THE IMPACT OF SEGREGATION AND EDUCATION ON LEVELS OF MATERNAL RISK AND THEIR JOINT CONTRIBUTION TO THE RISK OF PRETERM BIRTH IN NORTH CAROLINA

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Gillings School of Global Public Health (Department of Maternal and Child Health).

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ABSTRACT

STEPHANIE Z. REED: The Impact of Segregation and Education on Levels of Maternal Risk and Their Joint Contribution to the Risk of Preterm Birth in North Carolina
(Under the direction of Vijaya K. Hogan)

Racial/ethnic disparities in preterm birth (PTB) persist and cannot be fully explained by individual-level factors. Many individual-level risk factors have been associated with PTB; however, what remains unknown is what explains the differential distribution of risk factors by race/ethnicity. This research examined whether a contextual exposure, racial residential segregation (RRS), acts on individual factors known to influence PTB. Since RRS is more likely to be experienced as a negative exposure by African-American women, it may contribute to the disparity in PTB.

RRS is associated with an increased risk of PTB; however, it is unknown whether there are factors which may attenuate its effect. Preterm birth rates decrease as educational levels increase, so this research also examined whether maternal education moderates the effect of RRS on PTB.

Geocoded North Carolina birth records were merged with U.S. Census block group data. The first analysis addresses two questions: 1) Is RRS associated with the prevalence of maternal risk factors? and 2) Are there differences in the prevalence of risk factors by race/ethnicity within levels of segregation? Prevalence rates and 95% CI were calculated for each risk factor. There was a higher prevalence of risk factors among white and black women living in highly segregated areas, with higher prevalence for black women.
The second analysis addresses two questions: 1) Do PTB proportions vary by segregation level for black and white women? And 2) Does individual maternal education moderate the effect of segregation on PTB? Results indicate that PTB proportions do not differ by segregation levels for black women; however, they decreased as education increased within each segregation level. PTB proportions increased with increasing segregation level for white women with high education. Finally, maternal education does not moderate the effect of segregation on PTB.

There is an association between segregation and prevalence of some maternal risk factors for PTB; however, there is no consistent difference in the effect of segregation by education level on PTB risk. This research suggests that segregation may be a driving force behind differences in risk factor prevalence, and may, therefore, contribute to disparities in PTB.
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of inspiration for this work, and I hope we can see a day where no baby has to be born preterm and endure what you endured at birth. I am truly blessed and thankful to have you as my daughter.
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LIST OF ABBREVIATIONS

BG: block group
CDC: Centers for Disease Control and Prevention
CI: confidence interval
EMM: effect measure modification
ETJ: extraterritorial jurisdictions
GIS: geographic information systems
IUGR: intrauterine growth restriction
LB: live births
LBW: low birth weight
LMP: last menstrual period
MSA: Metropolitan Statistical Area
NICU: Neonatal Intensive Care Unit
NVSR: National Vital Statistics Report
OR: odds ratio
P: probability
PIH: pregnancy-induced hypertension
PNC: prenatal care
PTB: preterm birth
RRS: Racial Residential Segregation
SES: socioeconomic status
SCHS: North Carolina State Center for Health Statistics
SGA: small for gestational age
VLBW: very low birth weight
Yij: outcome in the ith individual living in the jth context
LIST OF SYMBOLS

\%: percent

<: less than

\leq, \leq=: less than or equal to

>: greater than

\geq, \geq=: greater than or equal to

\beta: beta

\gamma: gamma

S_i: Wong’s Local Spatial Segregation Index
CHAPTER 1: REVIEW OF LITERATURE

A. PRETERM BIRTH

Preterm birth is the largest contributor to infant mortality for black infants (Martin et al., 2006). Each year in the U.S., the PTB rate is nearly twice as high for black infants as it is for white infants. Between 2004 and 2008, the latest statistical data available for the U.S., preterm birth proportions peaked at 12.8% overall in 2006. PTB was 11.7% among white mothers and 18.5% among black mothers (Martin et al., 2010). In 2004, North Carolina’s PTB rates were 18.2% for black infants and 12.1% for white infants. Interestingly, although the disparity in PTB has decreased since 1981, this is due to a 3.6% increase in PTB among whites, not a reduction in PTB among blacks (Martin et al., 2006). Because of this disparity and the lack of progress in reducing it, there is considerable incentive to identify and understand what unique exposures affect black women more than other populations.

To unravel the contributors to the disparity, we propose starting from a foundation of understanding what contributes to PTB in general. We examine the literature on underlying causes of PTB to find clues to unravel the complex contribution of risks to disparities. The goal is to synthesize this knowledge to develop a stronger conceptualization of disparity causation and to develop a conceptual framework that models how these factors might contribute to the excess risk for the black population.

Many risk factors and markers of PTB have been examined in an effort to explain the persistent racial/ethnic disparity, with incremental success. To date, risk factors studied can
be categorized as biological, behavioral, and social, but no set of risk factors has fully explained the disparity. Following is a review of the factors examined to date, and findings.

B. RISK FACTORS/MARKERS FOR PRETERM BIRTH

1. Biological Risk Factors

   a. Maternal age

   Age is thought to be a marker of the effects of socioeconomic disadvantage on a woman’s health over her life course (Geronimus, 1992). Advanced maternal age may also be a marker for time of accumulation of effects from behavioral and environmental assaults over a woman’s life. In a study of birth outcomes for women with diabetes and hypertension, advanced maternal age was associated with increased risk of having both diabetes and hypertension. Coexistence of these morbidities was also associated with increased risk of preterm delivery, compared to having either one alone (Potti, Jain, Mastrogiannis, & Dandolu, 2012).

   Studies have shown that preterm birth risk also increases as maternal age increases (Delbaere et al., 2007; Potti et al., 2012). In a study comparing 25- to 29-year-old women to women of advanced maternal age (>=35 years of age), Delbaere et al. found that older women were more likely to have very preterm (<32 weeks gestation) and extreme preterm (<28 weeks gestation) births than younger women (Delbaere et al., 2007).

   Geronimus’ weathering hypothesis posits that there is survival advantage for infants born to black women during their teens, and to white women during their 20’s and early 30’s, and that infant mortality risk increases at ages 35 and above (Geronimus, 1992). There is also an age effect that is differential by race/ethnicity, with black women having an increased risk of infant mortality at older ages compared to white women.
b. **Hypertension**

According to the CDC (2005), 31% of all women have hypertension. Hypertension, whether chronic or pregnancy-induced (PIH), increases the risk for preterm birth due to increased risk of complications such as pre-eclampsia, eclampsia, intra-uterine growth restriction, and abnormal umbilical artery blood flow (Fatemeh, Marziyeh, Nayereh, Anahita, & Samira, 2009; Gruslin & Lemyre, 2009). Presentation of these conditions during pregnancy is likely to result in labor induction and/ or preterm delivery (Czeizel & Banhidy, 2010; J. A. Turner, 2010). In 2004, chronic hypertension was indicated in 18.5 per 1,000 LB among black women, and 9.9 per 1,000 LB among white women (Martin et al., 2006). Pregnancy-induced hypertension was the most common medical complication of birth, with a prevalence rate of 37.9 per 1,000 live births (42.2 and 43.3 per 1,000 LB for black and white women, respectively) (Martin et al., 2006).

The association between preterm birth and pregnancy-related hypertension was demonstrated in a study of the disparity in prevalence of biophysical factors among low-income women living in rural areas. Jesse, Swanson, Newton and Morrow (2009) found that women delivering preterm were more likely than other mothers to be black and to have pregnancy-related hypertension; hypertensive women were more than three times as likely to deliver preterm [OR=3.42 (95% CI: 1.13–10.32)] (Jesse, Swanson, Newton, & Morrow, 2009).

c. **Diabetes**

Diabetes is the second most common medical complication of pregnancy, with a prevalence of 35.8 per 1,000 live births (LB) in 2004 (Martin et al., 2006). Hypertension and diabetes have been linked to preterm birth and low birth weight (El Mallah, Narchi, Kulaylat,
Rosenberg found that both chronic and gestational diabetes were associated with preterm birth for all women. According to Howarth et al. (2007), maternal diabetes is associated with increased risk for pre-eclampsia, which is a secondary risk factor for preterm birth. In their study, pregnant women with diabetes were 1.4 times more likely to deliver preterm as women without diabetes. In 2005, black women were nearly twice as likely to have diabetes as white women (Centers for Disease Control and Prevention, 2007a).

d. **Incompetent Cervix**

Cervical insufficiency, or incompetent cervix, has been indicated in a number of studies as being predictive of preterm birth (Fuchs et al., 2010; Iams et al., 1996; Rajaeeefard, Mohammadi, & Choobineh, 2007). Cervical insufficiency can result from cervical colonization, a procedure performed in cases of cervical dysplasia (abnormal cervical cells), or from unknown causes, leading to premature shortening of the cervix during pregnancy (Kristensen, Langhoff-Roos, & Kristensen, 1993; Kristensen, Langhoff-Roos, Wittrup, & Bock, 1993). In a study of cervical insufficiency and risk of premature delivery, Iams et al. (1996) found that the relative risk for preterm birth increased as cervical length decreased. In their study, women with a cervical length less than 25 mm at 24 weeks gestation had a relative risk of preterm birth of 6.19 [95% CI (3.84 to 9.97)]. Cervical length at or below 22 mm was associated with a relative risk of 9.49 [95% CI (5.95 to 15.15)] for preterm delivery.

Although cervical insufficiency is more common among white women, the difference in prevalence may reflect a disparity in access to care whereby white women are able to access care more readily and be screened, diagnosed, and treated for cervical abnormalities.
In the U.S. in 2004, the infant death rate for pregnancies affected by cervical insufficiency was 11.1 per 100,000 live births. The rates were 7.7 per 100,000 live births to white mothers, and 30.2 per 100,000 live births to black mothers.

2. Behavioral Risk Factors

   i. Tobacco use

   Behavioral risk factors such as tobacco and alcohol use increase women’s risk for preterm delivery. Women may practice these behaviors as stress-coping mechanisms, with long-term effects to their health and the health of their fetus (Keyes, Barnes, & Bates, 2011). Tobacco use has been associated with intrauterine growth restriction through a process that retards fetal growth (Bada et al., 2005; Wilcox, 2001). Bada et al. (2005) found that nearly 14% of IUGR infants can be attributed to maternal tobacco use during pregnancy. Maternal exposure to smoking has also been associated with uterine bleeding, placenta abruptia and placenta previa (Ananth, Savitz, & Luther, 1996), all of which are indications for early delivery.

   Tobacco use also affects the health of the mother, such that her risk of preterm delivery is increased. Smoking has been associated with increased risk for hypertension, cardiovascular disease and diabetes (Virdis, Giannarelli, Neves, Taddei, & Ghiadoni, 2010; Yeh, Duncan, Schmidt, Wang, & Brancati, 2010). Smoking also increases the risk of coronary artery disease and sudden death through the promotion of atherosclerosis, and by reducing the capacity of the blood to deliver oxygen (Prasad, Kabir, Dash, & Das, 2009). In a study of maternal smoking by trimester, women who quit smoking by the third trimester were not at increased risk of having a low birthweight infant; however, women who began smoking late in the second or third trimester had a risk of low birthweight equal to that of
women who smoked during the entire pregnancy (Lieberman, Gremy, Lang, & Cohen, 1994).

According to the 2008 Pregnancy Risk Assessment and Monitoring System (PRAMS), 13% of women reported smoking during pregnancy (Centers for Disease Control and Prevention, 2012). Although white women are more likely to use tobacco, its use has been linked to low birth weight and preterm birth among both white and black infants (Ahern, Pickett, Selvin, & Abrams, 2003; Ananth et al., 1996; Heaman, Blanchard, Gupton, Moffatt, & Currie, 2005; M. S. Kramer, Seguin, Lydon, & Goulet, 2000).

ii. Alcohol use

Heavy alcohol use during pregnancy is associated with poor pregnancy outcomes, including preterm birth, fetal alcohol syndrome, birth defects, developmental disorders, and spontaneous abortion (Patra et al., 2011; Richardson et al., 2011). In a meta-analysis of preterm birth risk with alcohol use, the risk of preterm birth increased for infants born to heavy consumers of alcohol (about 1.5 drinks/day or 18 g pure alcohol) compared to abstainers; however, there was no effect on preterm birth up to that amount. There was a monotonically increasing risk for preterm birth for maternal alcohol consumption above 1.5 drinks per day (Patra et al., 2011).

PRAMS estimates reveal that 61.6% of white women and 35.7% of black women in the U.S. consumed alcohol during the three months prior to pregnancy; in North Carolina, 59.8% of white women and 36.4% of black women reported consuming alcohol three months pre-partum (Centers for Disease Control and Prevention, 2007b).
iii. **Timing of entry into prenatal care**

Mixed results have been found on the effectiveness of prenatal care in reducing the risk of poor birth outcomes (Baldwin et al., 1998). Prenatal care coordination, a benefit of the federal Medicaid program introduced in 1985, was found to reduce the risk of LBW [OR = 0.842; 95% CI (0.777, 0.912)], preterm birth [OR = 0.831; 95% CI [(0.776, 0.890)], and having an infant transferred to the NICU [OR = 0.829; 95% CI (0.759, .906)] in adjusted analyses (Van Dijk, Anderko, & Stetzer, 2010).

No study has found that amount or timing of prenatal care fully explains the racial/ethnic disparity in preterm birth. Healey et al. (2006) compared the effect of early prenatal care on the disparity in adverse birth outcomes among white, black, and Hispanic racial/ethnic groups. Although all of the women had received early prenatal care, black women were 3.5 times as likely as white women to experience perinatal mortality (infant or fetal death) [OR =3.5 (95% CI: 2.5– 4.9)] (Healy et al., 2006). Other researchers have found that prenatal care is associated with improvements in rates of low birth weight, very low birth weight, and preterm birth among black and white women (Murray & Bernfield, 1988; Vintzileos, Ananth, Smulian, Scorza, & Knuppel, 2002). Murray and Bernfield (1998) found that black women used prenatal care less extensively than white women did; however, the difference in prenatal care use accounted for less than 15 percent of the black-white disparity in low birth weight (Murray & Bernfield, 1988). Rowley (1995) advises caution in the interpretation that prenatal care alone can reduce the disparities seen in adverse birth outcomes, because “factors that cause a woman to enter prenatal care early may also be related to factors that protect against LBW birth,” or any adverse birth outcome (Rowley, 1995). This caution is well warranted given the results of an analysis of the impact of
prenatal care on preterm birth conducted with over 14 million births. Although preterm birth rates decreased markedly for both blacks and whites with increasing numbers of prenatal care visits, the black-white disparity in preterm birth remained (Vintzileos et al., 2002). Given the lack of an explanation for black-white disparities, examination of factors that explain the differential distribution and/or the virulence of these factors is warranted.

3. Social Risk Factors

   i. Education

   Although to date no social factor has fully explained the racial/ethnic disparity in preterm birth, examination of social factors has helped to expand the dialogue around disparities and highlight more potential contributors. Trends in infant mortality and preterm birth follow a gradient across levels of education and income. Table 1.1 details the educational attainment levels for black and white non-Hispanic women who gave birth in the U.S. (Martin et al., 2006) and North Carolina in 2004.

<table>
<thead>
<tr>
<th>Educational Level</th>
<th>U.S. *</th>
<th>North Carolina†</th>
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<tr>
<td></td>
<td>Black</td>
<td>White</td>
</tr>
<tr>
<td>&lt;High School</td>
<td>27%</td>
<td>23%</td>
</tr>
<tr>
<td>&gt;=4 years College</td>
<td>10.1%</td>
<td>31%</td>
</tr>
</tbody>
</table>

† Results from preliminary analyses

In the U.S. and North Carolina, a greater proportion of black women than white women who gave birth in 2004 had less than a high school education, and nearly three times as many white women than black woman who gave birth had at least four years of college (Martin et al., 2006). As income and education increases, levels of preterm birth and infant mortality decrease. Within racial/ethnic groups, the same trend exists; however the magnitude of the trend varies. Although infant mortality rates are lowest at the highest levels of education for each racial/ethnic group, the infant mortality rates for black women are higher at the highest education levels than for white women at the lowest education levels (Mathews & MacDorman, 2006). Figure 1.1 illustrates the infant mortality rates across educational levels for blacks, whites and in total in 2003 (adapted from 2006 NVSR) (Mathews & MacDorman, 2006). Given the predictive relationship between preterm birth and infant mortality, it is expected that preterm birth rates follow the same trend by education level across racial/ethnic groups.
ii. Income

Income may influence preterm birth by limiting the resources available for healthy lifestyles and for acquiring goods and services. Researchers have found an increased risk of preterm birth with socioeconomic disadvantage measured at both the individual and neighborhood levels (Blumenshine, Egerter, Barclay, Cubbin, & Braveman, 2010; Love, David, Rankin, & Collins, 2010). Low income may also limit where one can live, exposing residents to varying levels of crime, inadequate built environments and poor housing conditions in lower income neighborhoods. These living conditions also have health implications. A poor built environment has been linked to less physical activity and higher obesity among both children and adults (Li et al., 2008; Lovasi et al., 2011). Changes in income over time may lead to improvements in risk of preterm birth. Collins et al. (2011) demonstrated that upward economic mobility from early life impoverishment is associated with a decreased risk of preterm birth (Collins, Rankin, & David, 2011).
Other studies suggest that socioeconomic status is a fundamental cause of disease (Link & Phelan, 1995; Phelan, Link, & Tehranifar, 2010) and that declines in social conditions are associated with poor health status (Ensel and Lin, 1991; Rosenfield, 1989). Blacks have a history of lower socioeconomic status in the U.S., which may contribute to the disparities seen in so many health outcomes, including preterm birth.

**iii. Contextual effects**

Contextual effects have gained attention as possible contributors to preterm birth risk. Contextual effects, such as neighborhood level deprivation, violent crime rates and racial residential segregation may predict the presence of individual risk factors that increase women’s risk for preterm birth or other adverse birth outcomes. Many studies have been conducted that show associations between contextual effects and poor health outcomes such as hypertension and diabetes (Bell, Zimmerman, Mayer, Almgren, & Huebner, 2007; Kershaw et al., 2011; Subramanian, Acevedo-Garcia, & Osypuk, 2005; Subramanian, Chen, Rehkopf, Waterman, & Krieger, 2005). These outcomes are also risk factors for preterm birth (El Mallah et al., 1997; Healy et al., 2006; Howarth et al., 2007; Rosenberg et al., 2005). Kershaw et al. (2011) examined the association between segregation and hypertension by race and found that racial disparities in hypertension were modified by segregation levels and neighborhood poverty (Kershaw et al., 2011).

**iv. Stress**

Several mechanisms have been offered to explain how stress causes poor birth outcomes, including: 1) blunting, weathering, or dysfunction of neuroendocrine and immune function in response to chronic stress activation through the life course; and 2) individuals’
adoption of risky behaviors such as smoking as a response to stressful stimuli (M. R. Kramer, Hogue, Dunlop, & Menon, 2011). According to Kramer et al., evidence exists for dysfunction of neuroendocrine and immune function, but it is not clear whether this association is causal or whether it explains a significant portion of the black-white disparity in preterm birth.

Indirectly, psychosocial stress has been linked to the dysregulation of stress hormones, immune function and cardiovascular reactivity (Sandman, Wadhwa, Chicz-DeMet, Dunkel-Schetter, & Porto, 1997; Wadhwa, Culhane, Rauh, & Barve, 2001; Wadhwa, Culhane, Rauh, Barve et al., 2001; Wadhwa, Sandman, & Garite, 2001), which increase women’s risk for preterm birth (Culhane et al., 2001; Hatch et al., 2006; Sandman et al., 1997). The physiologic deregulation of women’s hypothalamic-pituitary-adrenal axis (HPA) due to stress is associated with an increased risk of preterm birth (Hobel, Dunkel-Schetter, Roesch, Castro, & Arora, 1999; Korebrits et al., 1998; Wadhwa, Culhane, Rauh, Barve et al., 2001). In these studies, higher levels of corticotrophin-releasing hormone (CRH) were found among women who delivered preterm than among those who delivered at term. Roy-Matton, Moutquin, Brown, Carrier, and Bell (2011) found that women delivering preterm perceived more stress during weeks 10-20 of gestation than did women with term pregnancies.

Racial discrimination has been appraised as a stressor experienced daily by many African Americans (Ong, Fuller-Rowell, & Burrow, 2009), (Essed, 1991). Racial discrimination experienced during pregnancy is a risk factor for black women’s adverse birth outcomes (Jackson, Phillips, Hogue, & Curry-Owens, 2001) and is associated with preterm birth via its effects on both health behaviors (Flores, Tschann, Dimas, Pasch, & de Groat, 2010) and cardiovascular health (D. R. Williams & Neighbors, 2001). Collins found an
increased association between racial discrimination and very low birth weight (<1500 g) among women greater than 30 years of age and among women who had at least a high school diploma, compared to all other women [OR for >= 3 domains was 3.2, 95% CI (1.5, 6.6)] (Collins, David, Handler, Wall, & Andes, 2004). In a study of 352 black and white births, 50% of black women had experienced racial discrimination, which was associated with a three-fold risk of preterm birth in both racial groups [OR=3.05, 95% CI (1.29, 7.24)] (Mustillo et al., 2004).

One of the limitations of previous research that has examined social influences on health has been the reliance on self-reported measures of these influences. For example, examination of racial discrimination to document the effect of psychosocial stress on health outcomes has relied on self-reported measures of racial discrimination (Davis, Liu, Quarells, & Din-Dzietharn, 2005; Din-Dzietham, Nembhard, Collins, & Davis, 2004). Relying on self-reports may underestimate the prevalence of the exposure because participants may not recognize that they are indeed exposed. For example, one may be exposed to the result of institutional forms of discrimination, such as racial residential segregation, but not recognize it as such because it has been experienced all of one’s life. Without having a critical analysis of how politics and history have contributed to this present social condition, one may not be able to name one’s experiences as racism. This argues for the use of a more objective measure of racism.

v. **Inflammation/Infection**

Black women have a higher prevalence than do other women of urogenital tract infections (Newton et al., 2001), and have higher vaginal colonization with pathogens such as Chlamydia thrachomatis, Neisseria gonorhoeae, and bacterial vaginosis (BV) (Goldenberg et
al., 1996). Wadhwa et al. (2001) hypothesize that women experiencing chronic stress have weaker immune responses that make them vulnerable to higher rates of infection. Culhane et al. (2001) found that higher levels of chronic stress during pregnancy are associated with bacterial vaginosis (BV), and that black women were 2.5 times more likely to have BV than non-black women. Fiscella et al. (1996) noted that disparities in prevalence of bacterial vaginosis (BV) between blacks and whites may explain up to 30% of the black-white disparity in PTB.

C. SUMMARY OF RISK FACTOR REVIEW

For all of these risks, either black women have a higher prevalence of the risk, the risk has a stronger negative impact among black women, or both. But what explains the higher prevalence or stronger effect?

The relationship of the risks to the disparity may not be understood outside of the context of population-specific exposures and circumstances. Mullings and Wali (2001) operationalized this by posing the question, “What is unique about the experience of being a black woman in America that places her at higher risk for morbidity and mortality — especially during pregnancy?” (Mullings & Wali, 2001). We theorize that racism and segregation are unique exposures that interact to increase the prevalence and/or impacts of these common risk factors among blacks. If there is a difference in the prevalence of the risk factors that affect an outcome, there may also be a difference in the contextual factors that influence the prevalence of the risk factor. The contextual factor may be the driving force behind the disparity, after controlling for the individual risk factor (V.K. Hogan, 2004). Since we haven’t succeeded in explaining the disparities with the traditional individual risk factors, it may be beneficial to examine whether macro-social effects impact health...
outcomes. Contextual effects such as neighborhoods and communities, as well as social and economic policies, may impact more proximal influences on health to lead to health disparities. They may also affect the outcomes through pathways that we have not been successful in identifying or measuring. Therefore, we need to measure the contextual effects to capture more of what the proximal effects are missing.

D. RACIAL RESIDENTIAL SEGREGATION: A THEORETICAL CONTRIBUTOR TO STRONGER EFFECT/HIGHER PREVALENCE OF RISK FACTORS

Why are certain factors (e.g., bacterial vaginosis) more prevalent among black women than white women? What contributes to certain risk factors (e.g., weathering) having a stronger effect among black women compared to others? Contextual effects are a likely explanation for these differences in prevalence and effects because they affect populations rather than individuals. All individuals living within a given context, e.g., racial residential segregation, are exposed to the conditions within that context, whether positive or negative. Examining context can help us understand the patterning of disease by subgroups (e.g., racial/ethnic groups) or places (e.g., highly segregated neighborhoods), an understanding not gained by focusing on individual risk factors (Rose, 1994). Previous research has suggested that social context may contribute to a greater risk of adverse birth outcomes than do individual factors alone. Phenomena such as the foreign-born effect and better birth outcomes for Latinas (Acevedo-Garcia, Soobader, & Berkman, 2005) provide preliminary evidence that contextual effects may contribute to the disparity. A foreign-born black woman is less likely to have a LBW or preterm delivery than is a black woman born in the U.S. (Howard, Marshall, Kaufman, & Savitz, 2006); however, the longer she resides in the U.S., the worse her birth outcomes become (Bates & Teitler, 2008).
There is no known genetic difference between black, white or Latina women that would cause black women to be at greater risk for developing risk factors, or would protect Latina women from the hazards of certain risk factors (David & Collins, 1991). If there were, we would expect to see similar prevalence of risk factors and birth outcomes among black women in Africa, Europe, the Caribbean, and other parts of the world. Instead, compared to their counterparts in the U.S., black women in other parts of the world have lower prevalence of risk factors (Borrell, Crawford, Barrington, & Maglo, 2008; Read, Emerson, & Tarlov, 2005) and better birth outcomes (Elo, Vang, & Culhane, 2011; Howard et al., 2006).

So, what is different about the experiences of black women in the U.S. that would cause them to be at increased risk for poor birth outcomes? Specifically, are there experiences or factors that result in the differential distribution or effect of certain risk factors among black and white women? It is possible that risk factors that contribute to a poor outcome are systematically and differentially distributed across certain populations due to contextual effects. For example, differences in levels of education are associated with differences in rates of preterm birth (Luo, Wilkins, & Kramer, 2006; McGrady, Sung, Rowley, & Hogue, 1992; Scott-Wright, Wrona, & Flanagan, 1998). Differences in education across populations may lead to disparities across populations. In this example, a contextual factor that is associated with the unequal distribution of educational levels or access to education, or causes a risk factor to exert a stronger effect on one population group over another, should be examined as a contributor to a disparity. A unique contextual effect influencing education access is racial residential segregation. Those living in racially
segregated areas have less access to quality education, and may be less likely to graduate from high school (M. A. Turner & Fortuny, 2009).

E. HISTORY OF RACIAL RESIDENTIAL SEGREGATION

Racial Residential Segregation (RRS) has shown promise in many studies that examine contextual effects on birth outcomes. Previous work has found that preterm birth may be partially explained by RRS (Bell, Zimmerman, Almgren, Mayer, & Huebner, 2006; Herrick, 1996; M. R. Kramer, Cooper, Drews-Botsch, Waller, & Hogue, 2010; M. R. Kramer & Hogue, 2008; S. M. Mason, Messer, Laraia, & Mendola, 2009; Osypuk & Acevedo-Garcia, 2008), but the geographical areas studied have varied. Several researchers have examined segregation’s effects in metropolitan areas using Metropolitan Statistical Areas (MSAs) as the unit of analysis (Bell et al., 2006; M. R. Kramer & Hogue, 2008; Polednak, 1991). The MSAs studied are mostly in the northern and northwestern parts of the U.S. and have a history of in-migration from the south. Racist housing policies regulated where blacks could live, and restricted their home ownership. The history of segregation in these areas has been well documented (Massey & Denton, 1993; McGrew, 1997). Less densely populated areas, such as micropolitans (cities with populations between 10,000-50,000), and cities in the south have only recently been included in segregation research (Herrick, 1996; S. M. Mason et al., 2009). The history of segregation in these areas is much different than in the north. For instance, in North Carolina, segregation resulted in part from a history of slavery, Jim Crow laws, and municipal underbounding. Municipal underbounding occurred when local governments annexed certain portions of their cities, which received municipal services, and left other areas unannexed (J. H. Johnson, Jr., Parnell, Joyner, Christman, & Marsh, 2004; Parnell, Joyner, Christman, & Marsh, 2004).
1. Segregation in North Carolina

North Carolina is a southern, rural state, with a population that has increased dramatically over the past 30 years. At the time of the 2000 Census, 8,049,313 people lived in NC, an increase of 21.4% from 1990. Fifty-one percent of the population lived in rural areas (North Carolina Rural Economic Development Center, 2007).

The history of the residential distribution of blacks in the south, including North Carolina, has evolved from blacks living in close proximity to whites on plantations, to being more segregated from whites. Although in the north and northwest these patterns of distribution seem to show a clear trajectory from integration to segregation, patterns in the south are less linear. During slavery, blacks lived in quarters on plantations adjacent to the homes of their owners. As a result, the levels of segregation were very low, albeit there were vast differences in the living conditions. At the end of slavery, many blacks became sharecroppers and continued to live on the plantations on which they had been enslaved. As the desire for independence grew, the tenant system was developed, in which the plantation was partitioned into smaller farm units. Blacks built dwellings on their parcels of land, so that many blacks lived quite a distance from the main home. This resulted in a pattern of resettlement, with blacks being dispersed into more rural areas (Aiken, 1985).

The settlement patterns of blacks began to change around 1950 (Aiken, 1985), when blacks began to move closer to cities and towns. This move marks the beginning of present-day segregation in many southern “micropolitans,” including cities in North Carolina. Blacks began to move out of rural areas into small towns and new hamlets. Aiken (1985) defines a hamlet as:

a group of five or more houses … owned by blacks. Within a single hamlet may be shacks modeled after
tenant houses, mobile homes, Jim Walter-type shell houses, and neat brick-veneered houses with garages. Dwellings usually are close to the road, and on a lot behind the main structure may be one or two others occupied by family members (p. 394).

Segregation in the south, and particularly in North Carolina, arose out of a systematic process of “underbounding” whereby local governments annexed areas outside of their cities which received municipal services, whereas other areas, particularly black neighborhoods, were left unannexed. These non-annexed areas are politically termed “Extraterritorial Jurisdictions” (ETJ). According to Parnell et al. (2004), ETJ was created as an area outside of a town’s boundaries over which the town has complete land-use, permitting and zoning control. The rationale for an ETJ is that it is a mechanism for rational planning for growth. Residents of an ETJ have no elected representative in the town government that makes decisions regarding their property. Further, there is no mechanism that limits the duration that an area can stay within an ETJ before annexation occurs, allowing some towns to keep “less desirable” neighborhoods in their ETJ in potential perpetuity (p. 5-6).

ETJs exist in present-day NC. ETJs limit residents’ access to municipal resources, including sanitation services and water. There is also evidence that municipalities locate landfills and waste facilities in ETJs. According to Parnell (2004), “[North Carolina’s] laws give towns the discretion to annex only properties with high tax values, even non-contiguous properties, resulting in discontinuous boundaries that skip over poor and black neighborhoods” (p. 17). These communities are inherently segregated by race/ethnicity, but they also become economically segregated due to these measures. Communities disenfranchised in this manner may suffer the same neighborhood and segregation effects as metropolitan areas because they are suffering the economic effects of disinvestment and the social effects of isolation in their communities.
2. Racial residential segregation and health

How can RRS affect health? Some researchers have begun to develop hypotheses about pathways of effect. RRS has a negative impact on women’s preconceptional health and birth outcomes (Bell et al., 2006; Grady, 2006; M. O. Hearst, Oakes, & Johnson, 2008; Kershaw et al., 2011; M. R. Kramer et al., 2010; T. A. Laveist, 1993; S. M. Mason et al., 2009; Mobley et al., 2006; Polednak, 1996a; Subramanian, Acevedo-Garcia et al., 2005; White & Borrell, 2011; David R. Williams & Collins, 2002). Neighborhood violent crime levels, socioeconomic characteristics, chronic hypertension and pregnancy-related hypertension may mediate the association between RRS and birth outcomes because they affect women’s preconceptional health and access to prenatal care (Grady & Ramirez, 2008; M. R. Kramer et al., 2010).

Segregated populations are distributed by race, and segregation influences social, educational and economic resources available in communities (Thomas A. LaVeist & Wallace, 2002; Morland, Wing, & Poole, 2002; David R. Williams & Collins, 2002). The effect of education and income on health outcomes has been well documented (Collins, David, Simon, & Prachand, 2007; Luo et al., 2006; Orr, James, Garry, Prince, & Newton, 2006; Pickett, Ahern, Selvin, & Abrams, 2002; Pickett, Collins, Masi, & Wilkinson, 2005). Concentrated poverty and diminished educational and economic resources may occur as a result of community disinvestment, leading to fewer employment opportunities, decreased neighborhood quality through exposure to personal and property crimes, noxious odors, pollutants and allergens, lack of grocery stores with fresh produce, and poor built environment for physical activity and well-being (Galea, Ahern, Rudenstine, Wallace, & Vlahov, 2005; Handy, Boarnet, Ewing, & Killingsworth, 2002; Thomas A. LaVeist &
Wallace, 2002; Mobley et al., 2006; Morland et al., 2002; Rauh, Chew, & Garfinkel, 2002; David R. Williams & Collins, 2002). These factors are associated with poor health outcomes (Apelberg, Buckley, & White, 2005; Handy et al., 2002; Maroziene & Grazuleviciene, 2002; Messer, Kaufman, Dole, Herring, & Laraia, 2006; Messer, Kaufman, Dole, Savitz, & Laraia, 2006; Mobley et al., 2006).

3. Racial residential segregation and preterm birth

Segregation has a differential effect on preterm birth depending on neighborhood characteristics and level of segregation (Bell et al., 2006; Collins & David, 1990; Grady, 2006). Several researchers have found associations between segregation and poor birth outcomes (Baker & Hellerstedt, 2006; Bell et al., 2006; Grady, 2006; M. R. Kramer et al., 2010; S. M. Mason et al., 2011; S. M. Mason et al., 2009). Specifically, Bell et al. (2006) found that high segregation (isolation) was associated with preterm birth and low birth weight. Segregation may act to concentrate behaviors and neighborhood characteristics that are detrimental to the health of women and their babies (Grady, 2006; Massey & Denton, 1993). This association may be mediated by smoking, lung disease, and hypertension (Grady & Ramirez, 2008; M. R. Kramer et al., 2010); however, more research is necessary to determine other potential mediators.

F. CONCEPTUAL FRAMEWORK LINKING RRS TO PTB RISK FACTORS

The conceptual framework for this study (see Figure 1.2) takes into account important factors shown in the literature to influence the risk of preterm birth. We expect that there is a multidimensional effect of racial residential segregation on the health of black and white women in segregated areas that places them at increased risk of having preterm deliveries. Racial residential segregation derives from a history of racial prejudice in the United States,
which was instrumental in the development of racist housing policies that systematically dictated where blacks could and could not purchase homes. These practices lead directly to racial residential segregation. Segregation has been linked to the unequal distribution of food and educational resources, location of employment of opportunities and unequal distribution of resources in communities (Thomas A. LaVeist & Wallace, 2002; Massey & Denton, 1993; Morland et al., 2002). These effects of segregation more directly influence health through lack of knowledge of health care practices, psychosocial stress, poor access to care, lack of health insurance, and lack of resources to support a healthy lifestyle (Massey & Denton, 1993; McEwen & Seeman, 1999; Sandman et al., 1997; Wadhwa, Sandman, Porto, Dunkel-Schetter, & Garite, 1993). The unequal distribution of educational resources and stress lead to poor health and health behaviors, which include, but are not limited to, smoking, alcohol use, and late or no prenatal care. Stress may also lead to poor health outcomes such as hypertension and diabetes. The unequal location of employment opportunities and unequal distribution of educational resources both directly influence access to care. Concentrated poverty results in a lack of money for healthy lifestyles. Both poor access to health care and concentrated poverty can result in poor health and health behaviors, including late or no prenatal care, incompetent cervix, diabetes and hypertension. All of these poor health outcomes and health behaviors have been linked to preterm birth.
Figure 1.2. Conceptual Framework of the multidimensional effect of segregation on the health of blacks in segregated areas
G. METHODOLOGIC ISSUES FOR STUDYING RRS AND PRETERM BIRTH.

Measuring the effect of contextual factors on health disparities is very complicated. Measurement of RRS in particular is problematic because of its close association with socioeconomic status and poverty (Massey & Denton, 1993). Following the conceptual model offered for this line of research (Figure 1.2), we start from the premise that concentrated poverty is a direct result of RRS in areas where RRS exists. Therefore, measurement of RRS will capture the effect of concentrated poverty, but it will not overestimate the health effect of RRS and poverty combined because this concentrated poverty is a direct result of RRS.

Measurement of RRS is further complicated because we do not always know how long a person has resided in an area of high segregation. The Moving to Opportunity study gives us some indication of how people move when not counseled; they prefer to move to areas that are racially and socio-demographically similar to those they are moving from (Bembry & Norris, 2005). Collins, Wambach, David, and Rankin’s (2009) study of women with life-long exposure to neighborhood poverty revealed that 78% of black and 84% of white women had life-long residence in low-income and high-income neighborhoods, respectively. Since we cannot randomly assign subjects to live in areas of specific segregation levels, we must make assumptions about the length of time subjects have lived in RRS areas and/or conduct research to justify these assumptions. It is therefore assumed that a person has lived in an area of segregation long enough for the hypothesized effects of segregation to occur.

The index of isolation has been used in previous studies to measure the isolation dimension of segregation. The index of isolation measures the degree to which blacks are
isolated from other racial/ethnic groups (Grady & Ramirez, 2007). One limitation of the index of isolation is that it does not take into account the spatial positioning of subjects or potential interaction of subjects with persons in neighboring areas across block group or other boundaries. People are most likely unaware of the boundary of an areal unit, and therefore would not know that they should not interact with people on the other side of the boundary for the sake of research. Therefore, spatial measures have been developed that weight the probability of a subject’s interacting with someone in an areal unit adjacent to or within a given distance of their own. Although people do not apply distance weights to their interactions, spatial measures give a better indication of potential interaction with persons in neighboring areal units, rather than ignoring the possibility of interaction.

H. SEGREGATION DEFINED: WONG’S LOCAL SPATIAL INDEX OF SEGREGATION.

Racial residential segregation is the degree to which racial groups live separate from one another (Kaplan & Holloway, 1998). Massey and Denton (1993) identify five dimensions of segregation: evenness, centralization, concentration, clustering, and isolation. The mechanism by which segregation affects health may be different depending on the dimension being used to represent segregation. Evenness is the degree to which blacks are overrepresented or underrepresented in neighborhoods relative to the overall proportion of blacks in the city. Centralization is the degree to which blacks live in the urban core, or center of the city. Concentration is the degree to which blacks occupy a smaller space than whites. Isolation is the degree to which black residential areas are scattered across an area, (thus isolated from mainstream society). Clustering is the degree to which minority residential areas are contiguous. An analysis of blacks in the U.S. revealed that blacks are distinctly disadvantaged in that they are the only racial/ethnic group to experience
segregation in each of these five dimensions, a phenomenon described as hypersegregation (Massey & Denton, 1993).

The dimension of segregation assessed can have implications for the interpretation of the effects of segregation on preterm birth rates. It is important to distinguish how each dimension may have negative or positive effects on preterm birth. Some previous studies have used measures of isolation to assess segregation’s effect on birth outcomes (Bell et al., 2006; Grady, 2006; M. O. Hearst et al., 2008). The isolation dimension of segregation implies that blacks are deprived of access to resources that may be beneficial for health due to isolation from mainstream society (M. O. Hearst et al., 2008). If blacks are isolated from resources such as education and health care, employment opportunities, locations for physical activity, and locations to obtain fresh fruits and vegetables, they may experience poorer health. Massey and Denton (1993) also point out that isolation deprives blacks of receiving health information and knowledge that would benefit their health. The isolation dimension most closely portrays the negative consequences that segregation has caused and concentrated in black communities (Massey & Denton, 1993), and its use has been justified by prior segregation research (Acevedo-Garcia, Lochner, Osypuk, & Subramanian, 2003; Subramanian, Acevedo-Garcia et al., 2005); therefore, we consider it to be the most appropriate dimension of segregation to aid in understanding disparities.

Wong’s Local Spatial Segregation Index ($S_i$) measures the potential for interaction between two racial/ethnic groups, taking into account the spatial distribution of members of the group in the index and neighboring units (Equation 1) (Wong, 2002). For example, a black person living in block group A has $x$ probability of interacting with a white person in block group A, $y$ probability of interacting with a white person of block group B, and so on.
Wong’s index allows the potential for interaction to be weighted by either the adjacency of block group B from A (yes=1, no=0), or the distance of block group B from A (distance-decay function). Therefore, $S_i$ is calculated as:

$$S_i = 1 - \frac{(a_i \sum c_{ij} b_j) + (b_i \sum c_{ij} a_j)}{(a_i \sum b_j) + (b_i \sum a_j)}$$

(equation 1)

where $a_i$ and $b_i$ are the population counts of whites and blacks, respectively, within block group $i$; $c_{ij}$ is equal to the inverse distance weight ($1$/distance between block group centroids) for block groups that adjoin the index block group. Alternately, an indication of adjacency can be used to indicate whether a block group is an immediate neighbor of the index block group (1=adjacent, 0=not adjacent); however, researchers have advocated the use of inverse distance weight, indicating that spatial interaction follows a distance decay function, with less potential for interaction as the distance from the index block group increases (Fotheringham & O'Kelly, 1989; Wong, 2002). Since groups $a_i$ and $b_i$ can also interact with each other within the index block group, $i$ can be equal to $j$. $S_i$ ranges from 0 to 1, with 0 indicating complete integration, and 1, complete segregation. This full segregation index measures the potential interaction of two racial/ethnic groups with each other (e.g., blacks with whites and whites with blacks). In the context of measuring racial/ethnic disparities, we are interested in the health effects of living in a highly segregated neighborhood that is composed mostly of black residents. In order to show potential interaction of blacks with whites only, $S_{iba}$ can be calculated as

$$S_{iba} = 1 - \frac{(b_i \sum c_{ij} a_j)}{(b_i \sum a_j)}$$

(equation 2)
The abbreviated version of Wong’s index (equation 2) has also been used by Grady (2006) in her analysis of segregation’s contribution to racial/ethnic disparities in low birthweight rates in New York City.

Given the ability of Wong’s index to capture the spatial component of people’s locations, to incorporate a distance decay function, and to potentially capture the isolating effect of segregation on health, this measure can be used to measure segregation in research where the aim is to determine the contribution of segregation to disparities.

Wong’s index of segregation can be used to estimate levels of segregation across which the prevalence of risk factors for preterm birth can be assessed. The cut-points for segregation measures for the geographical area of the study population are not intrinsic. Other studies have used indices exceeding 0.60 to indicate high levels of segregation (Massey & Denton, 1993; Osypuk & Acevedo-Garcia, 2008). These studies used Metropolitan Statistical Areas to study segregation, and/or non-spatial measures of segregation. Since the spatial measure of segregation is relative to the entire study population, it is likely that absolute cut-points for segregation may not adequately capture the variance in segregation levels for the population being studied.

If cut-points for segregation categories are to be used, as in this analysis, they should be determined by constructing quantiles (tertiles, quartiles, quintiles, etc.) based on the reference population. The cut-points should be determined using exposure distribution data only, not outcome data. Subjects should be assigned a segregation value equal to the segregation level of the areal unit in which they reside.

The goal of this study is to examine the influence of RRS on the distribution of social and medical risk factors for preterm birth for all women who gave birth in North
Carolina in 2004. It is our hypothesis that RRS results in a greater prevalence of social and medical risk factors among women living in highly segregated areas, regardless of the women’s races/ethnicities. The data used for this dissertation are from the 2004 North Carolina composite matched birth files and the 2000 U.S. Census. The composite matched birth file is produced annually by the NC State Center for Health Statistics (SCHS). The matched file contains data from Health Department files, Medicaid files, and birth certificates. The data file contains 119,773 birth records. Eighty-nine percent (89%) of the subjects were geocoded to the block group level by the SCHS, using ESRI ArcGIS 9.0 and TeleAtlas Multinet (roads database) 2005. Population counts of blacks and whites from the 2000 North Carolina Census block group shapefile were used to calculate the local spatial segregation index for each block group in North Carolina (n=5,263).

I. SIGNIFICANCE OF STUDY

Assessing the effects of racial residential segregation on the distribution of individual risk factors has the potential to further demonstrate how RRS contributes to the disparity in preterm birth. To date, no study has examined the distribution of risk factors by RRS. This study contributes empirical results of the differential distribution of risk factors associated with PTB by RRS, and subsequently, race/ethnicity. This research highlights a potential mechanism of disparities in PTB.

Link and Phelan (1995) discuss the importance of understanding the influence of context on health outcomes. This method provides a framework for understanding how segregation can impact proximal factors to preterm birth and the black-white disparity that persists. But the main goal of this research method is to demonstrate that there is an empirical effect of RRS, the contextual factor, on proximal risks for preterm, and not to
highlight proximal factors that should instead be intervened on. As Link and Phelan (1995) point out with the example of SES, even if proximal factors are intervened upon, other proximal factors will emerge as contributors to an outcome “because a deeper sociological process is at work” (p. 87). Moreover, they write, “the essential feature of fundamental social causes, is that they involve access to resources (money, knowledge, power, prestige, interpersonal resources, e.g., social support) that can be used to avoid risks” (p. 87).

Segregation creates systems that limit access to a plethora of resources, and is shown here to have a fundamental association with racial/ethnic disparities in preterm birth.

Categories of segregation will be used to present the prevalence of each individual-level risk factor; therefore, the greatest amount of change will be achieved by addressing this contextual factor. This is not to say that black and white residents should be forced to move to make residential areas more heterogeneous, but rather to focus attention on the economic, health, educational, and social resources available in an area, with interventions that normalize these differences. Therefore, the greatest significance of this line of research is empirically delineating how residential segregation affects the health of individuals. These results will help researchers better understand where to intervene to address a health issue affected by social context. The results should also have policy implications for funding research and interventions that will take the U.S. closer to eliminating racial and ethnic disparities in health.
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CHAPTER 2: DETERMINING THE IMPACT OF SEGREGATION AND EDUCATION ON THE PREVALENCE OF MATERNAL MEDICAL AND SOCIAL RISK FACTORS FOR PRETERM BIRTH IN NORTH CAROLINA

A. INTRODUCTION

Racial/ethnic disparities in preterm birth and infant mortality have remained steady despite concerted medical and public health efforts to reduce them. One goal of the Department of Health and Human Services in Healthy People 2020 is to eliminate all health disparities, (U.S. Department of Health and Human Services, 2010a), but current efforts focused on changing individuals’ health behaviors and treating medical risk factors alone have not been effective at reducing these disparities. This suggests that the context within which these risk factors emerge and act is not well understood (Healy et al., 2006; V. K. Hogan, Njoroge, Durant, & Ferre, 2001; Rowley, 1995). Some researchers posit that disparities result from a complex interaction between social and biological forces (V. K. Hogan & Ferre, 2001). To eliminate health disparities, we need a better understanding of both the social and biologic contributors and how these might interact to produce risk. This study will examine the relationship between social and biologic risk in the excess risk of preterm birth among blacks.

Investigators have shown that inequities in social contexts create inequities in the availability of employment and educational opportunities, socioeconomic status, access to health care, access to healthy foods, and criminal activity (Thomas A. LaVeist & Wallace, 2002; Morland et al., 2002; Shohaimi et al., 2004). Of particular relevance to blacks in the U.S. is the social experience of racial residential segregation. Racial residential segregation is
the degree to which racial groups live separate from one another (Kaplan & Holloway, 1998). Williams (2002) describes how racial residential segregation affects the life opportunities of blacks and is a fundamental cause of racial disparities in health. Racial residential segregation has been associated with heightened crime rates and poor self-rated health (M. R. Kramer et al., 2010; Subramanian, Acevedo-Garcia et al., 2005), and with an increased risk of poor birth outcomes (Bell et al., 2006; Grady, 2006; M. R. Kramer et al., 2010; M. R. Kramer & Hogue, 2008; S. M. Mason et al., 2009; Polednak, 1996b).

Massey and Denton (1993) identify five dimensions of segregation: evenness, centralization, concentration, clustering, and isolation. An analysis of blacks in the U.S. revealed that blacks are distinctly disadvantaged in that they are the only racial/ethnic group to experience segregation in each of the five dimensions of segregation, a phenomenon described as hypersegregation (Massey & Denton, 1993). The mechanism by which segregation affects health may differ depending on the dimension being used to represent segregation. Evenness is the degree to which blacks are overrepresented or underrepresented in neighborhoods relative to the overall proportion of blacks in the city. Centralization is the degree to which blacks live in the urban core, or center of the city. Concentration is the degree to which blacks occupy a smaller space than whites. Isolation is the degree to which black residential areas are scattered across an area (thus, isolated from mainstream society). Clustering is the degree to which minority residential areas are contiguous (Massey & Denton, 1993). The isolation dimension of segregation may be the most insidious social force; it acts by depriving blacks of access to resources that may be beneficial for health due to isolation from mainstream society (M. O. Hearst et al., 2008). If blacks are isolated from resources such as education and health care, employment opportunities, locations for
physical activity, and locations to obtain fresh fruits and vegetables, they may experience poorer health. Massey and Denton (1993) also point out that isolation deprives blacks of receiving health information and knowledge that would benefit their health. Bell (2006) found that isolation was associated with low birthweight and preterm birth, while clustering was inversely associated with low birthweight and preterm birth. The isolation dimension most closely portrays the negative consequences that segregation has caused and concentrated in black communities (Massey & Denton, 1993), and its use has been justified by prior segregation research (Acevedo-Garcia et al., 2003; Subramanian, Acevedo-Garcia et al., 2005).

The purpose of this research is to examine the influence of segregation on the distribution of social and medical risk factors for preterm birth for women who gave birth in North Carolina in 2004. We hypothesize that racial residential segregation, specifically the isolation dimension, will result in a greater prevalence of social and medical risk factors among women living in highly segregated areas.

B. BACKGROUND

1. History of Segregation in North Carolina

North Carolina is a southern, rural state, with a population that has increased dramatically over the past 30 years. At the time of the 2000 Census, 8,049,313 people lived in NC, an increase of 21.4% from 1990. Fifty-one percent of the population lived in rural areas (North Carolina Rural Economic Development Center, 2007).

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distribution seem to show a clear trajectory from integration to segregation, patterns in the south are less linear. During slavery, blacks lived in quarters on plantations adjacent to the homes of their owners. As a result, the levels of segregation were very low, albeit there were vast differences in the living conditions. At the end of slavery, many blacks became sharecroppers and continued to live on the plantations on which they had been enslaved. As the desire for independence grew, the tenant system was developed, in which the plantation was partitioned into smaller farm units. Blacks built dwellings on their parcels of land, so that many blacks lived quite a distance from the main home. This resulted in a pattern of resettlement, with blacks being dispersed into more rural areas (Aiken, 1985).

The settlement patterns of blacks began to change around 1950 (Aiken, 1985), when blacks began to move closer to cities and towns. This move marks the beginning of present day segregation in many southern “micropolitans,” including cities in North Carolina. Blacks began to move out of rural areas into small towns and into new hamlets. Aiken (1985) defines a hamlet as:

  a group of five or more houses … owned by blacks. Within a single hamlet may be shacks modeled after tenant houses, mobile homes, Jim Walter-type shell houses, and neat brick-veneered houses with garages. Dwelling usually are close to the road, and on a lot behind the main structure may be one or two others occupied by family members” (p. 394).

Segregation in the south, and particularly in North Carolina, arose out of a systematic process of “underbounding” whereby local governments annexed areas outside of their cities which received municipal services, and other areas, particularly black neighborhoods, were left unannexed. These non-annexed areas are politically termed “Extraterritorial Jurisdictions” (ETJ). According to Parnell et al. (2004),
ETJ was created as an area outside of a town’s boundaries over which the town has complete land-use, permitting and zoning control. The rationale for an ETJ is that it is a mechanism for rational planning for growth. Residents of an ETJ have no elected representative in the town government that makes decisions regarding their property. Further, there is no mechanism that limits the duration that an area can stay within an ETJ before annexation occurs, allowing some towns to keep “less desirable” neighborhoods in their ETJ in potential perpetuity (p. 5-6).

ETJs exist in present-day NC. ETJs limit residents’ access to municipal resources, including sanitation services and water. There is also evidence that municipalities locate landfills and waste facilities in ETJs. According to Parnell (2004), “[North Carolina’s] laws give towns the discretion to annex only properties with high tax values, even non-contiguous properties, resulting in discontinuous boundaries that skip over poor and black neighborhoods” (p. 5-6). These communities are inherently segregated by race/ethnicity, but also become economically segregated based on race due to these measures. Communities disenfranchised in this manner may suffer the same neighborhood and segregation effects as metropolitan areas because they are suffering the economic effects of disinvestment and the social effects of isolation in their communities.

2. Segregation and Preterm Birth

In the United States, inequities in social context have their roots in a history of racism and segregation (Massey & Denton, 1993). Segregation influences social and economic resources available in communities, and distributes them by race (Thomas A. LaVeist & Wallace, 2002; Morland et al., 2002; David R. Williams & Collins, 2002). Since many inequities are propagated through systemic segregation (Jones, 2000; T. A. Laveist, 1993; Massey & Denton, 1993; David R. Williams & Collins, 2002), analysis of risk factors for
preterm birth and how they might contribute to racial/ethnic disparities in preterm birth should include contextualization by racism, measured by segregation, as segregation is a result of institutionalized racism (Jones, 2000; David R. Williams & Collins, 2002).

Many individual maternal risk factors, including smoking, lack of prenatal care, socioeconomic status, advanced maternal age, psychosocial stress, incompetent cervix, hypertension, diabetes, and being unmarried (Bennett, Braveman, Egerter, & Kiely, 1994; Geronimus, 1992; Healy et al., 2006; Hillemeier, Weisman, Chase, & Dyer, 2007; Miller, Hassanein, & Hensleigh, 1978; Sandman et al., 1997; Vintzileos et al., 2002; Wadhwa, Dunkel-Schetter, Chicz-DeMet, Porto, & Sandman, 1996), have been linked to poor birth outcomes. Linking maternal risk factors to social conditioning of segregation will let us determine whether these risk factors occur more frequently in high or low segregated areas. For instance, smoking has been found to be associated with segregation and inequalities (Barnett, 2000; Bell et al., 2007; Shohaimi et al., 2003). Addressing segregation and inequalities and its impact on smoking may reduce the burden of smoking on health.

Figure 1.2 is a conceptual framework demonstrating how segregation may influence the risk of preterm birth through its effect of disinvestment in black communities, and the subsequent effect of its impact on health and health behaviors. We believe that there is a multidimensional effect of segregation on the health of black and white women in segregated areas that places them at increased risk of having preterm deliveries. Segregation is a population-level effect; therefore, in the absence of buffers, its effect is experienced by everyone exposed to that level of segregation, regardless of race/ethnicity. Segregation has been linked to the unequal distribution of food and educational resources, location of employment opportunities and unequal distribution of resources in communities (Thomas A.
LaVeist & Wallace, 2002; Massey & Denton, 1993; Morland et al., 2002). It is these effects of segregation that more directly influence health through the lack of knowledge of health care practices, poor access to care, lack of health insurance, and lack of resources to support a healthy lifestyle (Massey & Denton, 1993). The unequal distribution of educational resources leads to poor health and health behaviors, which include but are not limited to smoking, alcohol use, and late or no prenatal care. The unequal location of employment opportunities and unequal distribution of educational resources both directly influence access to care. Concentrated poverty results in a lack of money for healthy lifestyles. Both poor access to health care and concentrated poverty can result in poor health and health behaviors, including late or no prenatal care, incompetent cervix, diabetes and hypertension. All of these poor health outcomes and health behaviors have been linked to preterm birth.

Several researchers have examined segregation’s effects in metropolitan areas using Metropolitan Statistical Areas (MSAs) as the unit of analysis (Bell et al., 2006; M. R. Kramer & Hogue, 2008; Polednak, 1991). The MSAs studied are mostly in the north and northwestern parts of the U.S. and have a history of in-migration from the south. Racist housing policies regulated where blacks could live, and restricted their home ownership. The history of segregation in these areas has been well documented (Massey & Denton, 1993; McGrew, 1997), and the segregation that exists is very visible. Less densely populated areas, such as micropolitans (cities with populations between 10,000-50,000), and cities in the south have only recently been included in segregation research (Herrick, 1996; S. M. Mason et al., 2009).

The purpose of this research is to determine whether the prevalence of proximal PTB risk factors differs by RRS, race/ethnicity and maternal education in a southern U.S. State.
This research will apply a spatial measure of segregation in NC to empirically assess how prevalence of risk factors varies at different levels of segregation. Further, we will test the conceptual model, which hypothesizes that macro-social factors are associated with individual health.

C. DATA AND METHODS

This cross-sectional analysis uses data from the 2004 North Carolina composite matched birth files, produced annually by the NC State Center for Health Statistics (SCHS), and the 2000 U.S. Census. The matched file contains 119,773 birth records from Health Department files, Medicaid files and birth certificates. Eighty-nine percent (89%) of the birth files were geocoded to the block group level by the SCHS, using ESRI ArcGIS 9.0 and TeleAtlas Multinet (roads database) 2005. Population counts of blacks and whites from the 2000 North Carolina Census block group shapefile were used to calculate Wong’s local spatial segregation index for each block group in North Carolina (n=5,263).

1. Record Inclusion

Records were included in the analyses if they gave birth to singletons; were white, non-Hispanic or black, non-Hispanic; delivered and reside in North Carolina in 2004; have data for gestational age or last menstrual period; have education data reported; have completed greater than 20 weeks gestation; are not missing covariate data; have block group geocoded data; and were born without birth defects. We omitted births occurring in block groups where there are no black residents because we are interested in segregation of blacks from whites. Analyses included 83,439 subjects and 5,118 block groups.
2. Exposure definition

Wong’s Local Spatial Segregation Index ($S_i$) measures the potential for interaction between two racial/ethnic groups, taking into account the spatial distribution of members of the group in the index and neighboring units (Wong, 2002). For example, a black person living in census block group A has $x$ probability of interacting with a white person in block group A, $y$ probability of interacting with a white person of block group B, and so on.

Wong’s index allows the potential for interaction to be weighted by either the adjacency of block group B to A (yes=1, no=0), or the distance of block group B from A (distance-decay function). In this analysis, the potential for interaction is weighted using a distance-decay function, $c_{ij}$, calculated as the inverse distance weight ($1/$distance between block group centroids) for block groups that adjoin the index block group. Within the context of measuring racial/ethnic disparities, we are interested in the health effects of living in a highly segregated neighborhood that is composed mostly of black residents, calculated by equation 1 below. In order to show potential interaction of blacks with whites only, $S_i$ was calculated

$$S_i = 1 - \frac{(b_i \sum_j c_{ij} a_j)}{(b_i \sum_j a_j)} \quad \text{(equation 1)}$$

where $a_i$ and $b_i$ are the population counts of whites and blacks, respectively, within census block group i; $c_{ij}$ is equal to the inverse distance weight ($1/$distance between block group centroids) for block groups that are neighbors of the index block group. A block group was considered a neighbor if its centroid-distance was within 8.25 miles of the index block group centroid. The 8.25 mile threshold was statistically determined using a Python script (Butler, 2005), which indicates the distance at which the correlation in percent white between block groups becomes zero. Since groups $a_i$ and $b_i$ can also interact with each other within the
index census block group, i can be equal to j. \( S_i \) ranges from 0 to 1, with 0 indicating complete integration, and 1, complete segregation. Segregation measures for study data ranged from 0.21-0.99.

Segregation cut-points were determined by creating quartiles of the segregation values across Census block groups using Proc Rank in SAS 9.1.2. Quartile values were 0.21-0.83 for low segregation, 0.83-0.88 for medium segregation, 0.88-0.92 for high segregation, and 0.92-0.99 for very high segregation.

3. Operationalization of exposures

Information for the exposure variables was abstracted from the birth certificates. Socioeconomic status was operationalized using the mother’s level of education. Categories of education were used to show births occurring to mothers younger than 18 years of age who had not had the opportunity to complete high school, as well as mothers who were older than 18 who also had not completed high school. To account for possible delays in graduation due to retention (students being held back in school and, therefore, graduating after age 18), categories for those completing less than high school were split at 20 years of age. Maternal education categories were “1”= <20 years old and < high school, “2”= ≥20 years old and < high school, “3”= high school or equivalent, and “4”= > high school.

Hypertension is defined as having a systolic pressure ≥140 mm Hg and/or a diastolic pressure above 90 mm Hg. Pregnancy-induced hypertension (PIH) is defined as hypertension occurring during pregnancy. Tobacco use is defined as smoking at least one cigarette per day during pregnancy. Hypertension, PIH and tobacco use were all coded as “0”=No, “1”=Yes. Timing of entry into prenatal care is defined as the trimester during which the initial prenatal care (PNC) visit occurred. PNC timing was categorized as 0=none
or late (third trimester), “1”=first trimester and “2”=second trimester. The age of the mother at time of delivery was coded as a categorical variable with age categories “1”=12-14, “2”=15-19, “3”=20-29, “4”=30-34, “5”=35-39, and “6”=40-52. Additional independent variables included in analyses were marital status, diabetes mellitus, and incompetent cervix, also coded as “0”=No, “1”=Yes, and abstracted from birth certificates.

The prevalence and 95% confidence intervals were calculated for each risk factor. Prevalence was stratified by level of segregation, socioeconomic status and race/ethnicity. This method allows us to examine whether there is a disparity in prevalence of sociodemographic, medical and behavioral risk factors that predict preterm birth across levels of segregation. Stratifying by race/ethnicity and SES allows us to examine possible interaction effects in prevalence across levels of segregation. All analyses were completed using SAS v. 9.1.2.

D. RESULTS

Table 2.1 displays the prevalence and 95% confidence intervals (CI) for risk factors for all NC birth mothers by segregation level. Nearly 34% of women giving birth in North Carolina in 2004 lived in highly segregated block groups. Both black and white women living in highly and very highly segregated areas had higher prevalence of risk factors than did women in less segregated areas. Women in highly segregated areas were more likely to be unmarried, to give birth at younger ages, to be Medicaid eligible (low income), to receive no or late prenatal care, and to smoke during pregnancy. There were no differences in the prevalence of hypertension, diabetes or incompetent cervix across segregation levels.

Table 2.2 provides the prevalence of maternal risk factors across segregation and education levels. For several risk factors, including young maternal age (12-14), Medicaid
eligibility, marital status, lack of prenatal care, and chronic hypertension, prevalence increased as segregation increased. Prevalence also increased across each respective educational level as segregation levels increased, indicating a possible interaction between education and segregation, although this was not directly tested in this study. Tobacco use was the only risk factor with decreasing prevalence as segregation levels increased. There were increases in prevalence of chronic hypertension and diabetes among women more than 20 years old, with and without a high school diploma, for all segregation areas. There were no differences in prevalence of hypertension, diabetes or incompetent cervix by segregation levels.

Table 2.3 displays the racial/ethnic distribution of maternal risk factors by level of segregation. The total study population was 27% Black and 73% White. More than 36% of blacks lived in very highly segregated areas, compared to nearly 8% of whites. Blacks had higher prevalence of most risk factors, with greater prevalence for both whites and blacks living in very highly segregated areas compared to less segregated areas. Prevalence of birth to women with less than a high school education was higher among blacks; however the prevalence increased for both whites and blacks with increasing segregation. The same pattern was seen for women of young maternal age (12-19 years old), unmarried women, those receiving late/no prenatal care, and women using tobacco during pregnancy. The proportion of married women decreased for both racial/ethnic groups as segregation levels increased. Though the confidence intervals overlap, the proportion of black women with chronic hypertension decreased as segregation levels increased.
E. DISCUSSION

The results of this study indicate that there is an association between segregation and prevalence of some maternal risk factors for preterm birth. At higher levels of segregation, there was higher prevalence of births to black and white women who were unmarried, had low education, gave birth at young maternal ages, were Medicaid eligible, and received late/no prenatal care. There was a greater prevalence of most risk factors among both black and white women in highly racially segregated areas than in less segregated areas. The stratum of low education and high segregation also yielded a greater prevalence of the behavioral risk factors. The findings of this study provide empirical support for theories of the effects of contextual factors like segregation on risk factors for poor birth outcomes (Abdel-Latif et al., 2006; Acevedo-Garcia et al., 2003; Baker & Hellerstedt, 2006; Bell et al., 2006; Diez Roux, 2003; Gorman, 1999; Grady, 2006; V. K. Hogan & Ferre, 2001; Jacobs, 1979; M. R. Kramer et al., 2010; T. A. Laveist, 1993; S. M. Mason et al., 2009; Massey & Denton, 1993; Messer, Kaufman, Dole, Savitz et al., 2006; Reagan & Salsberry, 2005; Subramanian, Acevedo-Garcia et al., 2005; White & Borrell, 2011; David R. Williams & Collins, 2002).

Higher prevalence of risk factors in more highly segregated areas may suggest that these factors are mediators of the segregation-preterm birth relationship. Grady & Ramirez (2008) found that the segregation-LBW association was partially mediated by chronic hypertension and pregnancy-induced hypertension (PIH) for black women. Conversely, in this study, the prevalence of chronic hypertension, PIH, and diabetes was highest at medium levels of segregation and decreased as segregation levels increased for black women. This study also provides empirical evidence that segregation is associated with prevalence of individual-level factors that are routinely controlled for in epidemiologic studies of preterm...
birth. To determine the mechanism for segregation’s effect on preterm birth, we cannot merely adjust for individual factors but must examine how segregation structures those factors, for the individual factors may also be mediators of the segregation-PTB relationship. Differences in individual risk factors between black and white women may contribute to increased risk of preterm birth among black women, and may help explain the disparity.

This research provides empirical evidence of the association between context and health. According to Williams and Collins (2002), segregation affects health through lack of health care facilities, lack of goods and services beneficial to health, and the perpetuation of poor health behaviors within highly segregated communities. This research lends empirical support to this theory, showing higher rates of poor health behaviors among those in highly segregated areas, such as women receiving late/no PNC, young age at childbearing, and being unmarried. Efforts to reduce disparities may be improved with interventions that address the social contexts in which these behavioral factors exist, as many researchers have suggested that addressing biological factors alone will not eliminate disparities (Collins & Hawkes, 1997; V.K. Hogan, 2004; Moultrie, 2007; Rowley, 2001; David R. Williams & Collins, 2002).

1. Study Limitations

Accuracy of North Carolina birth certificate data varies depending on the type of data (Buescher, Taylor, Davis, & Bowling, 1993). Buescher et al. found higher levels of accuracy for prenatal care indicators for North Carolina birth certificates than for national studies; however, medical history and risk factor data were poor (Buescher et al., 1993; Clark, Fu, & Burnett, 1997). Vinikoor et al. (2010) found high agreement for maternal demographic and birth outcome data on the birth certificate when compared to cohort birth data. They found
moderate agreement for most medical risk data and behavioral risk data, including tobacco use and pregnancy-induced hypertension (Vinikoor, Messer, Laraia, & Kaufman, 2010). According to birth certificate data, 15% of the women who gave birth in 2004 reported using tobacco. This proportion is similar to that reported by the Pregnancy Risk Assessment Monitoring System, which showed 14.8% of women smoking during the last three months of pregnancy in 2004 (North Carolina State Center for Health Statistics, 2004). There was much less agreement between birth certificate and medical records data for medical history factors. This may, in part, explain the weaker association of segregation with chronic hypertension, PIH and diabetes; therefore, these data should be interpreted with caution.

Prenatal care data from the birth certificate is less valid when using month PNC began (Buescher et al., 1993), so coding for trimesters provides higher accuracy of prenatal care data for this analysis. More studies are needed with more accurate data to determine whether there are differences in prevalence for these risk factors across segregation levels.

There are no data to determine how long an individual has lived in a particular block group, or how long she may have been exposed to a particular level of segregation. Therefore, we assume the women have been sufficiently exposed to their respective levels of segregation for the time necessary for it to affect their birth outcomes. Researchers have suggested that blacks are less likely to move to desegregated areas due to political and structural inequities, such as local zoning practices, land use regulations and experiences of discrimination (Rossi & Schlay, 1982). Furthermore, there may be sociocultural, individual-level influences among poor blacks driving such decisions (Bembry & Norris, 2005). In their study of 150 families comparing the types of neighborhoods that African-American subjects moved into, Bembry and Norris (2005) found that nearly 3.5 times as many families (47.6%)
moved to mostly African-American neighborhoods when unassisted in their housing search, compared to those who received assistance (13.8%). Although the authors attribute this difference to family poverty, it is plausible that these same mobility decisions are affected by the segregation levels of the neighborhoods one is accustomed to living in.

Geographic Information Systems are being used more often to understand how neighborhoods and geography are associated with health. Geocoding is limited, however, by the accuracy of the databases available to geocode the data. There may be errors in the addresses on the birth certificates, for example, ZIP codes or street directions that may cause addresses to be geocoded to the incorrect block group, resulting in errors in the segregation index assigned to them. There is also an urban/rural bias in geocoding, such that there are more matches in urban areas because addresses and database information are more accurate in urban than in rural areas. As rural counties embrace GIS technologies, matching is expected to improve.

This study did not directly examine stress as a risk factor due to lack of data. Chronic stress affects the immune and cardiovascular reactivity, increasing susceptibility to bacterial vaginosis, hypertension and other cardiovascular diseases (Juster, McEwen, & Lupien, 2010; McEwen, 2008; Sandman et al., 1997; Seeman et al., 2010; Wadhwa et al., 1996). Future research should examine the role of stress as a potential mediator.

2. Study Strengths
A strength of this study is the use of racial residential segregation as a measure of contextual effect. It is a logical factor to examine the contextual differences between blacks and whites. Racial residential segregation is also a good proxy for measuring racism. Following the conceptual model for this research, RRS arose out of a history of racial
prejudice and racist housing policies that led to residential segregation. One of the limitations of previous research on social influences on health has been the reliance on self-reported measures of racism. For example, the examination of racial discrimination to document the effect of psychosocial stress on health outcomes has relied on self-reported measures of racial discrimination (Davis et al., 2005; Din-Dzietham et al., 2004). Relying on self-reports may underestimate the prevalence of the exposure because participants may not recognize that they are exposed. For example, one may be exposed to the result of institutional forms of discrimination, such as segregation, but not recognize it as such because it has been experienced all of one’s life. Without having a critical analysis of how politics and history have contributed to the present social condition, one may not be able to name one’s experiences as racism. Justification for examining segregation as a contributor to disparities in preterm birth include its disproportionate prevalence among blacks, and its influence on community resources and access to services (T. A. Laveist, 1993; Thomas A. LaVeist & Wallace, 2002; Massey & Denton, 1993; Morland et al., 2002; David R. Williams & Collins, 2002). The use of segregation to empirically assess the effect of racism on health outcomes contributes to the literature on the effects of discrimination and place on health.
Figure 2.1. Conceptual Framework of the multidimensional effect of segregation on the health of blacks in segregated areas
Table 2.1. Prevalence and 95% confidence intervals for risk factors by segregation level, North Carolina, 2004.

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Total (%)</th>
<th>Low Segregation</th>
<th>Medium Segregation</th>
<th>High Segregation</th>
<th>Very High Segregation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=83439</td>
<td>n=34976 (41.9%)</td>
<td>N=19956 (23.9%)</td>
<td>N=15524 (18.6%)</td>
<td>N=12983 (15.6%)</td>
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<tr>
<td><strong>Education</strong></td>
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<tr>
<td>&lt;HS, &lt;20 years</td>
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<tr>
<td></td>
<td>6.3 (6.2, 6.5)</td>
<td>3.8 (3.6, 4.0)</td>
<td>6.0 (5.7, 6.4)</td>
<td>7.9 (7.5, 8.3)</td>
<td>11.9 (11.3, 12.4)</td>
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<tr>
<td>&lt;HS, &gt;=20 years</td>
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<td></td>
<td>8.9 (8.7, 9.1)</td>
<td>5.6 (5.4, 5.9)</td>
<td>9.1 (8.7, 9.5)</td>
<td>10.1 (9.6, 10.5)</td>
<td>15.9 (15.3, 16.5)</td>
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<tr>
<td>High School or equivalent</td>
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<td></td>
<td>29.7 (29.4, 30.0)</td>
<td>24.1 (23.6, 24.5)</td>
<td>32.2 (31.5, 32.8)</td>
<td>33.7 (32.9, 34.4)</td>
<td>36.4 (35.5, 37.2)</td>
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<tr>
<td>More than HS</td>
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<td></td>
<td>55.0 (54.7, 55.4)</td>
<td>66.5 (66.0, 67.0)</td>
<td>52.6 (51.9, 53.3)</td>
<td>48.3 (47.6, 49.1)</td>
<td>35.9 (35.1, 36.7)</td>
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<td><strong>Medicaid</strong></td>
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<td></td>
<td>40.9 (40.5, 41.2)</td>
<td>27.6 (27.1, 28.1)</td>
<td>41.3 (40.7, 42.0)</td>
<td>49.0 (48.2, 49.7)</td>
<td>66.2 (65.4, 67.0)</td>
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<tr>
<td>Not Eligible</td>
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<td></td>
<td>59.1 (58.8, 59.5)</td>
<td>72.4 (71.9, 72.9)</td>
<td>58.7 (58.0, 59.3)</td>
<td>51.1 (50.3, 51.8)</td>
<td>33.8 (32.9, 34.6)</td>
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<td><strong>Maternal Age</strong></td>
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<td>12-14</td>
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<td></td>
<td>0.2 (0.18, 0.24)</td>
<td>0.1 (0.08, 0.15)</td>
<td>0.1 (0.08, 0.19)</td>
<td>0.3 (0.19, 0.36)</td>
<td>0.5 (0.37, 0.61)</td>
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<td>15-19</td>
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<td>10.8 (10.6, 11.0)</td>
<td>7.1 (6.8, 7.3)</td>
<td>10.8 (10.3, 11.2)</td>
<td>13.1 (12.6, 13.7)</td>
<td>18.0 (17.3, 18.7)</td>
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<td>20-29</td>
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<td>52.6 (52.3, 52.9)</td>
<td>47.8 (47.3, 48.3)</td>
<td>55.1 (54.4, 55.8)</td>
<td>55.3 (54.6, 56.1)</td>
<td>58.3 (57.5, 59.2)</td>
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<td>30-34</td>
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<td>23.7 (23.4, 24.0)</td>
<td>29.0 (28.5, 29.4)</td>
<td>22.5 (22.0, 23.1)</td>
<td>20.5 (19.8, 21.1)</td>
<td>15.2 (14.6, 15.8)</td>
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<td>10.7 (10.4, 10.9)</td>
<td>13.6 (13.2, 14.0)</td>
<td>9.0 (9.1, 9.9)</td>
<td>9.0 (8.5, 9.4)</td>
<td>6.5 (6.0, 6.9)</td>
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<td>40-52</td>
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<td>2.1 (2.0, 2.2)</td>
<td>2.5 (2.3, 2.7)</td>
<td>1.9 (1.7, 2.1)</td>
<td>1.8 (1.6, 2.0)</td>
<td>1.5 (1.3, 1.7)</td>
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<td>33.8 (33.5, 34.2)</td>
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<td>39.1 (38.3, 39.9)</td>
<td>62.3 (61.5, 63.1)</td>
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<td>66.2 (65.8, 66.5)</td>
<td>77.7 (77.2, 78.1)</td>
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<td>60.9 (60.1, 61.7)</td>
<td>37.7 (36.9, 38.5)</td>
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<td><strong>Trimester prenatal care began</strong></td>
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<td>None/Late</td>
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*Low Segregation 0.21-0.83, Medium Segregation 0.83-0.88, High Segregation 0.88-0.92, Very High Segregation 0.92-0.99*
Table 2.2. Prevalence (95%CI) of maternal risk factors for preterm birth by level of racial residential segregation and education1.

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Low Segregation 0.21-0.83, Medium Segregation 0.83-0.88, High Segregation 0.88-0.92, Very High Segregation 0.92-0.99
Table 2.3. Racial/ethnic distribution of maternal risk factors for preterm birth by segregation level, North Carolina, 2004

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<td>40-52</td>
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\*Low Segregation 0.21-0.83, Medium Segregation 0.83-0.88, High Segregation 0.88-0.92, Very High Segregation 0.92-0.99
REFERENCES


the Norfolk cohort of the European Investigation into Cancer (EPIC-Norfolk). *J Epidemiol Community Health, 57*, 270-276.


CHAPTER 3: RACIAL RESIDENTIAL SEGREGATION, SOCIOECONOMIC STATUS, AND PRETERM BIRTH IN BLACK AND WHITE WOMEN IN NORTH CAROLINA

A. INTRODUCTION

There is a persistent racial/ethnic disparity in preterm birth, and research into causes of the disparity has not provided a full explanation of its etiology. In the U.S., black mothers are nearly twice as likely to deliver preterm as white mothers, and preterm delivery is the leading cause of perinatal mortality (MacDorman & Mathews, 2008; Simmons, Rubens, Darmstadt, & Gravett, 2010). In an effort to explain the cause of the disparity, studies have examined individual-level medical and social risk factors including smoking during pregnancy, prenatal care, and socioeconomic status (Healy et al., 2006; Heaman et al., 2005; Hillemeier et al., 2007; Leslie, Galvin, Diehl, Bennett, & Buescher, 2003; Savitz et al., 2004); however these studies have not yielded a complete understanding of the etiology of preterm birth, or a full explanation for the persistent racial/ethnic disparity. More researchers are now examining contextual effects such as racial residential segregation and neighborhood-level socioeconomic status to explain the disparity (Barnett, 2000; Bell et al., 2006; Grady, 2006; Herrick, 1996; P. J. Johnson, Oakes, & Anderton, 2008; M. R. Kramer et al., 2010; S. Mason, Messer, Laraia, & Mendola, 2008; Messer, Kaufman, Dole, Savitz et al., 2006; O’Campo et al., 2008; Sims & Rainge, 2002; Subramanian, Chen et al., 2005). This approach has promise, because it takes into account the effect of place on the health of individuals.
The spatial separation of population groups by race/ethnicity (segregation) is an important phenomenon in the U.S., as it has been shown to structure opportunity and predict the distribution of resources in communities (Barnett, 2000; Blumenshine et al., 2010; M. S. Kramer et al., 2000; T. A. Laveist, 1993; Link & Phelan, 1995; Shohaimi et al., 2003; Sparks, 2009). For instance, researchers have demonstrated that contextual factors produce differences in access to resources such as health care and healthy food options; increased exposure to health risks; and differences in built environment (T. A. Laveist, 1993; Thomas A. LaVeist & Wallace, 2002; Mohai, Lantz, Morenoff, House, & Mero, 2009; Morland et al., 2002; David R. Williams & Collins, 2002). There are also differences in the quality of education, employment opportunities and income, which influence a person’s ability to access health care and maintain a healthy lifestyle (Massey & Denton, 1993; David R. Williams & Collins, 2002). Segregation has also been associated with an increased risk for adverse birth outcomes, as well as racial/ethnic disparities in these outcomes (Bell et al., 2006; Mary O. Hearst, Oaks, & Johnson, 2008; M. R. Kramer et al., 2010; M. R. Kramer & Hogue, 2008; S. M. Mason et al., 2009).

Link and Phelan (1995) argue that socioeconomic status (SES) is a fundamental cause of disease because it predicts the distribution of resources, and continues to have an association with poor health outcomes even after more proximal risk factors are intervened upon. Socioeconomic status, measured individually or contextually, is inversely associated with poor birth outcomes (Luo et al., 2006; Parker, Schoendorf, & Kiely, 1994; Pickett et al., 2002; Ward, Mori, Patrick, Madsen, & Cisler, 2010). Although segregation is associated with individual and neighborhood SES, it is possible that differences in SES within
The purpose of this research is to determine whether segregation has a differential effect on preterm birth by socioeconomic status. We hypothesize that less segregated areas may protect against preterm birth for those with low education; and highly segregated areas may supersede the effects of maternal education to predict preterm birth, even among women with high education, due to the distribution of resources and neighborhood factors associated with segregation.

B. BACKGROUND

1. Racial Residential Segregation

Racial residential segregation is defined as the degree to which racial groups live separated from one another in the urban environment (Grady, 2006). Racial residential segregation is deeply rooted in the history of racial prejudice in the U.S. It is the result of decades of racist policies and practices that have systematically denied blacks the opportunity to purchase homes in white, non-impoverished neighborhoods, thereby denying them the ability to choose their neighborhoods or accumulate wealth. Measuring racial residential segregation provides a systematic way to capture the effect of race and institutional racism on preterm birth and other health outcomes (Cooper et al., 2001). One of the limitations of previous research examining the effect of segregation on health has been the reliance on self-reported measures of these influences, as in studies of racial discrimination and health outcomes (Davis et al., 2005; Din-Dzietham et al., 2004). Relying on self-reports may underestimate the prevalence of the exposure because participants may not recognize that they are exposed. For example, one may be exposed to the result of institutional forms of
discrimination (e.g. segregation), but not recognize it as such because it has been experienced all of one’s life. Without a critical analysis of how politics and history have contributed to segregation, one may not be able to name one’s experiences as racism.

Several researchers have found an association between racial residential segregation and health. For example, segregation has been linked to poor preconceptional health, low birth weight, preterm birth and infant mortality (Baker & Hellerstedt, 2006; Bell et al., 2006; Grady, 2006; Mary O. Hearst et al., 2008; Kershaw et al., 2011; M. R. Kramer et al., 2010; T. A. Laveist, 1993; S. M. Mason et al., 2011; S. M. Mason et al., 2009; Mobley et al., 2006; Polednak, 1996a; Subramanian, Acevedo-Garcia et al., 2005; White & Borrell, 2011; David R. Williams & Collins, 2002). Bell et al. (2006) found specifically that high segregation (isolation) was associated with preterm birth and low birth weight. Segregation may act to concentrate behaviors and neighborhood characteristics that are detrimental to the health of women and their babies (Grady, 2006; Massey & Denton, 1993).

Massey and Denton (1993) identify five dimensions of racial residential segregation: evenness, centralization, concentration, clustering, and isolation. Evenness is the degree to which blacks are overrepresented or underrepresented in neighborhoods relative to the overall proportion of blacks in the city. Centralization is the degree to which blacks live in the urban core, or center of the city. Concentration is the degree to which blacks occupy a smaller space than whites. Clustering is the degree to which minority residential areas are contiguous. Isolation (also referred to as exposure) is the degree to which black residential areas are scattered across an area. The dimension of racial residential segregation one uses can have implications on the interpretation of the effects of segregation on preterm birth. It is important to consider that the mechanism by which segregation affects preterm birth may
be different depending on the dimension being used to represent segregation. For example, Bell (2006) found that isolation segregation was associated with an increase in rates of low birth weight and preterm birth, while clustering was protective for these outcomes. Isolation connoted separation of residents from resources protective for health, while clustering connoted social support derived from social networks. Likewise, several studies have found adverse health effects associated with isolation (Grady, 2006; Guest, Almgren, & Hussey, 1998; Subramanian, Acevedo-Garcia et al., 2005).

This study will focus on the isolation dimension. The isolation dimension of segregation (hereafter, segregation) implies that women living in these areas are deprived of access to resources that may be beneficial for health. If women are isolated from educational and health care resources, employment opportunities, and locations to obtain fresh fruits and vegetables, for example, they may experience poorer health. Segregation has been shown to be associated with low birth weight and preterm birth (Bell et al., 2006), which may be linked through a myriad of behavioral, social and medical pathways. White and Borrell (2011) suggest that segregation affects health by influencing physical, economic, and social neighborhood environments, and by shaping health behaviors. Differential exposure to neighborhood stressors such as lower quality housing, disadvantaged neighborhood environment, lack of access to economic and educational opportunity structures, and concentration of poverty can affect health by shaping the socioeconomic attainment of racial/ethnic groups within segregated areas (Acevedo-Garcia et al., 2003; Schulz, Williams, Israel, & Lempert, 2002; White & Borrell, 2011; David R. Williams & Collins, 2002). Figure 3.2 is the conceptual model of how segregation may impact intermediary behavioral, medical and social factors to impact preterm birth risk.
2. Socioeconomic Status

Krieger (2001) describes socioeconomic status as a “prestige-based measure of socioeconomic position, as determined by rankings in a social hierarchy, privileging status over material resources as the key determinant of socioeconomic position” (p. 697). Following Krieger, maternal education is conceptualized in this analysis as a prestige-based measure of SES. Socioeconomic position can affect in which neighborhoods people live (Krieger, 2001). In other words, where people live is not always a matter of choice, but it may be influenced by their income or wealth. For example, having less income restricts residential options to lower income neighborhoods, and all of the associated maladies.

Socioeconomic status (SES) has been studied as both a contextual and individual-level factor affecting health status. Measurement of socioeconomic status varies by study. It has been measured as individual income, neighborhood income, and education, and has been shown to be associated with preterm birth, as documented by a number of studies (Ahern et al., 2003; Goza, Stockwell, & Balistreri, 2007; M. S. Kramer et al., 2000; Pickett et al., 2002; Sparks, 2009; Ward et al., 2010). Prior studies have found that segregation and socioeconomic status are each independently associated with birth outcomes, including low birth weight and preterm birth (Collins et al., 2007; Goza et al., 2007; Grady, 2006; S. Mason et al., 2008). For example, Parker et al. (1994) found that low SES was independently associated with an increased risk of preterm birth among all women, with a higher risk among blacks compared to whites.

Trends in infant mortality and preterm birth follow a gradient across levels of education. Table 3.1 details the educational attainment levels for black and white non-Hispanic women who gave birth in the U.S. (Martin et al., 2006) and North Carolina in 2004.
In the U.S. and North Carolina, a greater proportion of black women than of white women who gave birth had less than a high school education, and nearly three times as many white women as black women had at least four years of college (Martin et al., 2006) (NC results from data analyses).

Levels of preterm birth and infant mortality decrease as income and education increase. Within racial/ethnic groups, the same trend exists; however the magnitude of the trend varies. Although infant mortality rates are lowest at the highest levels of education within each racial/ethnic group, the infant mortality rates for black women at the highest education levels are higher than for white women at the lowest education levels (Mathews & MacDorman, 2006). Figure 3.1 illustrates the infant mortality rates across educational levels for blacks, whites (both Hispanic and non-Hispanic) and all races in 2004 (adapted from 2006 NVSR) (Mathews & MacDorman, 2006). Given the predictive relationship between preterm birth and infant mortality, it is expected that preterm birth rates follow the same trend by education level across racial/ethnic groups.
Nearly all studies of the association between segregation and birth outcomes adjust for SES, but only one was found that examined how SES and segregation may act jointly to affect the risk of low birth weight. SES, measured as neighborhood poverty, was found to have little impact on the effect of residential segregation on low birth weight (Grady, 2006). Some researchers posit that the complex intertwining of racial residential segregation and socioeconomic disadvantage inhibits the disentangling of their individual effects (Mary O. Hearst et al., 2008). One reason is that some researchers characterize SES as a mediator on the pathway between segregation and health outcome; however, White and Borrell (2011) contend that adjusting for SES in segregation analyses could underestimate the effect of segregation because SES may be on the causal pathway (White & Borrell, 2011). Although research has shown that segregation predicts SES through employment and educational opportunities, some racially segregated neighborhoods are more affluent than others. Further, segregation may have a differential effect on preterm birth depending on
neighborhood characteristics and maternal characteristics (Bell et al., 2006; Collins & David, 1990; Grady, 2006).

Neighborhood make-ups that vary by levels of segregation and SES may differentially affect the risk of preterm birth. Some blacks may continue to live in racially segregated areas to benefit from established familial and social support networks and to escape racial discrimination, regardless of increases in income over time. Although they benefit from having higher SES, the neighborhood effects may attenuate these benefits. Ahern et al. (2003) found that neighborhood unemployment and change in the proportion of African-American residents modified the effect of socioeconomic status on the risk of preterm birth. In another study, O’Campo, Xue, Wang, and Caughy (1997) found that neighborhood level risk factors moderated the effect of SES on low birth weight. Grady (2006) found that segregation and neighborhood poverty operated at different scales to increase the risk of low birth weight. In her study, she found that poverty had little impact on the effect of segregation at the neighborhood scale. Additionally, segregation did not negate the effect of individual income status on low birth weight. These inconsistent results warrant further studies of how SES and segregation work jointly to affect preterm birth.

Because of the independent effects of segregation and SES on health outcomes, merely controlling for one in the analysis of the other may conceal that one may moderate the effect of the other (Messer, Oakes, & Mason, 2010). Given the independent effects of SES and segregation on birth outcomes, inconsistencies in studies of their joint effect, and their potential contribution to disparities, we wondered whether joint exposure increases women’s risk for preterm birth in North Carolina. In this study, we examine the moderating effect of
education on the association between segregation and preterm birth for black and white women. Our hypotheses are:

1). PTB proportions for black women will increase as segregation increases and education decreases.

2). White women will have higher preterm birth rates in highly segregated areas than in less segregated areas.

3). Education will moderate the effect of segregation on the risk of PTB.

C. DATA AND METHODS

This cross-sectional analysis uses data from the 2004 North Carolina composite matched birth files, produced annually by the NC State Center for Health Statistics (SCHS), and the 2000 U.S. Census. The matched file contains data from Health Department files, Medicaid files and birth certificates. The data file contains 119,773 birth records. Eighty-nine percent (89%) of the birth files were geocoded to the block group level by the SCHS, using ESRI ArcGIS 9.0 and TeleAtlas Multinet (roads database) 2005. Population counts of blacks and whites from the 2000 North Carolina Census block group shapefile were used to calculate Wong’s local spatial segregation index for each block group in North Carolina (n=5,263).

1. Record Inclusion

Records were included in the analyses if they gave birth to singletons; were white, non-Hispanic or black, non-Hispanic; delivered and reside in North Carolina; have data for clinical estimate of gestational age; have education data reported; have completed greater than 20 weeks gestation; are not missing covariate data; have block group geocoded data; and gave birth to infants without birth defects. Four block groups were surrounded by water;
therefore, subjects residing in these block groups were omitted because their interactions with members of other races/ethnicities would be limited by geography. We omitted births occurring in block groups where there are no Black residents because we are interested in segregation of blacks from whites. Analyses included 83,439 subjects and 5,118 block groups.

2. Exposure definition

Wong’s Local Spatial Segregation Index ($S_i$) measures the potential for interaction between two racial/ethnic groups, taking into account the spatial distribution of members of the group in the index and neighboring units (Wong, 2002). For example, a black person living in census block group A has $x$ probability of interacting with a white person in block group A, $y$ probability of interacting with a white person of block group B, and so on. Wong’s index allows the potential for interaction to be weighted by either the adjacency of block group B to A (yes=1, no=0), or the distance of block group B from A (distance-decay function). In this analysis, the potential for interaction is weighted using a distance-decay function, $c_{ij}$. In the context of measuring racial/ethnic disparities, we are interested in the health effects of living in a highly segregated neighborhood that is composed mostly of black residents, calculated by equation 1 below. In order to show potential interaction of blacks with whites only, $S_i$ was calculated as:

$$S_i = 1 - \left( \frac{b_i \sum c_{ij} a_j}{b_i \sum a_j} \right)$$  \hspace{1cm} (equation 1)

where $a_i$ and $b_i$ are the population counts of whites and blacks, respectively, within census block group $i$; $c_{ij}$ is equal to the inverse distance weight (1/distance between block group centroids) for block groups that are neighbors of the index block group. A block group was
considered a neighbor if its centroid-distance was within 8.25 miles of the index block group centroid. The 8.25 mile threshold was statistically determined using a Python script (Butler, 2005), which indicates the distance at which the correlation in percent white between block groups becomes zero. Since groups \( a_i \) and \( b_j \) can also interact with each other within the index census block group, \( i \) can be equal to \( j \). \( S_i \) ranges from 0 to 1, with 0 indicating complete integration, and 1, complete segregation. Segregation measures for study data ranged from 0.21-0.99.

Segregation cut-points were determined by creating quartiles of the segregation values across Census block groups using Proc Rank in SAS 9.1. Quartile values were 0.21-0.83 for low segregation, 0.83-0.88 for medium segregation, 0.88-0.92 for high segregation, and 0.92-0.99 for very high segregation.

Preterm birth (PTB) is defined as a birth occurring prior to 37 completed weeks of gestation. Information for the independent variables was abstracted from the birth certificates. Socioeconomic status was operationalized using the mother’s level of education categorized as “1”= <20 years old, <high school education; “2”= >=20 years old, <high school; “3”= high school or equivalent, and “4”= four years of college. Medicaid eligibility was identified as a confounder using a directed acyclic graph, and operationalized as “1”= “Eligible” and “2” = “Ineligible”.

Preterm birth proportions were calculated for non-Hispanic black and white women, stratified by level of segregation, education and race/ethnicity. Cochran-Mantel-Haenszel statistics were calculated to determine whether there were significant differences in prevalence across racial/ethnic groups.
3. Mixed Effects Multilevel Models

Multilevel logistic regression models were utilized to calculate the modifying effect of education on the association between segregation and preterm birth. Segregation was modeled as having a random intercept and a fixed slope. The random intercept allows the block group-level risk to vary across block groups. A fixed slope for segregation indicates that the effect of segregation is expected to operate similarly across all block groups. Level 1 of the multi-level model included estimates for the effect of being eligible for Medicaid. The second level of the model included the block group level measurement, segregation level. The statistical model for the logistic analysis is as follows:

**Mixed-model form for Model 1: Preterm Birth – Segregation**

*Level 1 model:* Preterm Birth (yes, no) = $\beta_{0j} + \beta_{1j}X_1 + r_{ij}$

*Level 2 model:*

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{Segregation})_j + \mu_{0j}$

$\beta_{1j} = \gamma_{10} + \gamma_{11}(\text{Segregation})_j + \mu_{1j}$

Where,

$\beta_{0j}$ = the log-odds of preterm birth compared to term birth in block group j (fixed slope)

$\beta_{1j}$ = the log-odds of being eligible for Medicaid compared to being non-eligible in block group j

$X_1$ = Medicaid eligibility (1=yes, 0=no)

$\gamma_{00}$ = the mean of the intercepts for all block groups in North Carolina

$\gamma_{01}$ = the intercept for the slope of segregation for all block groups in North Carolina

$\gamma_{10}$ = the intercept for the slope of the coefficient (Medicaid).

and
\[ r_{ij} \sim N(0, \sigma^2) \]

\[ u_{oj} \sim N(0, \tau_{oo}) \]

And where \( j \)=block group, \( i \)=individual, and \( u \) = the level-2 error term.

Specifically, we measured the associations between segregation and preterm birth, stratified by level of education (crude and adjusted). Medicaid was included in adjusted models as a proxy for income to examine any independent effects of segregation on preterm birth. We modeled the effect of segregation separately for black and white women.

D. RESULTS

Table 3.2 provides demographic characteristics for the entire study population. The study population was 27% black, non-Hispanic, and 73% white, non-Hispanic. White mothers were more likely to give birth at older ages, have more than a high school education (60.8% vs. 39.5%), be married, initiate prenatal care during the first trimester, and to use tobacco during pregnancy. Black mothers were more likely to receive Medicaid. A slightly greater proportion of black mothers delivered preterm compared to white mothers (7.2% vs. 5.8%). Nearly 50% of white mothers lived in low segregation block groups, compared to 25% of black mothers. Contrarily, more than 36% of black mothers lived in very high segregation block groups, compared to 7.8% of whites.

Tables 3.3-3.6 display individual demographic factors and preterm birth rates by level of segregation, stratified by education. Preterm birth proportions varied by level of segregation and education. The highest preterm birth proportion for whites was 7.8% (\( >20, <\text{HS}, \text{medium segregation} \)), and the lowest was 5.0% (\( >\text{HS}, \text{low segregation} \)). The combination of medium segregation and high education was most protective for blacks, with
a preterm birth proportion of 6.1%. The highest preterm birth proportions for blacks were among those living in low segregation areas. Blacks in very highly segregated areas had preterm birth proportions ranging between 6.6-8.7% across educational levels, lower than in low segregation areas. Blacks and whites with less education were more likely to receive Medicaid than women with higher education, and with increasing proportions for both race/ethnicities as segregation levels increased. Other risk factors followed a similar risk trend across segregation and education levels, including first trimester PNC initiation, tobacco use during pregnancy and marital status.

Tables 3.7 and 3.8 display crude and adjusted odds ratios for the association between segregation and preterm birth stratified by education. Maternal education does not moderate the association between segregation and preterm birth. White women living in very high and medium segregation with high education had increased odds of PTB, with adjusted odds ratios of 1.17 (95% CI: 1.0, 1.31) and 1.29 (95% CI: 1.08, 1.54), respectively, compared to white mothers living in low segregation areas. High education did not confer protection from effects of segregation, as women with low education did not have a higher risk of preterm birth. There were no differences in the effect of segregation on preterm birth across educational levels among black mothers.

E. DISCUSSION

This study demonstrates that preterm birth incidence increases as segregation increases, and decreases as education increases; however, the effect of segregation on PTB is not modified by education. This study contributes to the literature on the effects of isolation segregation. This dimension of segregation has been documented by other researchers to be
deleterious to health and birth outcomes (Ahern et al., 2003; Bell et al., 2006; Grady, 2006; M. R. Kramer et al., 2010; Subramanian, Acevedo-Garcia et al., 2005).

Blacks with high education living in medium segregation areas were most protected from high preterm birth proportions, with a proportion of 6.1%. This is a very low PTB prevalence for black women, and indicates that blacks can also achieve low PTB rates given the right contextual conditions. White mothers living in low segregation with more than a high school education were most protected, with a preterm birth rate of 5.0%. Very high segregation areas were least protective for white mothers, with preterm birth proportions ranging from 6.3%-6.5% across educational levels. Previous work has demonstrated that deleterious effects of place on health are independent of a person’s race/ethnicity (Collins & Hawkes, 1997; T. Laveist, Pollack, Thorpe, Fesahazion, & Gaskin, 2011; David R. Williams & Collins, 2002). Variations in preterm birth proportions, as well as proportions of known maternal risk factors for preterm birth, indicate that there is an effect of place on health in North Carolina.

The results of the multilevel analysis suggest that there is not a moderating effect of education on the segregation-preterm birth association in North Carolina; therefore, the study results are not in agreement with our hypotheses of modification by education. There were, however, increased odds of preterm birth for whites at very high segregation levels, indicating that segregation is deleterious to birth outcomes among white women in highly segregated areas. The odds of preterm birth increased as education increased for white mothers, indicating a possible active coping effect among whites who live in areas with fewer resources despite having higher education.
The study results did not show a differential effect of education on the segregation-preterm birth association across all strata. It is possible that the effects of segregation and education were attenuated due to the differences in geography across the state of North Carolina. North Carolina includes populations that are rural (e.g., Appalachia) and urban (e.g., Charlotte, Raleigh), with differential access to health care services within these geographic regions. In 2000, 51% of NC residents resided in rural areas (North Carolina Rural Economic Development Center, 2007). Future studies should examine these differences or concentrate study populations to either rural or urban populations to detect possible effects.

The study results provide a needed look at how contextual effects, specifically racial residential segregation, influence preterm birth proportions. The joint effect of SES and other contextual factors has been studied, including social stratification, community empowerment, environmental stressors, and neighborhood male unemployment rates, with mixed results (Ahern et al., 2003; O'Campo, Xue, Wang, & Caughy, 1997). Few studies have empirically assessed the association between segregation and birth outcomes; however, none has assessed the moderating effect of education on the association between isolation segregation and preterm birth. Grady (2006) found a significant effect of neighborhood poverty on low birth weight, but did not assess individual SES as an effect modifier. White and Borrell (2011) contend that examining effect measure modification at the individual level can provide valuable insight into the relationship between segregation and health. This study shows that isolation segregation and individual SES may jointly influence preterm birth risk among white mothers, but not black mothers.
Although we expected to see a stronger moderating effect, it is possible that individual education is so strongly predicted by segregation status that it cannot influence the effect of segregation on preterm birth. Although Luo (2006) found that maternal education was a stronger predictor of poor birth outcomes than was neighborhood income, it may be that in analysis with segregation, its effect is not as strong. It is also possible that maternal education and neighborhood income, although both measures of SES, are measuring different aspects of SES with different mechanisms for influencing birth outcomes.

1. Study Limitations

Although categorization of the segregation variable was necessary to show the variability in preterm birth and risk factors by SES, categorizing segregation may mask its variability. Estimating the effect of segregation using a continuous measure may provide more information about how segregation operates to influence preterm birth without restricting its effects to intervals. Since this segregation index is relatively new in its use to empirically assess the effect of segregation on health outcomes, application of categories used with other measures of segregation (e.g., index of dissimilarity) may not be appropriate. Further, since the association between isolation segregation and preterm birth is not linear across strata as indicated by study results, restricting the measure to categories may hide its effect and hinder its analysis as a potential contributor to health disparities. For example, the proportion of black women delivering preterm was 7.4% in low segregated areas, 6.7% in medium segregated areas, and 7.2% in highly and very highly segregated areas. There may be more variability within these strata that is lost due to categorization.

Geographic Information Systems are being used more often to understand how neighborhoods and geography are associated with health. Geocoding is limited, however, by
the accuracy of the databases available to geocode the data. There may be errors in the addresses on the birth certificates, for example, ZIP codes or street directions, that may cause addresses to be geocoded to the incorrect block group. It is not known how much error exists in these data, but such errors may affect whether births are geocoded to the correct block group, and thus the segregation index assigned to them. There is also an urban/rural bias in geocoding, in that there are more matches in urban areas because addresses and database information are more accurate in urban than in rural areas. As rural counties embrace GIS technologies, matching is expected to improve.

This study was cross-sectional and used existing data from birth certificates and the 2000 Census. These data do not provide information on the duration of residence at reported addresses. Further, women’s health is postulated to be a result of their lifetime exposures to risk factors and beneficial factors. Without information on time of exposure, we may be overestimating or underestimating the effect of segregation on health. For instance, if a woman lives in a highly segregated neighborhood from childhood until she graduates from high school, but earns a college degree and moves to a less segregated neighborhood for the remainder of her life, we are making the assumption in our study that she has lived in the less segregated neighborhood for a period of time long enough to impact her health and her birth outcomes. That assumption may be false in many instances, with changes in SES and segregation status occurring for black women as they advance in education and opportunity. Further, we do not know how long the women in the referent group were actually a part of this stratum. Therefore, differences in residence and SES status over a lifetime may attenuate the measured effects of segregation on preterm birth. For example, women who experience upward economic mobility by adulthood have decreased odds of preterm birth compared to
women who live in poverty over their lifetime (Collins et al., 2011). Longitudinal studies are needed to provide information on changes in SES and residential status over time. These studies can help us understand at what point(s) during the life course the effect of segregation occurs, the duration necessary for the effects to occur, and the mechanism by which they impact women’s risk of preterm birth.

2. Study Strengths

This study uses a spatial measure of segregation to account for interactions of residents with people outside of their census block group (M. R. Kramer et al., 2010; White & Borrell, 2011). Use of spatial measures has been encouraged to address several issues such as scale and boundary effects, and the modifiable areal unit problem (MAUP), as described in the geography literature (Reardon, 2006; Wong, 2002). Levels of segregation may vary depending on the size of the area and the racial/ethnic diversity of the population, leading to underestimation or overestimation of the health disparities of an area. Spatial measures of segregation such as Wong’s spatial segregation index help to address these issues (White & Borrell, 2011).

Most studies examining the association between segregation and birth outcomes utilize data from metropolitan areas in the US and cities in the Northeast and Midwest. This study examines the segregation-PTB association in a southern U.S. state, contributing to the literature of segregation in North Carolina.

3. Study Conclusions

RRS is associated with increased incidence of preterm birth for black and white women. Within levels of segregation, PTB incidence decreases with increasing levels of education. This contextual factor may help explain the disparity because a greater
proportion of blacks live in highly segregated areas compared to whites. Interventions focusing on individual factors alone may fail to change the inequities associated with segregated populations and thus may fail to contribute to disparity reduction. A focus on changing the inequities within contextual factors which affect whole populations is a more reasonable strategy.
Figure 3.2. Conceptual Framework of the multidimensional effect of segregation on the health of blacks in segregated areas
Table 3.2. Distribution of individual and contextual-level maternal risk factors and birth characteristics for non-Hispanic Black and White women, North Carolina birth cohort, 2004.

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<thead>
<tr>
<th>Individual Level Demographic Variables</th>
<th>Non-Hispanic Black</th>
<th>Non-Hispanic White</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of births n (%)*</td>
<td>22550 (27.0)</td>
<td>60889 (73.0)</td>
</tr>
<tr>
<td>Maternal age in years (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12-14</td>
<td>0.5</td>
<td>0.1</td>
</tr>
<tr>
<td>15-19</td>
<td>17.4</td>
<td>8.3</td>
</tr>
<tr>
<td>20-29</td>
<td>58.6</td>
<td>50.4</td>
</tr>
<tr>
<td>30-34</td>
<td>15.1</td>
<td>26.9</td>
</tr>
<tr>
<td>35-39</td>
<td>6.7</td>
<td>12.1</td>
</tr>
<tr>
<td>40-52</td>
<td>1.7</td>
<td>2.2</td>
</tr>
<tr>
<td>Maternal education completed (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20 years and less than high school</td>
<td>10.8</td>
<td>4.7</td>
</tr>
<tr>
<td>≥20 years and less than high school</td>
<td>12.5</td>
<td>7.6</td>
</tr>
<tr>
<td>High school or equivalent</td>
<td>37.1</td>
<td>27.0</td>
</tr>
<tr>
<td>More than high school</td>
<td>39.5</td>
<td>60.8</td>
</tr>
<tr>
<td>Receive Medicaid (%)</td>
<td>66.6</td>
<td>31.4</td>
</tr>
<tr>
<td>Married</td>
<td>32.6</td>
<td>78.6</td>
</tr>
<tr>
<td>Prenatal Care Initiation (PNC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late/No PNC</td>
<td>4.5</td>
<td>1.5</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Trimester</td>
<td>76.5</td>
<td>90.5</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Trimester</td>
<td>19.0</td>
<td>8.1</td>
</tr>
<tr>
<td>Tobacco Use during pregnancy (%)</td>
<td>10.2</td>
<td>15.2</td>
</tr>
<tr>
<td>Chronic Hypertension (%)</td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Diabetes (%)</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Incompetent Cervix (%)</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Pregnancy-Induced Hypertension (%)</td>
<td>4.7</td>
<td>5.1</td>
</tr>
<tr>
<td>Preterm Birth (%)</td>
<td>7.2</td>
<td>5.8</td>
</tr>
</tbody>
</table>

**Neighborhood Level Variables**

<table>
<thead>
<tr>
<th>Segregation&lt;sup&gt;a&lt;/sup&gt; (%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (&lt;0.21-0.83)</td>
<td>25.0</td>
<td>48.2</td>
</tr>
<tr>
<td>Medium (0.83-0.88)</td>
<td>17.6</td>
<td>26.3</td>
</tr>
<tr>
<td>High (0.88-0.92)</td>
<td>20.9</td>
<td>17.8</td>
</tr>
<tr>
<td>Very High (0.92-0.99)</td>
<td>36.5</td>
<td>7.8</td>
</tr>
<tr>
<td>Mean Segregation Index</td>
<td>0.9</td>
<td>0.8</td>
</tr>
</tbody>
</table>

* Total number of births includes singleton births to non-Hispanic Black or White mothers who reside in NC, were at least 20 weeks gestation, included maternal education data, and occurred in block groups with both White and Black residents.

<sup>a</sup> Calculated as Wong’s Local Spatial Index of Segregation. Calculated mean for each racial/ethnic group separately. Index ranges from 0-1, 0=Complete integration, 1=Complete segregation.

*Abbreviations: PTB, preterm birth; SE, Standard error; RRS, racial residential segregation
Table 3.3. Preterm birth proportions by race/ethnicity, segregation* level, and education, North Carolina birth cohort, 2004.

<table>
<thead>
<tr>
<th>Education Level†</th>
<th>Non-Hispanic Black</th>
<th>Non-Hispanic White</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Low Segregation</td>
<td>7.9</td>
<td>10.9</td>
</tr>
<tr>
<td>Medium Segregation</td>
<td>7.5</td>
<td>8.2</td>
</tr>
<tr>
<td>High Segregation</td>
<td>6.7</td>
<td>10.6</td>
</tr>
<tr>
<td>Very High Segregation</td>
<td>6.6</td>
<td>8.7</td>
</tr>
</tbody>
</table>

*Low Segregation: \(S_i=0.21-0.83\); Medium Segregation: \(S_i=0.82-<0.88\); High Segregation: \(S_i=0.88-0.92\); Very High Segregation: \(S_i=0.92-0.99\). Calculated as Wong’s local spatial segregation index.

†Education Levels 1: <20 years old, <High school; 2: >=20 years old, < High school; 3: High school or equivalent; 4: Greater than High School
Table 3.4. Unadjusted association between segregation and preterm birth, stratified by level of education.

<table>
<thead>
<tr>
<th>Black, Non-Hispanic</th>
<th>Education [Odds Ratio (95% CI)]</th>
<th>Segregation Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude association</td>
<td>&lt;High School, &lt;20 years old</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crude association</td>
</tr>
<tr>
<td>Very High</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>(0.8, 1.1)</td>
<td>(0.5, 1.3)</td>
</tr>
<tr>
<td>High</td>
<td>1.0</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>(0.8, 1.1)</td>
<td>(0.5, 1.4)</td>
</tr>
<tr>
<td>Medium</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>(0.8, 1.0)</td>
<td>(0.6, 1.7)</td>
</tr>
<tr>
<td>Low</td>
<td>Ref</td>
<td>Ref</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>White, Non-Hispanic</th>
<th>Education [Odds Ratio (95% CI)]</th>
<th>Segregation Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude association</td>
<td>&lt;High School, &lt;20 years old</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crude association</td>
</tr>
<tr>
<td>Very High</td>
<td>1.2</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>(1.0, 1.4)</td>
<td>(0.5, 1.2)</td>
</tr>
<tr>
<td>High</td>
<td>1.0</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>(1.0, 1.2)</td>
<td>(0.5, 1.1)</td>
</tr>
<tr>
<td>Medium</td>
<td>1.2</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>(1.1, 1.3)</td>
<td>(0.5, 1.0)</td>
</tr>
<tr>
<td>Low</td>
<td>Ref</td>
<td>Ref</td>
</tr>
</tbody>
</table>

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Table 3.5. Adjusted* association between segregation and preterm birth, stratified by level of education.

<table>
<thead>
<tr>
<th></th>
<th>Black, Non-Hispanic</th>
<th></th>
<th></th>
<th></th>
<th>White, Non-Hispanic</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Education [Odds</td>
<td>Segregation</td>
<td>High School or</td>
<td>More than High</td>
<td>Education [Odds</td>
<td>Segregation</td>
<td>High School or</td>
<td>More than High</td>
</tr>
<tr>
<td></td>
<td>Ratio (95% CI)]</td>
<td>Status</td>
<td>equivalent</td>
<td>School</td>
<td>Ratio (95% CI)]</td>
<td>Status</td>
<td>equivalent</td>
<td>School</td>
</tr>
<tr>
<td></td>
<td>&lt;High School,</td>
<td></td>
<td></td>
<td></td>
<td>&lt;High School,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;20 years old</td>
<td></td>
<td></td>
<td></td>
<td>&gt;=20 years old</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very High</td>
<td>0.9 (0.6, 1.4)</td>
<td>0.8 (0.6, 1.1)</td>
<td>1.0 (0.8, 1.3)</td>
<td>0.9 (0.8, 1.2)</td>
<td>0.8 (0.5, 1.2)</td>
<td>1.0 (0.6, 1.4)</td>
<td>1.0 (0.8, 1.3)</td>
<td>1.3 (1.1, 1.5)</td>
</tr>
<tr>
<td>High</td>
<td>0.9 (0.5, 1.4)</td>
<td>1.0 (0.7, 1.5)</td>
<td>0.9 (0.8, 1.3)</td>
<td>0.9 (0.7, 1.1)</td>
<td>1.0 (0.5, 1.1)</td>
<td>1.2 (0.8, 1.5)</td>
<td>1.1 (0.9, 1.2)</td>
<td>1.2 (0.9, 1.2)</td>
</tr>
<tr>
<td>Medium</td>
<td>1.0 (0.6, 1.7)</td>
<td>0.7 (0.5, 1.2)</td>
<td>0.9 (0.7, 1.2)</td>
<td>0.9 (0.7, 1.1)</td>
<td>0.7 (0.5, 1.0)</td>
<td>1.2 (0.9, 1.6)</td>
<td>1.1 (1.0, 1.3)</td>
<td>1.2 (1.0, 1.3)</td>
</tr>
<tr>
<td>Low</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
</tr>
</tbody>
</table>

*Adjusted for Medicaid status.
REFERENCES


CHAPTER 4: CONCLUSION

A. STUDY REVIEW: AIMS AND OUTCOMES

Racial/ethnic disparities in preterm birth continue to persist, with no effective intervention identified to reach the Healthy People 2020 goals of a 10% reduction in the national preterm birth rate (U.S. Department of Health and Human Services, 2010b) or the elimination of racial/ethnic disparities (U.S. Department of Health and Human Services, 2010a). The complete etiology and mechanisms leading to these disparities have not been identified after research on individual risk factors related to health behaviors or individual demographics; therefore, attention has shifted to contextual factors such as racial residential segregation to help understand how neighborhood and social conditions may contribute to disparities in health and preterm birth.

Racial disparities reflect a lack of health equity among racial/ethnic groups, which leads to poorer outcomes in health. This lack of health equity is reflected in differential access to health care, socioeconomic disparities, and disparities in social conditions, all influenced by contextual factors/neighborhood conditions (White & Borrell, 2011; David R. Williams & Collins, 2002). Understanding the mechanisms by which context influences health may help elucidate methods for intervening upon racial disparities and preterm birth risk.

Previous studies have examined the effect of racial residential segregation on birth outcomes. In these studies, racial residential segregation has been operationalized using various measures, including the dissimilarity index (Polednak, 1991) and percent black in
neighborhood (S. M. Mason et al., 2009), yielding varying results. Differences in results may be reflected by differences in the segregation measure used. Many of the previously used segregation measures are aspatial, that is, they measure the segregation level of a particular areal unit (e.g., census block group) without considering neighboring census block groups and how residents of one census block group may interact with residents in another. Further, these measures do not consider that some census block group boundaries may be drawn in a manner that divides actual residential neighborhoods.

Differences in results of segregation studies may also be affected by the dimension of segregation analyzed. Massey and Denton (1993) identify five dimensions of racial residential segregation: evenness, centralization, concentration, clustering, and isolation. The dimension of racial residential segregation used can have implications on the interpretation of the effects of segregation on preterm birth. For example, Bell (2006) found that isolation segregation was associated with increased rates of low birth weight and preterm birth, while clustering was protective for these outcomes. Isolation connoted separation of residents from resources protective for health, while clustering connoted social support derived from social networks (Bell et al., 2006). Likewise, several studies have found adverse health effects associated with isolation (Grady, 2006; Guest et al., 1998; Subramanian, Acevedo-Garcia et al., 2005).

This study focused on the isolation dimension because it most closely portrays the negative consequences that segregation has caused and concentrated in black communities (Massey & Denton, 1993). The isolation dimension of segregation implies that persons living in racially segregated areas are deprived of access to resources that are beneficial for health. If residents are isolated from educational and health care resources, employment
opportunities, and locations to obtain fresh fruits and vegetables, for example, they may experience poorer health.

This dissertation research also sought to contribute to the literature on how socioeconomic status and segregation may jointly contribute to the risk of preterm birth in North Carolina. Socioeconomic status (SES) has been studied as both a contextual and individual-level factor affecting health status. Prior studies have found that segregation and socioeconomic status (SES) are each independently associated with birth outcomes, including low birth weight and preterm birth (Collins et al., 2007; Goza et al., 2007; Grady, 2006; S. Mason et al., 2009). Nearly all studies of the association between segregation and birth outcomes adjust for SES. Only one was found that examined how SES and segregation may jointly affect the risk of low birth weight; SES, measured as neighborhood poverty, was found to have little impact on the effect of residential segregation on low birth weight (Grady, 2006). Some researchers posit that the complex intertwining of racial residential segregation and socioeconomic disadvantage inhibits the disentangling of their individual effects (Mary O. Hearst et al., 2008; Messer et al., 2010). One reason is that some researchers characterize SES as a mediator on the pathway between segregation and health outcome; however, adjusting for SES in segregation analyses could underestimate the effect of segregation because SES may be on the causal pathway (White & Borrell, 2011), i.e., SES is in part caused by segregation.

The Specific Aims for this dissertation research were to 1) Determine the prevalence of medical and social risk factors for preterm birth by levels of segregation for non-Hispanic black and white women in North Carolina, and 2) Determine whether socioeconomic status (measured as maternal education) modifies the effect of racial residential segregation on the
risk of preterm birth for black and white women in North Carolina. Racial residential segregation was measured using Wong’s spatial segregation index (Wong, 2002), which measures the potential interaction of one racial/ethnic group with another, accounting for the potential for interaction between racial/ethnic groups in both the index block group and neighboring block groups.

Results from the first analysis (Determining the Impact of Segregation and Education on the Prevalence of Maternal Biologic, Behavioral, and Social Risk Factors for Preterm Birth) show that there are differences in the prevalence of behavioral and social risk factors for preterm birth by levels of segregation for non-Hispanic black and white women in North Carolina. Both black and white women living in highly and very highly segregated areas had higher prevalence of risk factors than did women in less segregated areas. Women in highly segregated areas were more likely to be unmarried, to give birth at younger ages, to be Medicaid eligible (low income) and to receive no or late prenatal care. There was a higher prevalence of smoking during pregnancy among women living in more segregated areas compared to low; however, prevalence was higher for white women than black women. There were no differences in the prevalence of biologic risk factors (chronic and pregnancy-induced hypertension) across segregation levels.

The prevalence of maternal risk factors across segregation stratified by education levels was also calculated. Prevalence increased as educational and segregation levels increased for Medicaid eligibility, marital status, lack of prenatal care, and chronic hypertension. Tobacco use was the only risk factor with decreasing prevalence as segregation levels increased. There were no differences in prevalence for PIH, diabetes and incompetent cervix by segregation levels.
Examination of racial/ethnic differences across segregation levels revealed differences in risk factor prevalence as well. More than 36% of blacks lived in very highly segregated areas, compared to nearly 8% of whites. Blacks had higher prevalence of most risk factors, with greater prevalence for both whites and blacks living in very highly segregated areas compared to those living in less segregated areas. Prevalence of birth to women with less than a high school education was higher among blacks; however the prevalence increased for both whites and blacks with increasing segregation. The same pattern was seen for women of young maternal age (12-19 years old), women who were not married, women who had late/no prenatal care, and women who used tobacco during pregnancy. The proportion of married women decreased for both racial/ethnic groups as segregation levels increased.

The results of this study were as expected. Since there is no biological basis for differences in birth outcomes strictly based on one’s race, it was expected that the effects of segregation at various levels would be experienced by all, regardless of race. That is to say that white women as well as black women would be susceptible to conditions contributing to a higher prevalence of maternal risk factors. Segregation is deleterious to health, not solely because of the racial distributions that are used to define the segregation levels, but also because of the distribution of resources, the diffusion of knowledge of health practices, higher crime rates, and a myriad of other influences that are common to racially segregated areas (T. A. LaVeist, Keith, & Gutierrez, 1995; Thomas A. LaVeist & Wallace, 2002; David R. Williams & Collins, 2002).

Medical risk factor prevalence did not differ by segregation level. Chronic hypertension results in part from poor diet, lack of exercise, and stress. Inadequacies in the
built environment and the prevalence of fast food chains, lack of access to healthy foods, and locations of liquor stores potentially put residents in segregated areas at higher risk of chronic hypertension; however, there was no consistent trend in chronic hypertension prevalence in segregated areas in North Carolina. There were, however, differences across racial/ethnic groups. The hypertension prevalence decreased with increased segregation levels for black, non-Hispanic women, and was higher overall than for white, non-Hispanic women. There were no differences between black and white women, or across segregation levels, for diabetes or PIH. Null findings for prevalence differences for diabetes or PIH may be in part due to poor data quality for these health conditions on the birth certificate.

The aim of this study was to determine whether socioeconomic status modifies the effect of racial residential segregation on the risk of preterm birth for black and white women. Results of this study show that SES (measured as maternal education) does not modify the effect of racial residential segregation on the risk of preterm birth. Most of the confidence intervals for the effect measure included null. Many of the confidence intervals comparing non-Hispanic black and white women overlapped, indicating lack of a significant difference between races/ethnicities. There were, however, increased odds of preterm birth with increasing education levels for whites at very high segregation levels. This may indicate a possible active coping effect among non-Hispanic white women who live in areas with fewer resources despite having higher education. This finding parallels findings of John Henryism among black men, who exert high effort to cope in the face of inadequate resources needed for success, to the detriment of their health (James, 1994).

It was unexpected that education did not moderate the association between segregation and preterm birth. The null findings may have been influenced by a number of
factors in this study. The effects of segregation and education may have been attenuated due to the differences in geography across the state of North Carolina. North Carolina includes populations that are rural (e.g., Appalachia) and urban (e.g., Charlotte, Raleigh), with differential access to health care services within these geographic regions. In 2000, 51% of NC residents resided in rural areas (North Carolina Rural Economic Development Center, 2007). Future studies should examine these differences or concentrate study populations to either rural or urban populations to detect possible effects. A lack of a moderating effect may also have been due to a weak effect of individual-level SES, measured as maternal education. Maternal education may be influenced by the residential neighborhood, creating the inability to disentangle its effect from segregation, as some researchers warn (Mary O. Hearst et al., 2008; Messer et al., 2010). Individual education may be too weak to influence the contextual effects of segregation. Future studies should analyze contextual measures of SES to determine whether they modify the segregation-preterm birth association.

B. STUDY LIMITATIONS

Several factors presented limitations to this research. The study outcome and several of the main exposure variables were taken from birth certificate data, portions of which are known to be of questionable quality. This limitation was known going into the study, and attempts were made to minimize its impact on the study outcomes. This is a limitation that has been acknowledged in the literature and is certain to have impacted these study results. A second limitation is that categorization of segregation may mask its association with health by masking some of its variability. Using a continuous measure of segregation may provide more information of how segregation is associated with preterm birth without restricting its categorization to intervals. Since the Wong segregation index is relatively new in its use to
empirically assess the effect of segregation on health outcomes, application of categories used with other measures of segregation (e.g., index of dissimilarity) may not be appropriate. North Carolina is a highly segregated state compared to other areas studied in segregation research in the Northeast and Midwest; therefore, application of cut-points or categories from other segregation measures may limit understanding of how segregation measured by Wong’s index is associated with preterm birth. Finally, this study is limited by reliance on administratively defined boundaries to define neighborhood and limits of potential interaction with another racial/ethnic group. Administratively defined units may not accurately represent neighborhoods or neighborhood effects, as women may not define their neighborhoods or areas of potential interaction with other racial/ethnic groups consistent with administrative boundaries. Despite these concerns, census block groups have been used to successfully demonstrate associations between exposures and birth outcomes (Grady, 2006; Krieger et al., 2002).

C. STUDY STRENGTHS

There are several strengths to this study, which contributes to the literature on the associations between place and health and birth outcomes. First, this study uses a spatial measure of segregation that addresses several issues such as scale and boundary effects, and the modifiable areal unit problem (MAUP), as described in the geography literature (Reardon, 2006; Wong, 2002). Spatial measures of segregation such as Wong’s spatial segregation index help to address these issues because they consider potential interaction of residents of a particular block group with residents of another, across block group boundaries (White & Borrell, 2011). Secondly, since many inequities in social and economic resources are propagated through systemic segregation (Jones, 2000; T. A. Laveist, 1993; Massey &
Denton, 1993; David R. Williams & Collins, 2002), analysis of contributors to racial/ethnic disparities in preterm birth should include contextualization by racism. This study uses racial residential segregation to measure racism, as segregation is a result of institutionalized racism (Jones, 2000; David R. Williams & Collins, 2002). One of the limitations of previous research that has examined social influences on health has been the reliance on self-reported measures of these influences, which may underestimate the prevalence of exposure because participants may not recognize that they are exposed. For example, one may be exposed to the result of institutional forms of discrimination, such as segregation, but not recognize it as such because it has been experienced all of one’s life. Using segregation to measure racism eliminates this potential bias because it is measured independently of a person’s cognizance thereof. Finally, this study links maternal risk factors to segregation, providing insight into the mechanism by which segregation may contribute to disparities in birth outcomes. Only two studies were found that empirically examined the mechanism by which segregation affected birth outcomes (Grady & Ramirez, 2008; M. R. Kramer et al., 2010). This study provides evidence that several social and demographic risk factors may mediate the segregation-preterm birth association when contextualized by segregation due to their inequitable distributions across segregation levels.

D. FUTURE DIRECTIONS

To more fully elucidate the mechanisms behind the racial/ethnic disparities in preterm birth and the role of segregation, future studies should examine risk factors not available for study in this dissertation. This study did not directly examine chronic stress, inflammation, or infection because these data were not available in the datasets. Each of these factors has been linked to poor birth outcomes (Czeizel & Banhidy, 2010; Fatemeh et al., 2009; M. R.
Kramer et al., 2011; Magnussen et al., 2007); therefore, analysis contextualized by segregation may provide further insight into the mechanisms behind racial/ethnic disparities. Future studies should also examine the role of segregation for specific geographic areas to understand the possible attenuation of effect of segregation due to differences in geographical characteristics such as urban vs. rural or vast differences in geographical sizes of census block groups due to differences in population density. Consideration of these factors may give a more meaningful understanding of how segregation may contribute to racial/ethnic disparities in health and preterm birth.
REFERENCES


