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Understanding Maternal Smoking during Pregnancy: Does Residential Context Matter?

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Abstract

The goal of this paper was to investigate whether or not the factors beyond individual characteristics were associated with maternal smoking during pregnancy. Social capital has been found to have both negative and positive implications for health behaviors, and this study attempted to understand its association with maternal smoking during pregnancy. Specifically, the association between county-level social capital and rurality and maternal smoking during pregnancy was investigated. In this study, Putman's definition of social capital was used (e.g., connections among individuals—social networks and the norms of reciprocity and trustworthiness that arise from them). The ecological dimension of rurality was used to define rurality, where rural areas are smaller in population size and are less densely populated when compared to non-rural areas. Using data for all women who gave birth during the year 2007 in the United States, we implemented a series of multilevel logistic regression models. The results showed that social capital was significantly associated with maternal smoking during pregnancy. Specifically, higher social capital in a county was associated with higher odds that women will smoke during their pregnancy. However, in rural counties, higher social capital was associated with a decrease in the odds that a woman will smoke during her pregnancy. A one unit increase in the social capital index was found to reduce the risk of smoking during pregnancy among those women living in rural counties by 11 percent. The results also showed that improvement of the socioeconomic status of the counties in which women live reduced the risk of maternal smoking during pregnancy. As this study found that factors beyond individual characteristics are important for reducing the risk that women will smoke during pregnancy, county characteristics should be taken into account when developing policies focused on intervening maternal smoking during pregnancy.

Keywords

Maternal smoking; pregnancy; social capital; rural; multilevel models; United States

Introduction

There is growing evidence that smoking during pregnancy is associated with a number of poor health outcomes for both the woman and her child (in utero, childhood, and throughout adolescence). In addition to the multiple health risks associated with smoking at any time (e.g., stroke and heart disease), smoking during pregnancy is related to an increased risk of the woman developing breast cancer (Innes & Byers, 2001). Maternal smoking during pregnancy has been found to impose an adverse impact on birth outcomes, including placental abruption (Ananth et al., 1999), stillbirth (Hogberg & Cnattingius, 2007), greater irritability, hypertonicity (Stroud et al., 2009), physical abnormalities, birth defects (Lammer et al., 2005), slowed intrauterine growth, increased odds of pre-term delivery, reduced and low birth weight (Agrawal et al., 2010; US Department of Health Human Services, 2001), frequent admission to neonatal intensive care units, increased risk for sudden infant death syndrome (DiFranza & Lew, 1995; Martin et al., 2003; Mathews, 2001; Shah et al., 2006), and infant mortality (Cnattingius, 2004). The negative effects of maternal smoking during pregnancy could extend further into children's later life, such as conduct disorder, attention and cognitive deficits, low scholastic achievement, early age of smoking initiation, early age of regular smoking, and substance abuse (Agrawal et al., 2010; Buka et al., 2003; Fried et al., 1992; Leech et al., 1999; Wakschlag et al., 1997).

Despite these risks, at least half of women who smoke prior to their pregnancy continue to do so while they are pregnant (Ebrahim et al., 2000). In 2007, 10.4 percent of pregnant women in the US smoked while they were pregnant (US Department of Health and Human Services, 2011). *Healthy People 2020* aims to reduce the percentage of women who smoke while they are pregnant to 1.4 percent (US Department of Health and Human Services, 2011). To effectively address this concern, finding determinants of maternal smoking during pregnancy becomes crucial. The goal of this study is to investigate whether or not the factors beyond individual characteristics matter for maternal smoking during pregnancy.

Individual Factors of Maternal Smoking during Pregnancy

The majority of studies on maternal smoking during pregnancy concentrate on individual-level explanatory variables that cover a range of dimensions (e.g., socioeconomic, demographic, and health status). For example, women who continue to smoke during their pregnancy are featured by low household incomes (Martin et al., 2008; Wakschlag et al., 2003), poor education (Cnattingius et al., 1992; Colman & Joyce, 2003; Kahn et al., 2002; O'Campo et al., 1992; Orr et al., 2005; Wakschlag et al., 2003; Zimmer & Zimmer, 1998), unemployment (Zimmer & Zimmer, 1998), not married (Flick et al., 2006; Orr et al., 2005; Wakschlag et al., 2003), already having a child (Cnattingius et al., 1992; Colman & Joyce, 2003; Martin et al., 2008; O'Campo et al., 1992; Schramm, 1997), having elevated maternal depressive symptoms (Orr et al., 2005), receiving delayed prenatal care (Zimmer & Zimmer, 1998), consuming more than one drink per week during pregnancy (Martin et al., 2008), and smoking heavily prior to pregnancy (Cnattingius et al., 1992; Colman & Joyce, 2003; Wakschlag et al., 2003).

Race, ethnicity, and age of the woman also play a role in whether she continues to smoke during her pregnancy. Camilli and colleagues (1994) found that Mexican-American women were nearly three times more likely to quit smoking during their pregnancy than non-Hispanic white women. In addition, Zimmer & Zimmer (1998) found that black women were less likely to quit smoking than white women. Similarly, a study showed that although teenagers were more likely to quit smoking during pregnancy when compared to older women, they were substantially more likely to resume smoking after pregnancy (Colman & Joyce, 2003).

Residential Factors of Maternal Smoking during Pregnancy

According to *Healthy People 2020* (US Department of Health and Human Services, 2011), disparities in health outcomes and behaviors are not only relevant to biological differences and personal features, but are also a function of both residential environment and policies. The importance of residence and social interactions beyond individuals has drawn more and more health researchers' attention in the past few decades. The literature has confirmed that residential environment affects human health, and currently the key question has become how the residential factors affect individual behaviors and/or health (Boardman, 2004; Matthews & Yang, 2010; Taylor et al., 1997; Yang et al., 2011b).

Studies on maternal smoking during pregnancy in the US that considered residential environment have mainly focused on racial segregation and socioeconomic status. For example, Pickett and colleagues (2002) examined a sample of white women living in California and found that living in a predominantly working-class environment doubles the odds of smoking during pregnancy. In another study on pregnant women living in California, the results showed that women living in a neighborhood (defined by ZIP code) with a higher percentage of the population receiving public assistance were more likely to smoke while they were pregnant (Finch et al., 2001). The analytic results of a sample of women from South Carolina suggested that women living in medium poverty neighborhoods had greater odds of smoking during pregnancy compared to women living in low poverty neighborhoods (Nkansah-Amankra, 2010). This study also found that living in predominantly black neighborhoods reduces the odds of smoking during pregnancy by 64 percent (Nkansah-Amankra, 2010). Shaw et al. (2010) found that a more racially and ethnically homogeneous county is associated with reduced odds of smoking for US-born Hispanic and Black women; however, this study was limited to women of Hispanic and Black race/ethnicity.

The studies above indicated that residential context really matters in maternal smoking during pregnancy studies; however, their conclusions may not be easily generalized. More specifically, these studies were limited by only including women from one state or metropolitan area or restricting the samples to women of a particular race or ethnicity (e.g., Bell et al., 2007). Smoking prevalence in the US varies both regionally and by race/ethnicity (Datta et al., 2006; King et al., 2006; King et al., 1999; Mathews, 1998; Osypuk et al., 2006; Pastor et al., 2002; Perreira & Cortes, 2006); therefore, focusing attention on women from only one place or of one racial/ethnic background may limit our understanding of maternal smoking during pregnancy in the US. To the best of our knowledge, a study on maternal smoking during pregnancy that examines both individual and residential characteristics and uses nationwide data is not yet available.

Moreover, several residential factors have not been fully considered in the smoking during pregnancy literature. This study will fill this gap by investigating the relationships of rurality and social capital with maternal smoking during pregnancy. A recent study showed that smoking prevalence among pregnant women is higher among women living in rural areas than it is for women living in urban areas (Stevens et al., 2010), but whether this residential differential can be completely attributed to the difference in individual features (e.g., educational attainment) is unclear. Similarly, social capital has been found to be associated with human health and residential health disparities (Song et al., 2010; Yang et al., 2011a); however, its association with maternal smoking during pregnancy remains underexplored.

Rurality, Social Capital, and Maternal Smoking during Pregnancy

The relationships between rurality, social capital, and maternal smoking during pregnancy have not been widely discussed, but some recent articles lead us to believe that they are

interrelated. Before we discuss the reasons why we hypothesize rurality and social capital are associated with smoking during pregnancy, the complex concepts of social capital and rurality must first be defined.

Different disciplines have attributed the origin of the concept of social capital to various scholars. For instance, Portes (2000) argued that Durkheim, Marx, and Weber all contributed to the development of social capital (sociologists' perspective); whereas, Woolcock (1998) referred to the work by Marshall, Hicks, and Smith for the development of social capital (economists' standpoint). Despite the debate over who originated the concept, it has been suggested that the growing interest in the relationship between social capital and health has resulted from the efforts of Bourdieu, Coleman, and Putnam (Song et al., 2010).

There is no agreement on the definition of social capital. Bourdieu (1985) stated that social capital is the sum of the resources embedded in personal social relationships, and can be converted into other types of capital, such as economic and cultural capital. Coleman (1988) regarded social capital as a relationship within a social structure that can facilitate individual's actions. Bourdieu and Coleman defined social capital from a micro (individual) perspective and emphasized the advantages of social capital. Whereas, Putnam (2001) extended these definitions to a macro-level and suggested that social associations and organizations play a major role in developing social capital in a community. Putnam's definition of social capital has been criticized for lacking solid theoretical grounding (Paxton, 1999; Portes, 2000); however, in contrast to the micro-level definitions, Putnam's macro-level definition can be operationalized more easily in empirical research. This is the primary reason why the association of social capital with health has been increasingly studied (Song et al., 2010).

Social capital may be multi-dimensional. For instance, Colletta and Cullen (2000) decomposed social capital into "cognitive" and "structural" dimensions. Cognitive social capital places stress on the values and attitudes shared by the members of a community, while structural social capital could be described as the institutions and rules that connect the members of the group together. Similarly, Putnam (2001) proposed that social capital could be divided into bonding and bridging social capital. The former refers to the linkages between homogeneous groups, whereas the latter refers to the relationships between heterogeneous associations. Although social capital has been defined in the literature as a multi-dimensional concept, most empirical studies in health research rely heavily on a one-dimensional indicator (Ferlander, 2007). Putnam (2001) also used a single state-level social capital index to test his arguments. Even though leading health researchers have urged the scientific communities to develop multidimensional measures of social capital (Kawachi et al., 2004), to the best of our knowledge, there is no valid and reliable multi-dimensional social capital measure available.

As for rurality, it has been defined in a variety of ways over the years (Glasgow et al., 2004); however, most social scientists who study rural areas acknowledge that rurality is a multidimensional concept (Lichter & Brown, 2011). Most argue that what it means to be rural includes multiple dimensions, such as differences in occupations, environment, social mobility, migration patterns, and social interactions (Bealer et al., 1965; Miller & Luloff, 1981; Willits & Bealer, 1967; Willits et al., 1990). There is no consensus on how many different dimensions actually encompass the complex concept of rurality; however, there seems to be some agreement that rurality is comprised of ecological, occupational, and sociocultural dimensions (Bealer et al., 1965). The ecological dimension of rurality is the dimension that is most commonly used to distinguish rural from urban areas, with the general consensus that rural areas are smaller in population size and are less densely populated when compared to non-rural areas (Lichter & Brown, 2011). The ecological

dimension of rurality is the dimension that is comprised of the spatial distribution of the population across geographical units.

Findings from past research lead us to believe that rurality and social capital may be associated with maternal smoking during pregnancy. First, rural sociologists have suggested that social capital is stronger in rural than urban areas and rural dwellers are more likely to help and trust each other despite the sparse distribution of the population (Beaudoin & Thorson, 2004; Beggs et al., 1996; Hofferth & Iceland, 1998). Putman (2001) divided social capital into various dimensions (e.g., altruism and community engagement) and examined whether social capital differs by the size of community. He concluded that rural areas have stronger social capital than do urban, and discussed that the reason why metropolitan residents share low social capital is because of where they live, not who they are (Putnam, 2001). It is clear that social capital varies across residence (i.e., rural/urban).

Second, the rurality of a place where a person lives is associated with variations in smoking prevalence, with rates of smoking higher in rural areas (Stevens et al., 2010). Both female adolescents (19 percent) and female adults (27 percent) living in the most rural counties are more likely to smoke than their urban counterparts (11 percent and 20 percent, respectively) (Eberhardt et al., 2001). As for pregnant women, research has shown that the percentage of women who smoke is even higher among women living in rural areas (Bailey & Cole, 2009; Bullock et al., 2001; Stevens et al., 2010), with some studies reporting rates of maternal smoking during pregnancy in rural areas as high as 39 percent (Bailey, 2006).

Third, past research points toward a significant and apparently causal relationship between social capital and health outcomes (Berkman & Kawachi, 2000; Berkman & Syme, 1979; Wolf & Bruhn, 1998) and some potential links between social capital and health behaviors may be applied to the relationships between maternal smoking during pregnancy and social capital. Social capital has been found to provide both tangible and intangible assistance (Kawachi et al., 1999; Putnam, 2002), and the diffusion of information has been found to be more rapid in a community where residents know and trust one another and that are more tightly bounded (Rogers, 1995). Extending this argument, in communities with higher social capital, information about the adverse effects of smoking during pregnancy may more likely be shared, and this in turn may influence an individual woman's decision to not smoke during pregnancy. Similarly, if a new approach to quitting smoking is available, pregnant women are more likely to adopt it due to information diffusion.

Another path is drawn from the finding that social capital reinforces healthy behaviors and exerts control over deviant ones (Evans & Kutcher, 2011; Giordano & Lindstrom, 2011; Kawachi et al., 1999). The strong bonds that social capital represents will discourage the occurrence of unhealthy behaviors such as maternal smoking during pregnancy. On the other hand, positive behaviors, such as smoking cessation, are encouraged for their possible benefits. It is also likely that people would not smoke around pregnant women, which establishes a healthy environment to help women who want to stop smoking quit. The last potential explanation for why social capital may matter is that high social capital is a major source of moderators that can buffer stress (Ross & Mirowsky, 2001; Smith & Lincoln, 2011). As found in the individual level analysis, stressed or depressed women are more likely to smoke (Orr et al., 2005; Weaver et al., 2008). A woman living in an area with stronger social capital may receive better support to handle stressors and thus she may be less likely to smoke during pregnancy.

Despite the mechanisms above that explain why social capital improves population health, there also is evidence that suggests that social capital can be considered a double-edged sword (Kunitz, 2001). The negative consequences of social capital have been identified for

psychological health and health behaviors. For the former, while social capital creates strong psychological support to promote self-efficacy and attenuate stress, it may aggravate emotional burden for the support providers. For example, it has been suggested that women are more likely than men to be both caregivers and caretakers at the same time. The role of caregiver exposes women to more negative social outcomes than men, and outweighs the benefits of being a caretaker. Specifically, women with more social ties tend to be more deeply involved in the stress of others and experience a heavier psychological burden. Consequently, women generally report more mental health issues than do men (Kunitz, 2004; Sarason et al., 1997; Thoits, 2010). In other words, strong social capital may impose more obligations for the people in the community, become a source of strain, disappointment, and pressure, and finally, leads to negative psychological health outcomes (Ferlander, 2007).

As for behaviors, it has been found that risky health behaviors, such as tobacco and alcohol consumption, suicide, illicit drug use, and drug injecting behavior, are more prevalent among groups with stronger social capital or more frequent social interactions (Kirst, 2009; Kreitman et al., 1969; Kunitz & Levy, 2000; Landrine et al., 1994; Lovell, 2002; Neaigus et al., 1994; Skog, 1991). The people in a group who are more dependent on social capital are the same people who are more likely to treat the fact that they engage in these risky behaviors as the responsibility of the other members of the same group. For instance, a study in the US that used longitudinal data found that adolescents who are more embedded in their peer networks are more likely to participate in binge drinking, while on the other hand, socially isolated adolescents are protected from risky behaviors by their social isolation (Kramer & Vaquera, 2011). As Ferlander (2007) suggested, this negative impact of social capital on health behaviors may be attributed to “a human tendency to follow one’s peers. Whether this is beneficial or harmful to one’s health depends on the particular norms that prevail in the network and on the extent of external information added to it (p. 122).”

The discussion above suggests that social capital may be both a facilitator and a barrier to health outcomes. As the influence of social capital on maternal smoking behaviors remains underexplored, this study first aims to examine whether social capital is associated with maternal smoking during pregnancy, and then investigate whether social capital is positively or negatively related to maternal smoking after accounting for both individual- and ecological-level covariates.

Hypotheses

The previous section demonstrated that the associations among rurality, social capital, and maternal smoking during pregnancy are intertwined and little research has attempted to untangle them. We extend prior work on maternal smoking during pregnancy by focusing on how county-level social capital is associated with the odds of a woman smoking during her pregnancy and how social capital and rurality interact to affect maternal smoking during pregnancy. This study is among the first to explicitly take both factors into account and to depict a clear picture of whether and how these factors play a role in determining maternal smoking.

As earlier research has shown, factors associated with maternal smoking during pregnancy may not be limited to individual-level behaviors and characteristics; therefore, multilevel models were estimated to identify whether characteristics of counties in which women live affect the likelihood of maternal smoking during pregnancy. Multilevel modeling techniques are uniquely useful for identifying whether and how residential context is associated with individual health, even after individual characteristics are controlled. By utilizing logistic multilevel modeling, we tested the following hypotheses:

(H1) Social capital at the county-level is associated with maternal smoking during pregnancy at the individual level.

(H2) The association of social capital and maternal smoking is moderated by rurality.

Data and Measures

This study utilized multiple secondary data sources. The primary secondary data source was the National Center for Health Statistics (NCHS) non-public use detailed natality files with county identifiers for all counties in the US (National Center for Health Statistics, 2007a). This data file contains all women who had a live birth in the US during the 2007 calendar year. To create this dataset, NCHS compiles information from the standard birth certificate, which was prepared from individual records processed by each registration area through the Vital Statistics Cooperative Program (National Center for Health Statistics, 2007b). While these data files include information on all live births that occurred within the US (both US residents and nonresidents), these analyses were restricted to data on women having singleton births who reside within the continental US. In addition, because maternal smoking during pregnancy is not reported on the birth certificates in California, women residing in California were excluded from the analyses. The outcome variable and the independent individual-level variables (demographic, social, and health information of the women) were derived from this data source.

Individual-level measures—The outcome variable *maternal smoking during pregnancy* was measured as a dichotomous variable that indicated whether the woman smoked during her pregnancy (coded as 1 if she did and 0 otherwise). In the US, there are currently two different versions of the birth certificate that are being used—the 1989 Revised Birth Certificate and the 2003 Revised Birth Certificate—both of which are included in the detailed natality data file. Unfortunately, smoking is reported differently across the two versions of the birth certificate. For the 1989 Revised Birth Certificate, smoking is reported with a box that is checked indicating YES/NO on tobacco use, as well as a box where the number of cigarettes smoked daily is reported. For the 2003 Revised Birth Certificate, the number of cigarettes smoked daily per trimester is reported. In order to utilize data on all women in the continental US, the smoking variables were recoded to indicate that the woman smoked during her pregnancy if smoking one or more cigarettes daily during her pregnancy was reported, regardless of the version of the birth certificate that was used.

As for the independent variables, *maternal age* at the time of birth was measured as a continuous variable. *Maternal age squared* was also included in the model to capture potential curvilinear relationships with maternal smoking. Dichotomous variables representing various self-reported race and ethnicity data were included in the models. *Race* was measured as a set of three dichotomous variables: white (reference category), black, American Indian/Alaskan Native, and Asian, and *ethnicity* was measured as a dichotomous variable to specify whether the woman was Hispanic or non-Hispanic. A dichotomous variable measuring *marital status* was included in the model that specified whether or not the woman was married at the time of the infant's birth.

Measures of the woman's highest level of education completed at the time of the infant's birth were also included in the models as a measure of socioeconomic status. A set of three dichotomous variables were created to measure *maternal education*: less than high school (reference category), high school degree or equivalent, some college or associate degree, and bachelor's degree or higher.

A variable for maternal weight gain during pregnancy was included in the models as a way to assess the overall health and nutrition of the woman during her pregnancy (Sparks et al.,

2009). *Maternal weight gain* was measured as a continuous variable, and the model also included *maternal weight gain squared*. The Adequacy of Prenatal Care Utilization Index (APNCU) was used in this study. The APNCU is a measure of prenatal care utilization that takes into account the month when the prenatal care began and the number of prenatal care visits and then adjusts for the gestational age of the infant at delivery (Kotelchuck, 1994a, b). The *APNCU* was measured as a set of three dichotomous variables: inadequate care (reference category), intermediate care, adequate care, and adequate plus care. The dichotomous variable, *first birth*, was included in the models to identify whether this was the woman's first birth (coded 1) or higher order birth (coded 0).

County-level measures—The county is the level-2 unit of analysis that was used in this study. Counties were chosen as the spatial scale to measure residential context for the following reasons. First, when using counties, it allows for the inclusion of all geographic areas in the US, from the largest cities to the most remote rural places (McLaughlin et al., 2007). Since this paper is focused on examining how rurality and social capital affect maternal smoking during pregnancy, it was essential to be able to examine rural places. Second, since the 1980s, there has been a decentralization of governing responsibilities from higher to lower levels of government (Lobao & Kraybill, 2005), and the county is the smallest analytic unit with useful policy implications (Allen, 2001). As *Healthy People 2020* aims to reduce the percentage of women who smoke while they are pregnant to 1.4 percent (US Department of Health and Human Services, 2011), identifying determinants that can be addressed through policy is imperative. Third, counties as the unit of analysis do a better job of capturing people's social and economic ties and daily activities. Research has shown that, on average, Americans travel approximately 10 to 20 miles for personal/family errands, work, shopping, recreational, and religious activities (US Department of Transportation, 2009). This distance is much larger than the average ZIP code area or census tract, but not larger than the average county (Matthews, 2011). Finally, arguably the two most common measures of social capital, the Northeast Regional Center for Rural Development social capital index (Rupasingha & Goetz, 2008; Rupasingha et al., 2006) and the Petris Social Capital Index (PSCI) (Brown et al., 2006; Scheffler et al., 2007; Scheffler et al., 2008; Yoon & Brown, 2011), are measured at the county-level and are constructed using measures that are only available at the county-level.

Variables were created to capture the county-level socioeconomic status, social capital, rural/urban status, and racial/ethnic composition. Following Sampson and colleagues (1997), in order to measure the *socioeconomic status* of the county, we used principal component analysis (PCA) with the following seven social measures extracted from the 2005–2009 American Community Survey (ACS) county estimates (US Census Bureau, 2005–2009): log of per capital income (factor loading: 0.945), percentage of population with at least a bachelor degree (0.839), percentage of population employed in professional, administrative, and managerial positions (0.793), percentage of family with annual income greater than $75,000 (0.906), poverty rate (0.786), percentage of population receiving public assistance (−0.376), and percent of female-headed families with children (0.507). In preliminary analyses, the percentage of the population receiving public assistance was included in the PCA; however, the factor loading was low (0.376), and was excluded from the analysis. The PCA results indicated that 65 percent of the variance was explained by one factor (eigenvalue=3.921). The regression method was used to calculate the factor score, which was used as the SES variable in the analysis.

As discussed previously, there are two social capital measures at the county-level that are commonly available, the PSCI (Brown et al., 2006) and the social capital index by Rupasingha and colleagues (Rupasingha & Goetz, 2008; Rupasingha et al., 2006). These two measures are primarily focused on volunteer activities and the informal social ties

established by a range of associations and political participation (Paxton, 1999). These county-level social capital measures are similar to Putnam's definition of social capital. Following this line of work, we define social capital as "connections among individuals—social networks and the norms of reciprocity and trustworthiness that arise from them (Putnam 2001, p.19)." Based on this definition, we argue that the social connections among individuals can be established through participation in various organizations and activities. In contrast to PSCI, the social capital index by Rupasingha and Goetz (2008) covers a wider range of groups in society, such as sports clubs requiring membership, political clubs, bowling leagues, religious groups, and public golf courses, among others. These groups in a community are civil associations that most of the residents in a community can participate. Rupasingha et al. (2006) also take non-profit organizations into account, which are defined as the organizations that do not distribute surplus funds to owners or shareholders. In addition to these different types of associations, Census response rates and presidential voting rates have been found to be related to social capital (Alesina & La Ferrara, 2000; Knack, 2002) and are included in the Rupasingha et al. measure. All the factors discussed above have been found to be components of Putnam's definition of social capital (Paxton, 1999). Therefore, we believe that the social capital index captures the concept of social capital better, and unlike the PSCI, the measure is available for all counties in the US, including the most rural counties. As a result, the social capital index was used in this study.

In order to generate the *social capital index*, PCA was used. We obtained the following county-level variables used in Rupasingha et al. (2006): the number of civil associations per 10,000 population, the number of non-profit organizations per 10,000 population, mail response rate of 2000 census, and 2004 presidential election voting rate. In preliminary analyses, we identified that the factor loading for the mail response rate of the 2000 Census was low (0.398), so it was excluded from the PCA. The PCA indicated that one component (eigenvalue=1.859) would suffice to capture approximately 62 percent of the total variance among the variables, and the factor loadings for the three other variables were 0.719, 0.858, and 0.719, respectively. The PCA results were comparable with the original paper (Rupasingha et al., 2006).

The third county-level measure, *rural*, was used to measure the rural status of counties. We used the US Department of Agriculture Economic Research Service (ERS) Rural-Urban Continuum (RUC) Codes 8 (completely rural or less than 2,500 urban population, adjacent to a metro area) and 9 (completely rural or less than 2,500 urban population, not adjacent to a metropolitan area) to define rural. This measure of rurality takes into account population size and adjacency to a metro area or areas (Economic Research Service, 2003). For the analysis, rural counties were those with RUC Codes of 8 or 9 (coded 1) and those counties with RUC 1 through 7 are coded 0.

Since the racial/ethnic composition has been found to be significantly associated with maternal smoking during pregnancy (Nkansah-Amankra, 2010; Shaw et al., 2010), the racial/ethnic composition of the county was controlled for in the models. Specifically, the percentage of the population reporting *non-Hispanic white*, *non-Hispanic black*, and *Hispanic* were included in the models.

Methodology

In order to examine the factors associated with the odds of maternal smoking during pregnancy, two separate sets of regression analyses were conducted. First, individual-level characteristics of women were included in a model predicting the odds of maternal smoking during pregnancy. Second, because a two-level hierarchical structure characterizes this data, with pregnant women nested within their county of residence, we tested whether multilevel modeling was necessary for these analyses. These models were implemented in HLM 6

(HLM, 2008; Raudenbush & Bryk, 2002). In order to determine whether multilevel modeling was an appropriate analytic strategy, a null model with no explanatory variables included was estimated (results not shown). The null model had a statistically significant variance of the intercept, which indicated that multilevel modeling was an appropriate analytic strategy for this study. A null model is the equivalent of a one-way analysis of variance (ANOVA). A statistically significant intercept indicates the proportion of women who smoked during their pregnancy (i.e., proportion of women who are coded as 1) is significantly different across counties. Next, we investigated the relationship between individual- and county-level independent variables of maternal smoking during pregnancy among women across the continental US using multilevel logistic regression models. The models included a random intercept, which allows the effect to vary across counties and a random error term for each of the race/ethnicity measures that allows for the effect to vary within counties. These models allowed us to test the hypotheses proposed above.

As described earlier, there are inconsistencies in how maternal smoking during pregnancy is reported in the US. In some cases, a woman may have been smoking during her first trimester of pregnancy when she did not know that she was pregnant. In order to address this concern, we performed a sensitivity analysis for those women for which smoking information was available by trimester (2003 Revised Birth Certificate). The same model was estimated, with the exception that the outcome variable was for those who smoked cigarettes during the second and/or third trimester of pregnancy. Institutional review board approval was received for this study.

Results

Descriptive Statistics

Table 1 included the descriptive statistics for all measures included in the analyses. As for maternal smoking during pregnancy, approximately 10 percent of women reported smoking during their pregnancy, which was similar to what was reported in *Healthy People 2020* (10.4 percent) (US Department of Health and Human Services, 2011). The average age of women was 27 years. Roughly one out of six mothers was black and one out of twenty was Asian. The data included 20 percent of women who were Hispanic. Sixty percent of the women were married at the time their infant was born. As for maternal education, the distribution was comparable across the three groups, high school or equivalent, some college or an associate degree, and bachelor's degree or higher. Women gained an average of 34 pounds during their pregnancy. As for prenatal care utilization, 13 percent of women received intermediate care, 40 percent received adequate care, and 31 percent received adequate plus prenatal care. Approximately 40 percent of the women were having their first birth.

Twenty-one percent of the counties included in the model were rural counties. Both the SES and social capital index measures were created using PCA; therefore, these measures had a mean of 0 and a standard deviation of 1. The mean of the interaction between rural and social capital index was the average social capital index score among rural counties. Rural counties had a significantly higher social capital index score than non-rural counties, as indicated by a one-way ANOVA (results not shown). The racial/ethnic composition of counties were, on average, 9 percent non-Hispanic black, 80 percent non-Hispanic white, and 7 percent Hispanic.

Multilevel Logistic Regression Results

The results of the multilevel logistic regression models of maternal smoking during pregnancy were displayed in Table 2 and the odds ratios were reported. Model I included

only the individual-level measures. The individual-level results from Model I were consistent with the individual-level results in Model II, which included both the individual-level and county-level measures, with one exception, American Indian/Alaskan Native. This difference was noted below. For brevity, only the Model II results were discussed here.

In Model II, we found that with every year increase in maternal age, the odds of maternal smoking during pregnancy would be higher by 20 percent. However, as indicated by the age squared term, once a woman was at a certain age the likelihood that she would smoke during her pregnancy begins to decrease. Both racial and ethnic differences were found to be related to the odds of maternal smoking during pregnancy. The odds of maternal smoking during pregnancy for black and Asian women were lower than that for white women. Before controlling for the county-level characteristics (Model I), American Indian/Alaskan native women were 32 percent less likely than white women to smoke while they were pregnant. However, after taking county characteristics into account, American Indian/Alaskan Native women were 10 percent more likely to smoke during pregnancy than white women. Hispanic women were 67 percent less likely than non-Hispanic women to smoke while they were pregnant. Marriage had a negative association with the likelihood of smoking and higher educational attainment was associated with lower smoking during pregnancy.

Weight gain during pregnancy, prenatal care utilization, and parity were significantly associated with maternal smoking during pregnancy. With every pound of weight a woman gained during her pregnancy, the odds of smoking during pregnancy was lower by 3 percent. However, once a woman hit a certain weight gain, her odds of smoking during pregnancy began to increase. Compared to women who received inadequate prenatal care, women who received intermediate, adequate, or adequate plus prenatal care were approximately 18 percent, 26 percent, and 22 percent less likely to smoke while they were pregnant.

Accounting for maternal characteristics, those women who lived in rural counties were 9 percent less likely to smoke while they were pregnant compared to women who lived in metropolitan counties. In addition, other things equal, a one unit increase in the county SES score was associated with a 21 percent decrease in the likelihood of maternal smoking. After controlling for both individual- and county-level covariates, the social capital index was found to be positively associated with maternal smoking during pregnancy. Moreover, the interaction between rurality and social capital index helps to better understand whether the explanation above stands or not. Following the multiplicative approach proposed by Buis (2010), we found that among the women living in rural counties, a one unit increase in the social capital index would be related to roughly an 11 percent decrease in the likelihood of maternal smoking during pregnancy. Note that the value of 0 has empirical meaning in our social capital index measure. Specifically, we multiplied the main effects of rural residence (0.911) and social capital index (1.063) with their interaction effect (0.922). Doing so allowed us to examine the marginal effect of the social capital index (Buis, 2010). This finding was found after accounting for all other covariates, and followed the theoretical pathways linking social capital to better health outcomes (Kawachi et al., 1997; Song et al., 2010).

The racial/ethnic composition of counties was significantly associated with maternal smoking during pregnancy. Specifically, with every percentage point increase in the non-Hispanic black population and Hispanic population, the odds of a woman smoking during her pregnancy decreased by 25 and 36 percent, respectively. The percentage of the population non-Hispanic white was strongly associated with maternal smoking during pregnancy. As the non-Hispanic white population in a county increased by one percentage point, women were approximately 4 times more likely to smoke while they were pregnant.

The results of the sensitivity analysis (available upon request) showed that both the direction of the relationships and the significance of the associations were consistent across the models for smoking at any time during pregnancy and smoking during the second or third trimester of pregnancy. The only exception is that American Indian/Alaskan Native women were not significantly different from white women on smoking during the second and third trimester of pregnancy. In addition, for the all county sample, on average, 11 percent of women smoked during their pregnancy. For the sample of women whose information was recorded using the 2003 Revised Birth Certificate, 11 percent of women reported smoking during their second or third trimester of pregnancy and 13 percent reported smoking anytime during their pregnancy.

Discussion

Using multilevel logistic regression models, we were able to test our proposed hypotheses and gain a better understanding of how social capital was associated with maternal smoking during pregnancy. We were able to confirm that county social capital was associated with maternal smoking during pregnancy (H1). Specifically, after accounting for both county and individual level covariates, strong social capital increased the likelihood of smoking during pregnancy, which echoes the literature suggesting that social capital may lead to negative consequences of health behaviors (Ferlander, 2007). In addition, by including an interaction between rural status and social capital, we found direct support for our hypothesis that the association of social capital and maternal smoking is moderated by rurality (H2). That is, among women who lived in rural counties, social capital seemed to reduce the risk of smoking during pregnancy. Our findings corresponded to the argument that social capital may be a double-edged sword and have both beneficial and adverse implications for human health (Kunitz, 2004). The intertwined relationship between rurality and social capital is consistent with Yang and colleagues (2011a) who discussed the complexity of rurality and argued that social capital increases with rurality, regardless of how they operationalized rurality.

In addition, our individual-level measure results matched the findings reported in previous studies. Following Colman and Joyce (2003), we found that teenage women were less likely to smoke while they were pregnant. We also found racial and ethnic differences in the odds of maternal smoking during pregnancy. Consistent with the results reported by Perreira and Cortes (2006), black women were less likely to smoke while they were pregnant compared to white women. In this study, we found that Hispanic women were 90 percent less likely to smoke while they were pregnant compared to non-Hispanic women. This finding was similar to that reported by Camilli and colleagues (1994) who found that Mexican-American women were nearly three times more likely to quit smoking during their pregnancy than non-Hispanic white women. As reported previously, women who were married at the time their baby was born were less likely to smoke while they were pregnant (Flick et al., 2006; Orr et al., 2005; Wakschlag et al., 2003).

Maternal education was a significant determinant of maternal smoking during pregnancy. Consistent with previous findings, the higher the level of education the woman received the lower the odds of women smoking while she was pregnant (Cnattingius et al., 1992; Colman & Joyce, 2003; Kahn et al., 2002; O'Campo et al., 1992; Orr et al., 2005; Wakschlag et al., 2003; Zimmer & Zimmer, 1998). Consistent with previous research (Zimmer and Zimmer, 1998), more prenatal care utilization is associated with lower odds of maternal smoking during pregnancy. Women who were having their first birth were approximately 31 percent more likely to smoke compared to those women who were having a higher order birth.

Conclusions

This study made significant contributions to the maternal smoking during pregnancy literature by using a nationwide dataset to investigate whether and how two underexplored factors—rurality and social capital—were associated with maternal smoking during pregnancy. However, several limitations were notable. First, several individual-level measures that may be associated with maternal smoking during pregnancy such as employment status, income, and health insurance coverage were not included in the models as these measures were not included in the natality files.

Second, social capital is a complex concept to define, and the best way to measure social capital has not been developed in the literature. While we used a measure of social capital that has been utilized in past research, this measure does not include all aspects of social relationships that may be important for the measurement of social capital (e.g., social media and political climate). In addition, social capital for a particular county may vary depending on the political climate at the time. Due to data limitations, these measures cannot be captured in the social capital index.

Third, the measure of rural status used in this study may only capture the ecological dimensions of rurality; and hence, the positive relationship between social capital and maternal smoking may result from the argument that high social capital could be considered as a cultural dimension of rurality (Bealer et al., 1965). It should be noted that this explanation is a consequence of the fact that there is no agreement on how to measure rurality in rural sociology, and further investigations are warranted to examine how the occupational and sociocultural dimensions of rurality are associated with maternal smoking during pregnancy and whether or not they interact with county social capital.

Fourth, the residential context measures may have been measured using smaller units of geography such as the census-tract; however, the NCHS non-public use detailed natality files only include geographic information on the woman's state and county of residence. While the way to measure residential context is still debatable, it has been documented that the associations found with ecological data may be altered with the change of the definitions of ecology (Fotheringham & Wong, 1991). Therefore, using different spatial scales in the analysis may lead to different conclusions (Openshaw, 1984); however, we believe our ecologic unit is the most relevant to useful policy implications (Lobao & Hooks, 2003) and our measures, social capital in particular, are the best available in current literature. Our social capital measure reflects the definition used by Putnam (2001), and has been recently adopted in health studies (Yang et al., 2009; Yang et al., 2011a; Yang et al., 2012). This social capital index is not without flaws, but it offers a way for researchers to explore its applicability and usefulness (Rupasingha et al., 2006).

Fifth, the causality between maternal smoking during pregnancy and the explanatory variables could not be established, because the data are cross-sectional, and the analyses could not test the arguments such as whether or not social capital leads women who smoke and are thinking about becoming pregnant quit prior to pregnancy. Future research should try to utilize longitudinal data to clarify the causality. Similarly, the parameter estimates may be subject to omitted variable bias, because of the nature of the cross-sectional research design. As such, only associations can be determined from the results, causation cannot be rigorously inferred.[1] Moreover, measurement errors are universal in all surveys and the ACS

[1]One reviewer suggested that we implement a conditional fixed effects logit model where the fixed effect is the county (Chamberlain, 1980) in order to determine whether our results were driven by omitted variable bias. Unfortunately, this type of analyses requires multiple years of data, something that we did not have access to according to our restricted data user agreement. Future efforts should be warranted using multiple years of data.

is no exception. While the Census Bureau has taken many actions to minimize the measurement errors (e.g., questionnaire design reflecting friendliness), the findings of this study may still be subject to the effects of measurement errors. Several scholars have proposed methods to adjust for apparent measurement errors; however, the current HLM software program does not support this adjustment (Dedrick et al., 2009). Sixth, the results of this study cannot be generalized to women from California, Hawaii, and Alaska, as well as women with information missing from their infant's birth certificates.

Finally, it should be noted that issues related to the validity and reliability of data derived from information on birth certificates could potentially bias the results of this study. There are inconsistencies in who fills out the information on the birth certificate (Woolbright & Harshbarger, 1995), which could result in differences in how items are reported. Also, studies have shown that issues with validity may exist when using data that includes information on smoking and prenatal care utilization derived from birth certificates (Northam & Knapp, 2006). In spite of this, these data are the most representative that are available that include information on women's residence. In addition, these potential biases are not limited to the NCHS data, but are also present in other large secondary data sources.

Previous research has estimated that the neonatal costs of babies of mothers who smoke during pregnancy are $724 dollars more than their non-smoking counterparts (Adams et al., 2002); however, it has been estimated that for every one dollar spent on smoking cessation for pregnant women, three dollars in neonatal intensive care costs could be saved (Ershoff et al., 1990). The development and implementation of cost-effective smoking cessation programs for pregnant women is needed. This study showed that higher levels of education and higher levels of prenatal care utilization were associated with a decreased risk of maternal smoking during pregnancy. Both education and prenatal care utilization are areas that can be targeted in order to reduce smoking prevalence during pregnancy. However, as this study found, it is not only "down stream" approaches that may be helpful for reducing the prevalence of smoking during pregnancy. As shown in the Model II results, increases in the socioeconomic status (e.g., reducing the poverty and unemployment rate) of the counties in which women live can reduce the odds of maternal smoking during pregnancy. This is an "upstream approach" that may not only reduce the likelihood of women smoking while they are pregnant, but also will improve the overall condition of counties. This finding is consistent with the theory of fundamental causes, which is the argument that socioeconomic status is a "fundamental" cause of health inequalities, because the association of socioeconomic status with overall health is persistent even in the face of dramatic changes in mechanisms linking socioeconomic status and health (Phelan et al., 2010). More importantly, the negative association of social capital with maternal smoking during pregnancy among rural counties should be fully utilized. As social capital has been found to be stronger in rural than in urban areas (Beaudoin & Thorson, 2004; Beggs et al., 1996; Hofferth & Iceland, 1998), the stronger bonds that social capital represents may discourage the occurrence of smoking during pregnancy among women who live in rural areas. By increasing social capital in rural areas, this may in turn further minimize the maternal smoking prevalence among rural women.

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- Social capital was positively related to the likelihood of maternal smoking after accounting for both individual and county features.
- Among women living in rural counties, strong social capital was associated with low likelihood of maternal smoking.
- Beyond individual features, better county-level social conditions were related to lower likelihood of maternal smoking.
- Future research should consider both beneficial and adverse implications of social capital for health outcomes.

Table 1

Descriptive statistics of variables at both individual-level and county-level.

Variables	Mean	Standard Deviation
Individual-level measures (N=3,557,625)		
Smokes	11.00	NA
Maternal age		
Age	27.18	6.10
Age squared	775.77	344.19
Race (White=reference)		
Black	17.00	NA
American Indian/Alaskan Native	1.00	NA
Asian	5.00	NA
Ethnicity		
Hispanic	20.00	NA
Marital status		
Married	60.00	NA
Maternal education (Less than High School=reference)		
High school/GED	29.00	NA
Some college/Associate's degree	25.00	NA
Bachelor's degree or higher	26.00	NA
Weight gain during pregnancy		
Weight gain	34.11	20.79
Weight gain squared	1595.56	2189.65
Prenatal Care Utilization (Inadequate care=reference)		
Intermediate care	13.00	NA
Adequate care	40.00	NA
Adequate plus care	31.00	NA
Parity		
First birth	41.00	NA
County-level measures (N=3,047)		
Rural/urban status		
Rural	21.00	NA
Socioeconomic Status		
SES	0.00	1.00
Social Capital		
Social Capital Index	0.00	1.00
Social Capital Index*Rural	15.00	0.41
Racial/ethnic composition		
Percentage non-Hispanic black	9.00	15.00
Percentage non-Hispanic white	80.00	19.00
Percentage Hispanic	7.00	12.00

Note: The mean values represent the percentage of the groups coded 1 for the dichotomous measures; NA=Not applicable.

Table 2

Multilevel logistic regression models estimating the odds of maternal smoking during pregnancy with individual-level and county-levels variables.

Variables	Model I	Model II
Individual-level measures (N=3,557,625)		
Intercept	0.064	0.034
Maternal age		
Age	1.266	1.202
Age squared	0.996	0.997
Race (White=reference)		
Black	0.317	0.445
American Indian/Alaskan Native	0.681	1.104
Asian	0.213	0.335
Ethnicity		
Hispanic	0.103	0.334
Marital status		
Married	0.342	0.416
Maternal education (Less than High School=reference)		
High school/GED	0.617	0.706
Some college/Associate's degree	0.344	0.418
Bachelor's degree or higher	0.065	0.101
Weight gain during pregnancy		
Weight gain	0.997	0.997
Weight gain squared	1.000	1.000
Prenatal Care Utilization (Inadequate care=reference)		
Intermediate care	0.781	0.823
Adequate care	0.686	0.736
Adequate plus care	0.737	0.781
Parity		
First birth	0.722	0.769
County-level measures (N=3,047)		
Rural/urban status		
Rural		0.911
Socioeconomic Status		
SES		0.789
Social Capital		
Social Capital Index		1.063
Social Capital Index*Rural		0.922
Racial/ethnic composition		
Percentage non-Hispanic black		0.747
Percentage non-Hispanic white		3.847
Percentage Hispanic		0.641
Variance Components		

Variables	Model I	Model II
Intercept	0.286	0.132
Black		0.376
American Indian/Alaskan Native		0.612
Asian		0.345
Hispanic		1.297

Note: Results are reported in odds ratios.

All odds ratios are significant at the $p \leq 0.001$ level with the exception of percentage non-Hispanic black ($p \leq 0.05$) and percentage Hispanic ($p \leq 0.01$). The variance components are significant at the $p \leq 0.001$ level.