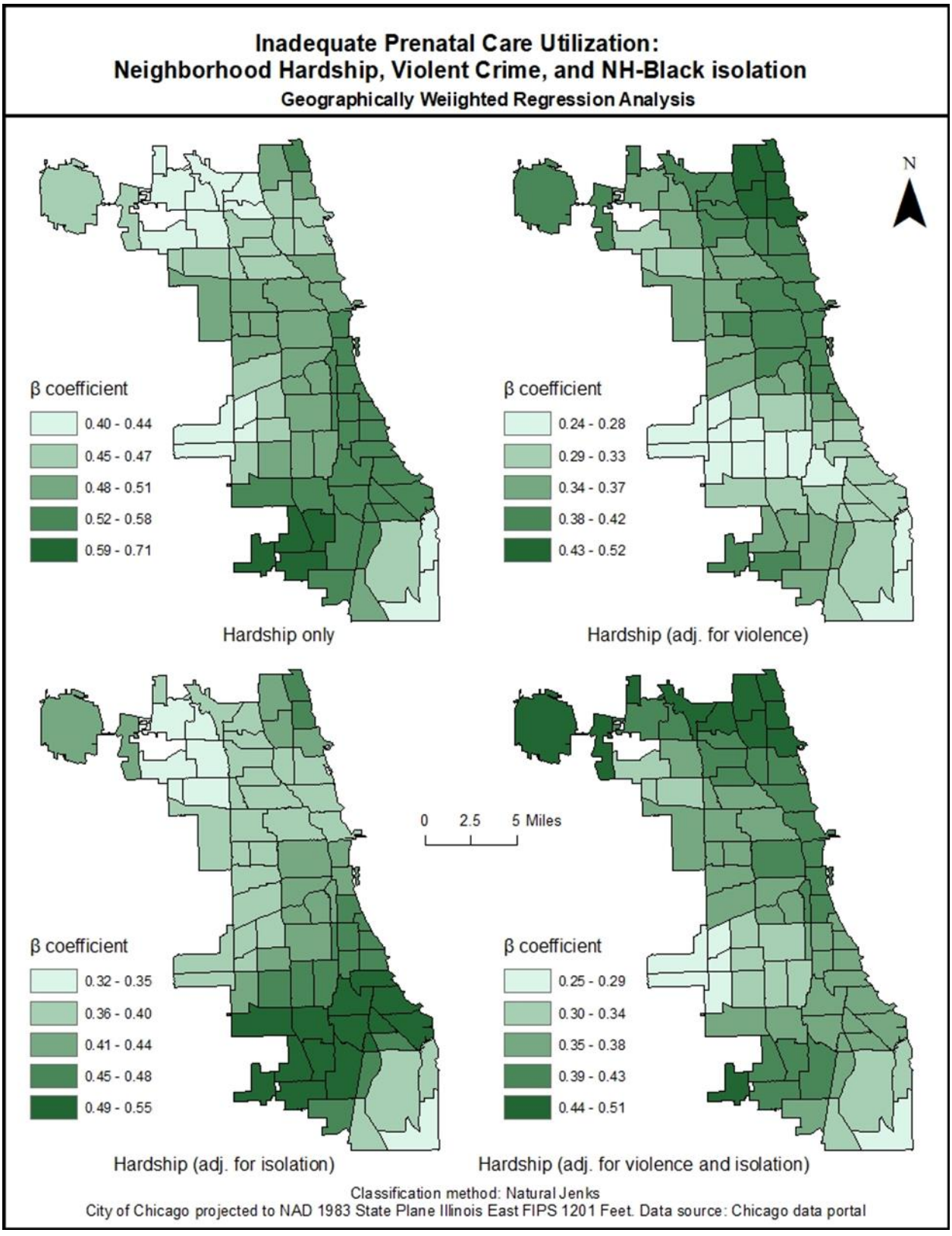


Figure 9. Prenatal care utilization: spatial variation in the regression coefficient for neighborhood hardship with sequential adjustment for other community-level variables

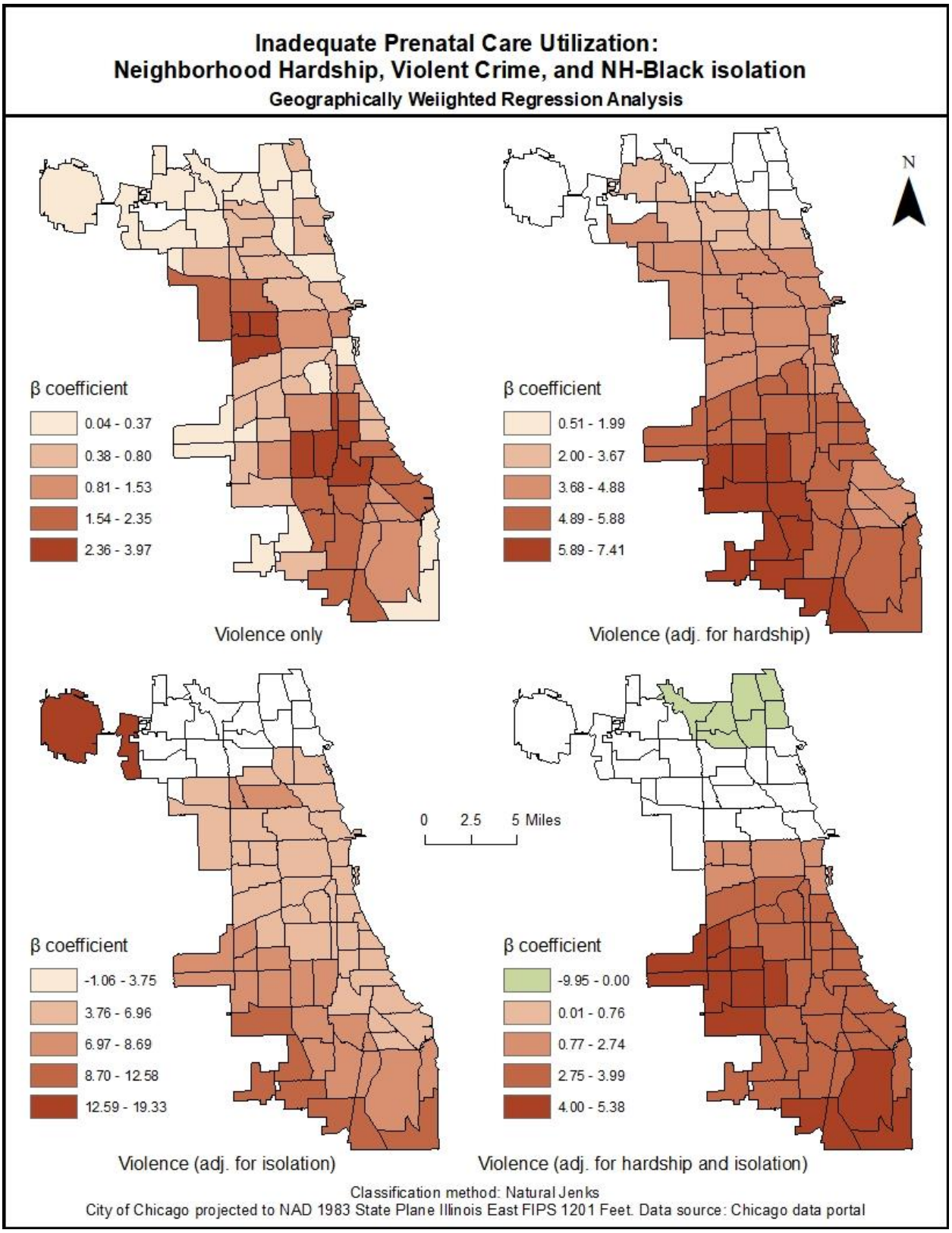


Figure 10. Prenatal care utilization: spatial variation in the regression coefficient for violent crime with sequential adjustment for other community-level variables

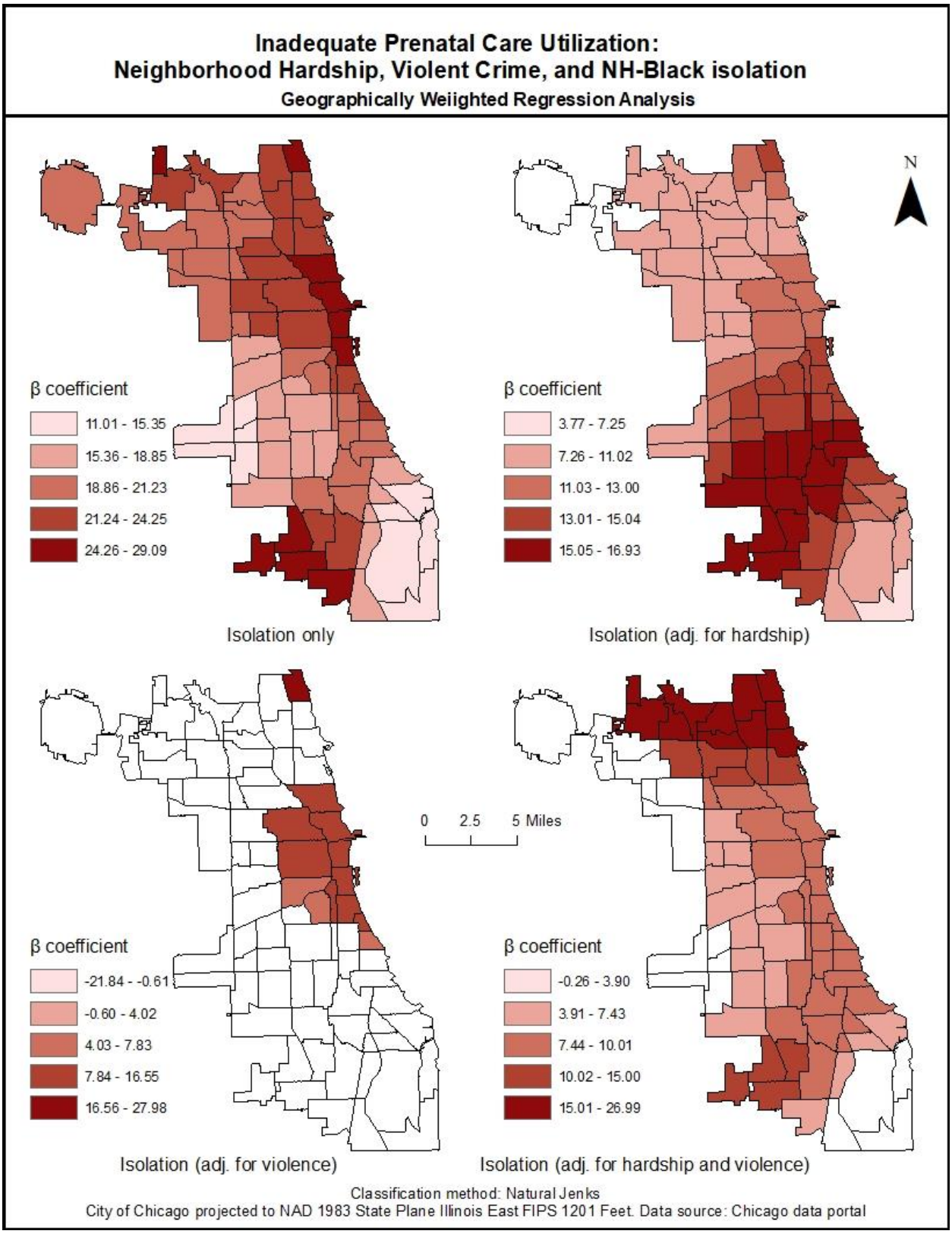


Figure 11. Prenatal care utilization: spatial variation in the regression coefficient for NH-Black isolation with sequential adjustment for other community-level variables

Table XXII

MULTILEVEL LOGISTIC REGRESSION MODELS[a] OF THE ASSOCIATION BETWEEN COMMUNITY-LEVEL CHARACTERISTICS AND INADEQUATE PRENATAL CARE UTILIZATION STRATIFIED BY CHICAGO HEALTH SYSTEM PLANNING REGIONS

Community-level variables[b]	*Model 1 OR (95% CI)*	*Model 2 OR (95% CI)*	*Model 3 OR (95% CI)*	*Model 4 OR (95% CI)*	*Model 4 OR (95% CI)*	*Model 5 OR (95% CI)*	*Model 6 OR (95% CI)*
	North, Northwest, West and Central Regions						
Neighborhood hardship	1.07 (1.03–1.11)*			1.10 (1.05–1.14)*	1.08 (1.04–1.13)*		1.10 (1.05–1.14)*
Violent crime rate		1.02 (0.92–1.13)		0.89 (0.80–0.99)		0.95 (0.75–1.21)	0.83 (0.68–1.02)
NH-Black isolation			1.01 (0.98–1.03)		0.98 (0.96–1.01)	1.02 (0.96–1.08)	1.02 (0.97–1.07)
	South, Southwest and Far South Regions						
Neighborhood hardship	1.02 (1.00–1.05)			1.00 (0.97–1.03)	1.02 (1.00–1.05)		1.00 (0.98–1.03)
Violent crime rate		1.07 (1.04–1.11)*		1.07 (1.03–1.12)*		1.06 (1.02–1.11)*	1.06 (1.01–1.12)*
NH-Black isolation			1.02 (1.01–1.03)*		1.01 (1.00–1.02)	1.00 (0.99–1.02)	1.00 (0.99–1.02)

[a] Regression estimates were obtained from stratified analyses by Chicago region.

[b] Neighborhood hardship, violent crime rate and NH-Black isolation were scaled to unit increase of 10%, 0.1 and 1 per 100 residents, respectively.

* Significant at α=0.05

Table XXIII

MULTILEVEL LOGISTIC REGRESSION MODELS[a] OF THE ASSOCIATION BETWEEN COMMUNITY-LEVEL CHARACTERISTICS AND INADEQUATE PRENATAL CARE UTILIZATION AMONG NON-HISPANIC WHITE MOTHERS STRATIFIED BY CHICAGO HEALTH SYSTEM PLANNING REGIONS

Community-level variables[b]	*Model 1 OR (95% CI)*	*Model 2 OR (95% CI)*	*Model 3 OR (95% CI)*	*Model 4 OR (95% CI)*	*Model 4 OR (95% CI)*	*Model 5 OR (95% CI)*	*Model 6 OR (95% CI)*
	North, Northwest, West and Central Regions						
Hardship Index	1.13 (1.07–1.19)*			1.12 (1.05–1.20)*	1.12 (1.05–1.19)*		1.13 (1.06–1.20)*
Violent crime rate		1.22 (1.01–1.48)*		1.04 (0.86–1.27)		1.12 (0.76–1.65)	0.77 (0.54–1.10)
Isolation Index			1.05 (1.00–1.09)		1.02 (0.98–1.06)	1.02 (0.94–1.12)	1.07 (0.99–1.16)
	South, Southwest and Far South Regions						
Hardship Index	1.07 (1.01–1.13)*			1.02 (0.96–1.09)	1.06 (1.00–1.12)		1.03 (0.96–1.10)
Violent crime rate		1.21 (1.08–1.36)*		1.18 (1.03–1.35)*		1.21 (1.03–1.43)*	1.16 (1.05–1.42)*
Isolation Index			1.03 (1.00–1.05)		1.02 (1.00–1.05)	1.00 (0.97–1.03)	1.00 (0.97–1.04)

[a] Regression estimates were obtained from stratified analyses by Chicago region and race/ethnicity.

[b] Neighborhood hardship, violent crime rate and NH-Black isolation were scaled to unit increase of 10%, 0.1 and 1 per 100 residents, respectively.

* Significant at α=0.05

Table XXIV

MULTILEVEL LOGISTIC REGRESSION MODELS[a] OF THE ASSOCIATION BETWEEN COMMUNITY-LEVEL CHARACTERISTICS AND INADEQUATE PRENATAL CARE UTILIZATION AMONG NH-BLACK MOTHERS STRATIFIED BY CHICAGO HEALTH SYSTEM PLANNING REGIONS

Community-level variables[b]	*Model 1 OR (95% CI)*	*Model 2 OR (95% CI)*	*Model 3 OR (95% CI)*	*Model 4 OR (95% CI)*	*Model 4 OR (95% CI)*	*Model 5 OR (95% CI)*	*Model 6 OR (95% CI)*
	North, Northwest, West and Central Regions						
Hardship Index	1.02 (0.98–1.06)			1.05 (1.00–1.11)	1.04 (0.99–1.09)		1.05 (1.00–1.11)
Violent crime rate		0.96 (0.88–1.04)		0.89 (0.80–0.99)		0.92 (0.76–1.13)	0.87 (0.72–1.05)
Isolation Index			0.99 (0.97–1.02)		0.98 (0.95–1.01)	1.01 (0.96–1.07)	1.01 (0.96–1.06)
	South, Southwest and Far South Regions						
Hardship Index	1.04 (1.01–1.08)*			1.03 (0.99–1.07)	1.04 (1.01–1.08)*		1.04 (1.00–1.08)
Violent crime rate		1.05 (1.01–1.10)*		1.03 (0.98–1.09)		1.05 (1.00–1.11)	1.01 (0.95–1.08)
Isolation Index			1.01 (0.99–1.03)		1.01 (0.99–1.03)	1.00 (0.98–1.02)	1.01 (0.99–1.03)

[a] Regression estimates were obtained from stratified analyses by Chicago region and race/ethnicity.

[b] Neighborhood hardship, violent crime rate and NH-Black isolation were scaled to unit increase of 10%, 0.1 and 1 per 100 residents, respectively.

* Significant at α=0.05

Table XXV

MULTILEVEL LOGISTIC REGRESSION MODELS[a] OF THE ASSOCIATION BETWEEN COMMUNITY-LEVEL CHARACTERISTICS AND INADEQUATE PRENATAL CARE UTILIZATION AMONG HISPANIC MOTHERS STRATIFIED BY CHICAGO HEALTH SYSTEM PLANNING REGIONS

Community-level variables[b]	*Model 1 OR (95% CI)*	*Model 2 OR (95% CI)*	*Model 3 OR (95% CI)*	*Model 4 OR (95% CI)*	*Model 4 OR (95% CI)*	*Model 5 OR (95% CI)*	*Model 6 OR (95% CI)*
	North, Northwest, West and Central Regions						
Hardship Index	1.08 (1.04–1.11)*			1.07 (1.03–1.12)*	1.06 (1.02–1.11)*		1.07 (1.03–1.11)*
Violent crime rate		1.14 (1.02–1.27)*		1.02 (0.90–1.15)		0.97 (0.77–1.21)	0.83 (0.67–1.01)
Isolation Index			1.03 (1.01–1.06)*		1.01 (0.99–1.04)	1.04 (0.99–1.09)	1.05 (1.01–1.09)*
	South, Southwest and Far South Regions						
Hardship Index	0.99 (0.96–1.03)			0.98 (0.95–1.01)	0.99 (0.96–1.03)		0.96 (0.93–0.99)
Violent crime rate		1.11 (1.04–1.19)*		1.12 (1.04–1.20)*		1.14 (1.02–1.27)*	1.22 (1.09–1.38)*
Isolation Index			1.01 (1.00–1.02)		1.01 (1.00–1.02)	0.99 (0.98–1.01)	0.98 (0.96–1.00)

[a] Regression estimates were obtained from stratified analyses by Chicago region and race/ethnicity.

[b] Neighborhood hardship, violent crime rate and NH-Black isolation were scaled to unit increase of 10%, 0.1 and 1 per 100 residents, respectively.

* Significant at α=0.05

Table XXVI
CHICAGO COMMUNITY AREAS CATEGORIZED BY THE PREDOMINANT RACIAL/ETHNIC GROUP, AMERICAN COMMUNITY SURVEY 2009–2013 (N= 77)

Community area	*Non-Hispanic White (%)*	*Non-Hispanic Black (%)*	*Hispanic (%)*	*Other race/ethnicity (%)*
NH-White Chicago Community Areas (n=14)				
Lake View	81.5	3.4	7.7	7.4
Lincoln Park	80.5	4.2	7.0	8.4
Mount Greenwood	80.1	4.1	5.6	10.2
Norwood Park	79.6	0.9	13.6	6.0
Forest Glen	76.0	0.9	12.3	10.9
Near North Side	74.3	10.3	6.1	9.4
Loop	73.2	14.3	7.0	5.5
Edison Park	72.0	0.0	5.0	23.0
Dunning	69.3	1.1	24.4	5.3
Jefferson Park	69.0	1.3	21.7	8.0
North Center	68.2	1.6	12.7	17.5
Near South Side	60.7	29.7	7.3	2.4
Lincoln Square	60.6	4.4	15.4	19.7
North Park	60.3	2.4	21.9	15.5
NH-Black Chicago Community Areas (n=26)				
Roseland	1.1	96.5	1.1	1.3
Washington Park	0.1	95.6	1.5	2.9
Riverdale	0.0	95.3	4.4	0.3
South Shore	1.5	95.0	1.5	2.1
Chatham	0.5	94.2	0.4	5.0
West Pullman	1.6	93.7	3.8	0.9
Calumet Heights	1.6	91.4	4.9	2.1
Avalon Park	1.8	91.3	0.3	6.5
Oakland	1.7	90.8	3.1	4.4
Grand Boulevard	4.2	90.1	2.8	2.9
Fuller Park	1.7	89.3	7.2	1.8
Woodlawn	8.0	88.0	2.1	1.8
West Garfield Park	1.4	86.8	0.8	11.1
East Garfield Park	3.2	85.7	2.3	8.8
Austin	4.6	85.5	9.5	0.4
Auburn Gresham	0.2	84.8	1.2	13.8
Greater Grand Crossing	1.0	80.8	1.5	16.7
Douglas	13.5	80.2	3.0	3.3
Pullman	8.2	79.7	9.6	2.6
West Englewood	0.9	79.2	2.4	17.5
Washington Height	0.8	76.9	0.9	21.5
Englewood	0.5	76.6	0.9	22.1
Kenwood	19.3	75.5	4.5	0.7
Burnside	0.5	74.7	0.0	24.8
North Lawndale	1.5	71.0	4.7	22.8
South Deering	4.3	63.8	30.5	1.4

Table XXVI (continued)
CHICAGO COMMUNITY AREAS CATEGORIZED BY THE PREDOMINANT RACIAL/ETHNIC GROUP[a], AMERICAN COMMUNITY SURVEY 2009–2013 (N= 77)

Community area	*Non-Hispanic White (%)*	*Non-Hispanic Black (%)*	*Hispanic (%)*	*Other race/ethnicity (%)*
Hispanic Chicago Community Areas (n=12)				
Gage Park	4.1	3.9	90.8	1.2
Hermosa	7.3	1.3	90.1	1.3
Brighton Park	8.4	1.8	89.1	0.7
South Lawndale	3.6	11.2	82.7	2.4
West Elsdon	18.4	1.4	80.1	0.2
West Lawn	15.9	3.3	79.6	1.2
East Side	17.5	2.5	78.3	1.8
Belmont Cragin	14.8	4.2	78.2	2.8
Lower West Side	11.7	3.6	77.0	7.7
Archer Heights	20.9	1.5	77.0	0.6
McKinley Park	21.9	3.5	73.3	1.4
Avondale	29.3	2.0	64.2	4.5
Mixed Chicago Community Areas (n=25)				
O'Hare	55.5	1.1	14.5	29.0
West Ridge	43.4	10.3	19.2	27.2
Edgewater	46.8	11.6	14.9	26.7
South Chicago	2.4	59.8	18.5	19.4
Albany Park	27.5	3.8	49.9	18.9
Morgan Park	33.6	45.8	5.2	15.4
Uptown	55.5	20.4	12.5	11.6
Beverly	50.6	32.4	5.4	11.6
Armour Square	37.5	39.2	11.9	11.4
Ashburn	14.3	44.0	30.9	10.9
Rogers Park	38.7	26.8	24.6	9.8
Irving Park	41.8	2.7	46.5	9.1
Portage Park	49.2	1.2	42.2	7.5
Chicago Lawn	3.3	48.9	42.0	5.8
West Town	57.7	7.8	28.8	5.7
Near West Side	47.7	35.1	11.9	5.3
Logan Square	43.1	5.9	47.7	3.3
Montclaire	38.0	4.5	54.8	2.6
Humboldt park	5.3	40.1	52.1	2.5
Clearing	52.2	0.6	45.0	2.2
Garfield Ridge	51.1	5.2	41.5	2.2
New City	14.9	28.9	54.2	2.1
Bridgeport	51.1	3.6	43.4	2.0
Hegewisch	40.5	7.0	51.4	1.2
Hyde Park	54.6	38.6	5.8	1.1

[a] Community areas were classified based on the predominant racial/ethnic group. Community areas where the percentage of the NH-white population was equal to or greater than 60% were grouped as NH-White communities. The same percentage cut-off point (60%) was used to define NH-Black and Hispanic communities. Mixed communities are communities that did not meet the classification criterium.

Table XXVII

SENSITIVITY ANALYSIS: RACIAL DISPARITIES IN INADEQUATE PRENATAL CARE UTILIZATION BY TYPE OF RACIAL/ETHNIC COMPOSITION OF COMMUNITY AREA OF RESIDENCE, CHICAGO 2010–2014 (N= 180,216)

	Community racial/ethnic composition= NH-White community				
% cut-off point	*50%*	*55%*	*60%*	*65%*	*70%*
	Late/No PNC				
Maternal race/ethnicity[a]					
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.46 (1.28–1.66)	1.51 (1.25–1.82)	1.34 (1.16–1.54)	1.35 (1.16–1.57)	1.39 (1.21–1.59)
Hispanic	1.13 (0.96–1.33)	1.10 (0.92–1.32)	1.15 (1.00–1.33)	1.11 (0.97–1.26)	1.09 (1.00–1.19)
	Inadequate PNCU				
Maternal race/ethnicity					
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.69 (1.41–2.04)	1.65 (1.43–1.91)	1.64 (1.39–1.93)	1.54 (1.32–1.81)	1.52 (1.29–1.79)
Hispanic	1.11 (0.92–1.35)	0.95 (0.84–1.08)	0.99 (0.85–1.16)	1.03 (0.90–1.19)	1.02 (0.90–1.15)
	Community racial/ethnic composition= NH-Black community				
% cut-off point	*50%*	*55%*	*60%*	*65%*	*70%*
	Late/No PNC				
Maternal race/ethnicity					
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.15 (1.01–1.31)	1.16 (1.01–1.33)	1.15 (1.00–1.31)	1.17 (1.00–1.36)	1.17 (1.03–1.33)
Hispanic	1.03 (0.89–1.19)	1.03 (0.91–1.17)	1.06 (0.93–1.20)	1.13 (1.01–1.26)	1.13 (1.05–1.22)
	Inadequate PNCU				
Maternal race/ethnicity					
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.17 (1.02–1.35)	1.18 (1.04–1.33)	1.15 (0.98–1.36)	1.16 (0.99–1.36)	1.16 (1.01–1.34)
Hispanic	0.90 (0.78–1.05)	0.91 (0.82–1.01)	0.86 (0.74–0.99)	0.86 (0.76–0.98)	0.86 (0.78–0.95)
	Community racial/ethnic composition= Hispanic community				
% cut-off point	*50%*	*55%*	*60%*	*65%*	*70%*
	Late/No PNC				
Maternal race/ethnicity					
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.22 (1.07–1.40)	1.37 (1.18–1.60)	1.38 (1.20–1.58)	1.38 (1.18–1.62)	1.38 (1.20–1.59)
Hispanic	0.98 (0.85–1.13)	0.98 (0.86–1.12)	0.98 (0.86–1.11)	1.01 (0.90–1.12)	1.01 (0.94–1.08)
	Inadequate PNCU				
Maternal race/ethnicity					
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.50 (1.33–1.70)	1.51 (1.34–1.69)	1.50 (1.27–1.77)	1.48 (1.26–1.74)	1.49 (1.30–1.71)
Hispanic	1.05 (0.92–1.20)	1.08 (0.98–1.18)	1.07 (0.93–1.24)	1.10 (0.97–1.24)	1.10 (1.00–1.20)
	Community racial/ethnic composition= Mixed community				
% cut-off point	*50%*	*55%*	*60%*	*65%*	*70%*
	Late/No PNC				
Maternal race/ethnicity					
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.28 (1.12–1.47)	1.27 (1.07–1.52)	1.32 (1.13–1.54)	1.28 (1.09–1.51)	1.30 (1.13–1.49)
Hispanic	1.01 (0.85–1.20)	1.05 (0.88–1.24)	1.06 (0.90–1.24)	1.04 (0.90–1.19)	1.05 (0.94–1.17)
	Inadequate PNCU				
Maternal race/ethnicity					
Non-Hispanic White	Reference	Reference	Reference	Reference	Reference
Non-Hispanic Black	1.44 (1.22–1.70)	1.48 (1.29–1.68)	1.58 (1.33–1.88)	1.58 (1.33–1.87)	1.64 (1.40–1.93)
Hispanic	0.89 (0.74–1.05)	0.97 (0.87–1.08)	1.00 (0.87–1.16)	0.98 (0.86–1.11)	1.00 (0.90–1.11)

[a] Other racial/ethnic groups are not shown.

Table XXVIII
SENSITIVITY ANALYSIS: ASSOCIATION BETWEEN COMMUNITY-AREA OF RESIDENCE AND PRENATAL CARE UTILIZATION BY RACE/ETHNICITY[a], CHICAGO 2010–2014 (N= 180,216)

	Race/ethnicity= Non-Hispanic White				
% cut-off point	*50%*	*55%*	*60%*	*65%*	*70%*
	Late/No PNC				
Racial/ethnic composition					
NH-White community	Reference	Reference	Reference	Reference	Reference
NH-Black community	1.11 (1.06–1.16)	1.09 (1.01–1.17)	1.08 (1.03–1.13)	1.11 (1.06–1.16)	1.13 (1.07–1.18)
Hispanics community	1.07 (1.02–1.13)	1.03 (0.96–1.11)	1.01 (0.95–1.07)	1.03 (0.97–1.10)	1.05 (0.98–1.12)
Mixed community	1.18 (1.16–1.20)	1.11 (1.07–1.14)	1.05 (1.03–1.07)	1.12 (1.10–1.15)	1.12 (1.09–1.16)
	Inadequate PNCU				
Racial/ethnic composition					
NH-White community	Reference	Reference	Reference	Reference	Reference
NH-Black community	1.71 (1.63–1.80)	1.77 (1.71–1.83)	1.75 (1.69–1.82)	1.82 (1.77–1.88)	1.79 (1.72–1.87)
Hispanics community	1.23 (1.15–1.31)	1.25 (1.20–1.31)	1.23 (1.18–1.29)	1.29 (1.24–1.34)	1.27 (1.21–1.33)
Mixed community	1.30 (1.28–1.33)	1.32 (1.30–1.34)	1.23 (1.21–1.25)	1.30 (1.29–1.32)	1.24 (1.22–1.25)

	Race/ethnicity= Non-Hispanic Black				
% cut-off point	*50%*	*55%*	*60%*	*65%*	*70%*
	Late/No PNC				
Racial/ethnic composition					
NH-White community	Reference	Reference	Reference	Reference	Reference
NH-Black community	0.88 (0.85–0.91)	0.84 (0.81–0.86)	0.93 (0.89–0.97)	0.96 (0.93–1.00)	0.95 (0.92–0.98)
Hispanics community	0.90 (0.87–0.93)	0.94 (0.91–0.97)	1.04 (1.00–1.08)	1.06 (1.03–1.09)	1.04 (1.01–1.07)
Mixed community	1.04 (1.03–1.05)	0.93 (0.92–0.95)	1.04 (1.01–1.06)	1.07 (1.05–1.09)	1.05 (1.04–1.07)
	Inadequate PNCU				
Racial/ethnic composition					
NH-White community	Reference	Reference	Reference	Reference	Reference
NH-Black community	1.19 (1.18–1.20)	1.26 (1.26–1.27)	1.23 (1.22–1.25)	1.37 (1.35–1.38)	1.37 (1.36–1.39)
Hispanics community	1.09 (1.08–1.10)	1.14 (1.14–1.15)	1.13 (1.11–1.14)	1.24 (1.22–1.25)	1.24 (1.22–1.26)
Mixed community	1.11 (1.10–1.11)	1.18 (1.18–1.18)	1.19 (1.18–1.20)	1.33 (1.32–1.34)	1.33 (1.32–1.34)

	Race/ethnicity= Hispanic				
% cut-off point	*50%*	*55%*	*60%*	*65%*	*70%*
	Late/No PNC				
Racial/ethnic composition					
NH-White community	Reference	Reference	Reference	Reference	Reference
NH-Black community	1.01 (0.97–1.04)	1.02 (0.99–1.05)	0.99 (0.94–1.04)	1.13 (1.08–1.19)	1.17 (1.11–1.23)
Hispanics community	0.93 (0.89–0.97)	0.92 (0.88–0.96)	0.86 (0.81–0.92)	0.94 (0.88–1.00)	0.97 (0.90–1.04)
Mixed community	1.05 (1.02–1.09)	1.05 (1.02–1.09)	0.96 (0.91–1.02)	1.05 (1.00–1.11)	1.08 (1.02–1.15)
	Inadequate PNCU				
Racial/ethnic composition					
NH-White community	Reference	Reference	Reference	Reference	Reference
NH-Black community	1.39 (1.37–1.41)	1.70 (1.66–1.73)	1.52 (1.47–1.57)	1.52 (1.48–1.57)	1.52 (1.46–1.57)
Hispanics community	1.16 (1.14–1.19)	1.42 (1.38–1.46)	1.33 (1.28–1.39)	1.37 (1.31–1.42)	1.36 (1.30–1.42)
Mixed community	1.04 (1.02–1.05)	1.35 (1.32–1.38)	1.25 (1.20–1.29)	1.23 (1.19–1.27)	1.21 (1.17–1.26)

[a] Other racial/ethnic groups are not shown.

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	Bell, A. F., Carter, C. S., Davis, J. M., Golding, J., Adejumo, O., Pyra, M., ... & Rubin, L. H. (2016). Childbirth and symptoms of postpartum depression and anxiety: a prospective birth cohort study. *Archives of Women's Mental Health, 19*(2), 219-227.

Adejumo, O.A. (2012). Effect of HIV Seropositivity on Birth Weight and Cord Leptin (Fellowship dissertation). *National Postgraduate College of Nigeria.*

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