Multilevel factors influencing preterm birth in an urban setting

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Racial disparity in preterm is a major problem in the US. Although significant strides have been made in identifying some of the risk factors, the complexities between community and individual factors are not understood. This study examines the influence of individual and community level factors affecting preterm birth among Black and White women in an urban setting. A 10-year live birth registry dataset from a mid-sized, racially diverse city was analyzed (N = 30,591). Data were geocoded and merged with block group level Census data. Five hierarchical models were examined using PROC GLIMMIX. Education, illicit drug use, pregnancy complications, previous preterm birth, paternal presence, inadequate and adequate plus prenatal care, and poverty were associated with preterm births in both Blacks and Whites. In Black women, increasing maternal age, maternal smoking, and a previous infant death were significant predictors of preterm births, which was not the case for White women. Residing in medium or high poverty neighborhoods resulted in 19% and 28% higher odds, respectively, of preterm birth for Black women. In addition to individual level factors, neighborhood poverty is an important risk factor influencing preterm birth. It is essential to engage multisectoral agencies in addressing factors influencing preterm birth.

Keywords: premature birth; health status disparities; multilevel analysis

Introduction

Adverse birth outcomes are a major threat to perinatal health. Infant mortality, preterm birth, and low birth weight are particularly important issues (Slattery & Morrison, 2002). There are approximately 25,000 infant deaths in the United States every year, resulting in an infant mortality rate of 6.1 per 1000 live births in 2011 (Hoyert & Xu, 2012). Preterm birth is one of the major causes of infant mortality and morbidity (World Health Organization, 2012). Babies born prematurely are at increased risk of short- and long-term health consequences. Physical and mental developmental disorders, respiratory problems, intellectual disabilities, cerebral palsy, vision and hearing loss, and digestive problems are a few of the sequelae resulting from premature births (Wood, Marlow, Costeloe, Gibson, & Wilkinson, 2000). In 2012, the overall rate of preterm births in the US was 11.5% (March of Dimes, 2013). Of significance is the striking racial disparity

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that exists between African American and European American births. According to the National Center for Health Statistics, the preterm rate among non-Hispanic Black women was approximately 58% higher compared to their non-Hispanic White counterparts (March of Dimes, 2013). Reducing the rates of preterm births and eliminating disparities are central issues of public health in the United States (US Department of Health and Human Services, 2012). Despite the plethora of research on adverse birth outcomes at the individual level, there is little consensus about how racial disparities affect the underlying mechanisms that cause the increased risk for preterm deliveries (Spong, Iams, Goldenberg, Hauck, & Willinger, 2011). Recently, research suggests these disparities may not be explained solely by individual factors, but rather may require a multilevel approach to understand the interaction of community and individual level factors that influence birth outcomes (Alio et al., 2010). This understanding will allow the development of strategies aimed at improving health based upon the complex relationships between individuals and their environment (Diez-Roux, 2001).

Many studies have used multilevel analysis to determine whether population-based characteristics have a significant impact on health outcomes (Diez-Roux, 2000; Pickett & Pearl, 2001). Existing multilevel studies were primarily used to assess community level effects on topics such as cardiovascular health (Diez Roux et al., 2001), sexually transmitted diseases (Cohen et al., 2000), and childhood asthma (Juhn et al., 2005). In recent years, studies have examined the influence of multilevel factors on poor birth outcomes. These studies have predominantly focused on low birth weight to determine the association between neighborhood social environment (Roberts, 1997), neighborhood socioeconomic status and ethnicity (Pearl, Braveman, & Abrams, 2001), racial disparities (O’Campo, Xue, Wang, & Caughy, 1997), and impoverished neighborhoods (Collins, Schulte, & Drolet, 1998). Recently, Schempf, Strobino, and O’Campo (2009) utilized multilevel modeling to examine the association between low birth weight and neighborhood risk factors as well as individual level factors and reported that neighborhood factors may influence birth outcomes by shaping maternal behavioral risks. While adverse birth outcomes are the focus of much research, thorough investigations of preterm birth using multilevel analytic models are needed (Masi, Hawkley, Piotrowski, & Pickett, 2007; Messer, Kaufman, Dole, Savitz, & Laraia, 2006; Nkansah-Amankra, 2010). This research will examine the influence of individual and community level factors on preterm birth using multilevel analysis.

Methods

A 10-year live birth registry dataset from a mid-sized, racially diverse city was analyzed (N = 30,591) (Virginia Department of Health, 2014). The data included all singleton births between 1 January 1997 and 31 December 2007 to women residing within the city limits of Richmond, Virginia. The birth data files were imported into ArcGIS version 10 software and geocoded using an 80% accuracy threshold. The geocoding process resulted in 87% of births matched to a valid address. The dataset was then exported into SAS version 9.2 statistical software for analysis. Community data from the 2000 US Census were extracted and merged with the birth data in accordance with the Census block group containing the residence of birth (United States Census Bureau, 2003). The merged dataset included demographic characteristics, lifestyle behaviors, reproductive characteristics, and birth outcome information, as well as Census level characteristics. Preterm birth, the main outcome variable, was defined as infants born at less than 37 weeks of gestation.
**Individual level variables from live birth registry data**

Individual level factors included demographic characteristics of maternal age, race, ethnicity, education, and paternal presence on the birth certificate. Maternal lifestyle behaviors included the use of tobacco, alcohol, or illicit drugs during pregnancy. Maternal age was examined as a continuous variable. Race was categorized as White and Black due to the small number of other racial groups (2.2%). Ethnicity was categorized as Hispanic and non-Hispanic and paternal presence was coded as ‘yes’ or ‘no’. Maternal education was examined as less than high school, high school graduate and more than high school education. Maternal risk behaviors, including tobacco, alcohol, and illicit drug use during pregnancy, were also categorized as ‘yes’ or ‘no’.

To assess access to and adequacy of prenatal care, the Kotelchuck index (Kotelchuck, 1994) was calculated, care being categorized as inadequate/intermediate, adequate and adequate plus. Reproductive variables including pregnancy complications, parity, and prior history of preterm births were examined. Pregnancy complications were captured in a single dichotomous variable signifying the presence of at least one of the following conditions: diabetes, hypertension, eclampsia, incompetent cervix, anemia, or maternal infection. Parity was coded as no previous live births, at least one previous live birth still living, and at least one previous live birth now dead. Any history of previously delivering a preterm or small-for-gestation-age infant was also assessed.

**Community level variables**

Data from the 2000 US Census were spatially joined to the geocoded addresses of infant births. The community level variables of interest for each Census block group were the percentage of residents living below 100% of the 1999 Federal Poverty Level as defined by the US Census Bureau and the average rate of youth violence (Oregon Center for Public Policy, 2000).

The percentage of residents living in poverty for each block group was categorized using tertiles as low (<14.9%), medium (14.9–8.5%), and high (>28.5%). The average violence rate for each block group was calculated using youth violence surveillance data for 2001 through 2007 from the Richmond Ambulance Authority (2011). The total number of violence-related ambulance pickups of those aged 10 to 24 was adjusted for the total block group population of the same age range (per 1000) for each year. The average of those annual rates was calculated and used as a representation of the level of violence in each block group. The violence rate was categorized using the median value as low (<3.97 events per 1000) and high (≥3.97 events per 1000).

**Data analysis**

Individual level factors and community level factors were initially examined separately. Descriptive analyses were performed on all study characteristics and summary statistics such as means and percentages were calculated. Continuous variables were examined using t-tests and p-values. Categorical variables were assessed using chi-square tests and odds ratios (ORs) with 95% confidence intervals (CIs). Individual and community characteristics were compared between normal gestational age and preterm infants.

Five hierarchical models were built using PROC GLIMMIX to fit multilevel logistical regression models incorporating randomly distributed block group-specific intercepts assuming a binary distribution and a logit link function (Diez-Roux, 2000). Model 1 examined the association between individual level maternal demographic factors and preterm births. Demographic factors included maternal age, ethnicity, education, and
paternal presence. Model 2 included the demographic factors listed above and maternal lifestyle behaviors. Model 3 included all variables from Model 2 and assessed access to and utilization of prenatal care using the Kotelchuck index. Model 4 included all the variables in Model 3 as well as reproductive history variables. Finally, Model 5 included all the variables from Model 4 and examined the influence of community level factors. Community level variables assessed included average violence rate and percentage of residents living in poverty in the block group. Odds ratios with 95% CIs were calculated for all models. Effect modification between variables was also investigated in all models using interaction terms in the SAS models. Race was found to be a significant effect modifier, and the models were re-fit stratifying by Black and White maternal race. A significance level of $\alpha = 0.05$ was used for all analyses.

Results

Characteristics of the study population and block group characteristics are shown in Table 1. The average maternal age was 26 years and nearly two-thirds of births were to Black women. Low birth weight infants, weighing less than 2500 grams, comprised 10.8% of the births and the rate of preterm birth was 12.3%.

As shown in Table 1, there was a statistically significant difference in age, education, paternal presence, smoking, alcohol use, illicit substance use, parity, pregnancy complication, and adequacy of prenatal care between White and Black births. Further, statistically significant racial differences were found in the community level variables including the average violence rate and percentage of residents in poverty. The unadjusted analysis showed statistically significant association between all of the individual level and community level characteristics and preterm birth (Table 2). Findings from the adjusted multilevel analyses for Black and White women are displayed in Tables 3 and 4, respectively.

Multilevel factors influencing preterm births in Black women

As shown in Model 1, there was a statistically significant association between education, maternal age, paternal presence, and preterm birth (Table 3). However, no statistically significant association was found between ethnicity and preterm births among Black women. The addition of lifestyle factors into the model (Model 2) did not alter the level of significance observed in Model 1. All of the demographic variables that were significant in Model 1 remained significant. Additionally, the model showed that tobacco and illicit drug use were statistically associated with preterm birth in Black women. In Model 3, the addition of adequacy of prenatal care variable did not alter the associations observed in Models 1 and 2. The model showed that the odds of preterm birth were higher among Black women who received inadequate/intermediate and adequate plus prenatal care. When reproductive variables were added into the model (Model 4), preterm birth was found to be associated with prior preterm birth, pregnancy complications, and prior live birth now deceased. Finally, Model 5 displays the influence of community level variables on preterm birth. The odds of preterm birth were higher among women who resided in block groups with medium or high levels of residents in poverty when compared to women residing in block groups with the lowest level of poverty.
Multilevel factors influencing preterm births in White women

Predictor variables for White women were fairly similar to the findings for Black women (Table 4). However the magnitudes of associations were different for White and Black women. Unlike the findings in the Black women, maternal age and smoking during pregnancy did not predict preterm birth for White women. Additionally, nulliparity was a risk factor for preterm birth in White women. Model 5, which included the community level variables along with the individual level variables, found that living in a block group with medium levels of poverty was a significant risk factor for preterm birth among White women, while the relationship with the highest level of poverty was not significant.

Table 1. Characteristics of study population.

| Characteristic                          | Total N = 30,524 | Black women N = 19,315 | White women N = 10,549 | Chi-square |
|-----------------------------------------|------------------|------------------------|------------------------|------------|
| Preterm birth (<37 weeks gestation) (%) | 12.34            | 14.75                  | 8.28                   | 261.8*     |
| Low birth weight (<2500 grams) (%)     | 10.82            | 13.93                  | 5.30                   | 523.4*     |

*Individual level variables*

| White mothers (%)                       | 34.56            |
| Black mothers (%)                       | 63.28            |
| Other mothers (%)                       | 2.16             |
| Mean age (SD)                           | 26.19 (6.45)     |
| Hispanic mothers (%)                    | 5.90             |
| Education                               |                  |
| Less than high school (%)               | 27.83            |
| High school (%)                         | 30.92            |
| More than high school (%)               | 41.24            |
| Paternal presence (%)                   | 38.50            |
| Maternal alcohol use (%)                | 1.18             |
| Maternal tobacco use (%)                | 10.46            |
| Maternal illicit drug use (%)           | 2.39             |
| Adequacy of prenatal care               |                  |
| Inadequate/intermediate (%)             | 31.10            |
| Adequate (%)                            | 40.36            |
| Adequate plus (%)                       | 28.54            |
| Pregnancy complications (%)             | 16.14            |
| Previous preterm birth (%)              | 0.65             |
| Parity                                  |                  |
| No previous live births (%)             | 44.67            |
| Previous live birth – still living (%)  | 53.76            |
| Previous live birth – now dead (%)      | 1.57             |

*Community level variables*

| Average violence rate                   |                  |
| Low (%)                                 | 50.13            |
| High (%)                                | 49.87            |
| Percent residents in poverty            |                  |
| Low (%)                                 | 32.81            |
| Medium (%)                              | 34.25            |
| High (%)                                | 32.94            |

Notes: *indicates p-value <0.05. †indicates t-test statistic used to calculate significance for continuous variables.
Although there are significant similarities, the multilevel analyses reported that there were differential effects of community and individual level factors among Black and White populations. Maternal education, paternal presence, illicit drug use, adequacy of prenatal care, prior preterm birth, and pregnancy complications were significant individual level predictors of preterm birth for both Black and White women. In addition, nulliparity was a risk factor for preterm birth for White women but not Black women. Among Black women, increasing maternal age, maternal smoking and a previous live birth infant that died were also significantly associated with preterm birth. While living in a block group with medium or high levels of poverty resulted in an increased risk of preterm birth for Black women, only medium levels of poverty posed increased risk of preterm birth for White women. Although the reasons for these differences are unclear, the increased odds of preterm birth with increasing age may be due to chronic stressors that have been postulated to cause racial disparities in preterm birth (Hogue & Bremner, 2005). The lack of significance between tobacco use and preterm birth in Whites may be due to under-reporting.

| Characteristics                          | Preterm birth | PROC GLIMMIX Crude OR (95% CI) |
|------------------------------------------|---------------|---------------------------------|
| Mean maternal age                        | 26.1 (SD = 6.6) | 1.12 (1.06, 1.18)**             |
| Black mothers                            | 14.8          | 1.82 (1.66–1.98)***             |
| White mothers                            | 8.3           | 1.0                             |
| Hispanic mothers                         | 8.8           | 0.67 (0.56–0.81)***             |
| Education                                |               |                                 |
| Less than high school                    | 15.0          | 1.50 (1.36–1.64)***             |
| High school                              | 13.8          | 1.39 (1.27–1.52)***             |
| More than high school                    | 9.6           | 1.0                             |
| Paternal presence                        | 14.5          | 1.56 (1.44–1.70)***             |
| Maternal alcohol use                     | 20.2          | 1.78 (1.37–2.33)***             |
| Maternal tobacco use                     | 18.4          | 1.55 (1.40–1.71)***             |
| Maternal illicit drug use                | 33.7          | 3.38 (2.88–3.98)***             |
| Low birth weight (≤2500 grams)           | 67.5          | 34.30 (31.34–37.55)***          |
| Adequacy of prenatal care                |               |                                 |
| Inadequate/intermediate                  | 9.3           | 1.58 (1.42–1.76)***             |
| Adequate                                 | 5.4           | 1.0                             |
| Adequate plus                            | 25.6          | 6.55 (5.96–7.20)***             |
| Previous preterm birth                   | 32.1          | 3.39 (2.49–4.61)***             |
| Pregnancy complications                  | 19.2          | 1.86 (1.72–2.02)***             |
| Parity                                   |               |                                 |
| No previous live births                  | 11.5          | 1.0                             |
| Previous live birth – living             | 12.9          | 1.07 (0.99–1.14)                |
| Previous live birth – dead               | 22.2          | 2.04 (1.63–2.55)***             |
| Percent residents in poverty             |               |                                 |
| Low                                      | 9.2           | 1.0                             |
| Medium                                   | 13.0          | 1.53 (1.36–1.73)***             |
| High                                     | 14.9          | 1.75 (1.54–1.99)***             |
| Average violence rate                    |               |                                 |
| Low                                      | 10.6          | 1.0                             |
| High                                     | 14.1          | 1.41 (1.25–1.58)***             |

Notes: **p-value <0.001.
***p-value <0.0001.
Table 3. Multilevel regression models analyzing community and individual variables associated with preterm birth among Black women.

| Characteristic               | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|------------------------------|---------|---------|---------|---------|---------|
|                              | OR      | 95% CI  | OR      | 95% CI  | OR      | 95% CI  | OR      | 95% CI  | OR      | 95% CI  |
| Ethnicity                    |         |         |         |         |         |         |         |         |         |         |
| Hispanic                     | 0.91    | 0.34–2.46 | 0.94    | 0.35–2.53 | 0.81    | 0.26–2.54 | 0.83    | 0.27–2.61 | 0.84    | 0.27–2.64 |
| Education                    |         |         |         |         |         |         |         |         |         |         |
| <High school                 | 1.46*   | 1.30–1.65 | 1.33*   | 1.17–1.50 | 1.65*   | 1.45–1.88 | 1.62*   | 1.42–1.86 | 1.59*   | 1.39–1.82 |
| High school                  | 1.22*   | 1.09–1.36 | 1.17*   | 1.05–1.30 | 1.34*   | 1.19–1.50 | 1.32*   | 1.18–1.49 | 1.31*   | 1.16–1.47 |
| Maternal age                 |         |         |         |         |         |         |         |         |         |         |
| [+ 10 year]                  | 1.46*   | 1.36–1.56 | 1.32*   | 1.23–1.42 | 1.28*   | 1.18–1.39 | 1.23*   | 1.13–1.33 | 1.23*   | 1.13–1.34 |
| Paternal presence            |         |         |         |         |         |         |         |         |         |         |
| Yes vs. No                   | 1.30*   | 1.16–1.47 | 1.23*   | 1.09–1.38 | 1.40*   | 1.23–1.58 | 1.41*   | 1.24–1.60 | 1.39*   | 1.22–1.58 |
| Maternal drug use            |         |         |         |         |         |         |         |         |         |         |
| Yes vs. No                   | 2.45*   | 2.02–2.97 | 3.12*   | 2.54–3.84 | 3.03*   | 2.46–3.73 | 3.04*   | 2.48–3.72 |         |         |
| Maternal alcohol use         |         |         |         |         |         |         |         |         |         |         |
| Yes vs. No                   | 0.97    | 0.69–1.36 | 1.05    | 0.74–1.49 | 1.04    | 0.73–1.48 |         |         |         |         |
| Maternal smoking             |         |         |         |         |         |         |         |         |         |         |
| Yes vs. No                   | 1.15*   | 1.01–1.30 | 1.23*   | 1.08–1.41 | 1.23*   | 1.08–1.41 | 1.23*   | 1.07–1.40 |         |         |
| Adequacy of prenatal care    |         |         |         |         |         |         |         |         |         |         |
| Inadequate                   | 1.31*   | 1.16–1.48 | 1.31*   | 1.16–1.49 | 1.31*   | 1.15–1.48 |         |         |         |         |
| Adequate                     | 1.0     |         |         |         |         |         | 6.63*   | 5.93–7.41 | 6.43*   | 5.75–7.19 | 6.44*   | 5.76–7.21 |
| Adequate plus                | 1.0     |         |         |         |         |         |         |         |         |         |
| Pregnancy complications      |         |         |         |         |         |         |         |         |         |         |
| Yes vs. No                   | 1.57*   | 1.42–1.75 | 1.57*   | 1.42–1.75 | 1.57*   | 1.42–1.74 |         |         |         |         |
| Previous preterm             |         |         |         |         |         |         | 2.34*   | 1.54–3.54 | 2.36*   | 1.56–3.57 |         |         |
| Parity                       |         |         |         |         |         |         |         |         |         |         |
| Previous birth – alive       | 1.0     |         |         |         |         |         |         |         |         |         |
| Previous birth – dead        | 1.45*   | 1.12–1.88 | 1.44*   | 1.11–1.88 |         |         |         |         |         |         |
| No previous birth            | 0.95    | 0.86–1.05 | 0.96    | 0.87–1.06 |         |         |         |         |         |         |
| Poverty                      |         |         |         |         |         |         |         |         |         |         |
| Low                          | 1.0     |         |         |         |         |         |         |         |         |         |
| Mid                          | 1.19*   | 1.02–1.38 |         |         |         |         |         |         |         |         |
| High                         | 1.28*   | 1.07–1.52 |         |         |         |         |         |         |         |         |
| Average violence rate        |         |         |         |         |         |         |         |         |         |         |
| Low                          | 1.0     |         |         |         |         |         |         |         |         |         |
| High                         | 0.98    | 0.86–1.11 |         |         |         |         |         |         |         |         |

Note: *p-value <0.05.
Table 4. Multilevel regression models analyzing community and individual variables associated with preterm birth among White women.

| Characteristic              | Model 1        |         | Model 2        |         | Model 3        |         | Model 4        |         | Model 5        |         |
|-----------------------------|----------------|---------|----------------|---------|----------------|---------|----------------|---------|----------------|---------|
|                             | OR  | 95% CI | OR  | 95% CI | OR  | 95% CI | OR  | 95% CI | OR  | 95% CI | OR  | 95% CI |
| Ethnicity                   |     |        |     |        |     |        |     |        |     |        |     |        |
| Hispanic                    | 0.67 | 0.53–0.86 | 0.73 | 0.56–0.94 | 0.94 | 0.71–1.24 | 1.01 | 0.76–1.33 | 0.99 | 0.75–1.30 |
| Education                   |     |        |     |        |     |        |     |        |     |        |     |        |
| <High school                | 1.69 | 1.31–2.19 | 1.59 | 1.22–2.07 | 2.09 | 1.57–2.76 | 2.37 | 1.77–3.17 | 2.27 | 1.68–3.05 |
| High school                 | 1.29 | 1.03–1.62 | 1.22 | 0.97–1.55 | 1.43 | 1.12–1.82 | 1.53 | 1.19–1.96 | 1.48 | 1.15–1.90 |
| >High school                | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    |
| Maternal age                |     |        |     |        |     |        |     |        |     |        |     |        |
| [+ 10 year]                 | 1.10 | 0.95–1.27 | 1.09 | 0.94–1.26 | 1.03 | 0.88–1.19 | 1.13 | 0.96–1.32 | 1.15 | 0.98–1.34 |
| Paternal presence           |     |        |     |        |     |        |     |        |     |        |     |        |
| Yes vs. No                  | 1.34 | 1.10–1.62 | 1.30 | 1.07–1.57 | 1.50 | 1.23–1.84 | 1.51 | 1.23–1.86 | 1.47 | 1.20–1.81 |
| Maternal drug use           |     |        |     |        |     |        |     |        |     |        |     |        |
| Yes vs. No                  | 1.93 | 1.03–3.65 | 2.60 | 1.32–5.11 | 2.45 | 1.24–4.84 | 2.42 | 1.22–4.77 |
| Maternal alcohol use        |     |        |     |        |     |        |     |        |     |        |     |        |
| Yes vs. No                  | 1.00 | 0.54–1.85 | 0.99 | 0.52–1.87 | 1.05 | 0.55–1.99 | 1.12 | 0.85–1.47 |
| Maternal smoking            |     |        |     |        |     |        |     |        |     |        |     |        |
| Yes vs. No                  | 1.19 | 0.92–1.54 | 1.08 | 0.82–1.42 | 1.13 | 0.86–1.48 | 1.12 | 0.85–1.47 |
| Adequacy of prenatal care   |     |        |     |        |     |        |     |        |     |        |     |        |
| Inadequate                  | 1.35 | 1.04–1.75 | 1.37 | 1.05–1.78 | 1.37 | 1.05–1.78 | 1.37 | 1.05–1.78 |
| Adequate                    | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    |
| Adequate plus               | 7.69 * | 6.32–9.35 | 7.49 * | 6.15–9.13 | 7.52 * | 6.17–9.17 | 7.52 * | 6.17–9.17 |
| Pregnancy complications     |     |        |     |        |     |        |     |        |     |        |     |        |
| Yes vs. No                  | 1.39 | 1.15–1.67 | 1.39 | 1.15–1.67 | 1.39 | 1.15–1.67 | 1.39 | 1.15–1.67 |
| Previous preterm            |     |        |     |        |     |        |     |        |     |        |     |        |
| Yes vs. No                  | 3.80 | 2.07–6.95 | 3.83 | 2.09–7.02 |
| Parity                      |     |        |     |        |     |        |     |        |     |        |     |        |
| Previous birth – alive      | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    |
| Previous birth – dead       | 1.28 | 0.62–2.63 | 1.25 | 0.61–2.57 |
| No previous birth           | 1.45 | 1.23–1.71 | 1.46 | 1.24–1.72 |
| Poverty                     |     |        |     |        |     |        |     |        |     |        |     |        |
| Low                         | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    | 1.0  | 1.0    |
| Mid                         | 1.26 | 1.02–1.55 | 1.27 | 0.95–1.71 |
| High                        | 1.0  | 1.0    | 0.98 | 0.78–1.23 |
| Average violence rate       |     |        |     |        |     |        |     |        |     |        |     |        |
| Low                         | 1.0  | 1.0    | 1.0  | 1.0    |
| High                        | 1.0  | 1.0    | 0.98 | 0.78–1.23 |

Note: *p-value <0.05.
Considering that White women in this dataset are more educated, it is possible that they were afraid of the stigma attached to smoking during pregnancy. However, data regarding these variables were not available for further investigation. Prior infant death is a risk factor for Blacks but not for Whites. A recent study has also reported that African American women tend to have increased odds of poor birth outcomes in subsequent pregnancies (Masho & Archer, 2011). Potential reasons include poor lifestyle behaviors, intergenerational influences, and genetic factors. Although the reasons for these differences between Blacks and Whites are unclear, these multilevel models demonstrate the complex relationship between the individual and their environment, and highlight some of the important predictors of preterm birth for both populations.

Although the relationship between individual level factors including demographic, lifestyle behaviors, access to prenatal care, and reproductive factors with preterm births are well documented, the influence of community factors were not well investigated. The percentage of block group residents living in poverty was found to be a significant factor for preterm birth in both White and Black women. However, the differential relationships between poverty level and preterm birth may demonstrate the fundamental disparity in birth outcomes for this population. Very few White women resided in block groups with the highest level of poverty compared to Black women (12.9% vs. 44.3%, respectively), which may explain the non-significant association between the highest poverty level and preterm birth observed for White women. Poverty level and lower socioeconomic conditions are well-known risk factors for adverse birth outcomes (Collins et al., 1998; Diez-Roux, 2001; Masi et al., 2007; O’Campo et al., 1997; Pearl et al., 2001; Pickett & Pearl, 2001; Roberts, 1997; Schempf et al., 2009; Spong et al., 2011). Poverty and poor social status are mostly coupled with stressful events. Studies have indicated that high levels of chronic stress are associated with the release of stress hormones that may lead to preterm births (Cha & Masho, 2013). Additionally, chronic stress is linked to inflammatory reaction that may be responsible for preterm births. While many of the significant individual factors act through biological pathways that result in adverse birth outcomes, such as illicit drug use, the prevalence of these risk factors is typically higher among women with lower socioeconomic status (Nkansah-Amankra, 2010). In addition, barriers to prenatal care exist for many women with lower socioeconomic status, since these women are more likely to be uninsured or have difficulty accessing healthcare services. This was demonstrated by the strong association between inadequate prenatal care and preterm births reported in this study. It is also important to note that this study found that women who reported adequate plus prenatal care were over six times more likely to have preterm birth. The adequate plus category consists of women who usually are identified as having high risk pregnancies. These women receive more frequent prenatal visits than women with normal pregnancies (Kotelchuck, 1994). Although our study controlled for some high risk medical conditions that were identified in the birth certificate data, there were other factors that may lead to high risk pregnancies that this study was not able to control for.

Vital records for births in Virginia do not record marital status or income; however, paternal presence (or the presence of paternal signature) functions as a proxy for both, albeit an increasingly outdated measure of family structure (Masho, Chapman, & Ashby, 2010). It can be assumed for research purposes that the lack of paternal signature on the birth certificate indicates that the women are unmarried and, therefore, the family’s income is likely lower than that of a family where a father is contributing income to the household. However, it is possible that many of these families receive
financial or social support from the father. Regardless of the limitations associated with using paternal presence, it was found to be a significant predictor of preterm birth.

Consistent with the literature, this study reported that block group poverty level is a risk factor for preterm birth (Masi et al., 2007; Messer et al., 2006; Nkansah-Amankra, 2010). Unlike our analysis, other studies have reported the association between neighborhood crime and poor birth outcomes (Collins & David, 1997; Messer et al., 2006; Papacek, Collins, Schulte, Goergen, & Drolet, 2002). Adverse birth outcomes were found to be significantly associated with crime rates and the level of neighborhood impoverishment in geographically defined areas in Chicago, IL (Collins & David, 1997; Papacek et al., 2002). Neighborhood crime rates and economic deprivation were also significantly associated with higher preterm birth rates for all races (Messer et al., 2006). Our results support a similar conclusion regarding preterm births in that increases in the percentage of residents living in poverty increased the risk of preterm birth; however, the average violence rate was not found to be significant. Messer et al. (2006) investigated the link between preterm birth, neighborhood deprivation and crime in North Carolina. Their analysis reported that as the level of neighborhood deprivation increased, adverse birth outcomes also rose, similar to the results found in this study. While their measure of neighborhood deprivation was calculated by principal components analysis using Census variables, the analysis presented here looks at these variables individually to determine predictors of preterm birth. Their use of crime reports, rather than ambulance pickups, may provide a larger sample size of incidents which perhaps explains why our measure of violence was not a significant risk factor for adverse birth outcomes.

An ecological study conducted by Paul, Mackley, Locke, Stefano, and Kroelinger (2009) reported that the state level factors associated with infant mortality were the percentage of mothers with non-Hispanic African ancestry, tobacco use, and adolescent birth rate, which is consistent with many of our findings. However, since our multilevel analysis included data on individual demographics and behaviors, our findings are more robust and the results can be used to make inferences about the association on the individual and population levels.

Maternal race of African American is one of the major risk factor for adverse birth outcomes and these racial disparities have been thoroughly investigated by epidemiologic studies (Alio et al., 2010; Collins et al., 1998; March of Dimes, 2013; Masho et al., 2011; Papacek et al., 2002; Spong et al., 2011). Despite a multitude of research, the exact reason for the disparity of birth outcomes remains unclear. This current research investigated community level factors and reported that low socioeconomic conditions were associated with adverse birth outcome. Furthermore, this research reported significant risk factors at both the individual and community levels that are involved with preterm birth, which point to a more complex relationship between the mother and her community, particularly among African Americans predisposed to higher levels of adverse environmental conditions.

Most of the individual factors identified in this study are modifiable. While some of the risk factors, such as smoking or substance use, are seemingly easier to address, community level factors are complex. Although there are many public policies aimed at decreasing poverty rates or unemployment rates, most of these issues are not viewed as a public health problem. However, a plethora of research, including the present study, provides evidence that the social environment may influence birth outcomes as much as maternal behaviors (Alio et al., 2010; Collins & David, 1997; Collins et al., 1998; Diez-Roux, 2001; Grewal, Carmichael, Song, & Shaw, 2009; Masi et al., 2007; Messer et al., 2006;
Nkansah-Amankra, 2010; O’Campo et al., 1997; Papacek et al., 2002; Paul et al., 2009; Pearl et al., 2001; Pickett & Pearl, 2001; Roberts, 1997; Schempf et al., 2009).

This study has several strengths and limitations. A major strength of this study was using 10 years of birth records which allowed us to investigate racial differences using a large sample size. It is possible that we are able to identify small differences due to the large sample size. However, the findings of this study are consistent with those of others (Alio et al., 2010; Collins & David, 1997; Collins et al., 1998; Grewal et al., 2009; March of Dimes, 2013; Masi et al., 2007; Messer et al., 2006; Nkansah-Amankra, 2010; O’Campo et al., 1997; Papacek et al., 2002; Pearl et al., 2001; Roberts, 1997; Spong et al., 2011). Conversely, the lack of statistical significance between age, smoking, previous death, and preterm birth could be due to the small number of Whites in these groups. Our community level analysis included variables which were analyzed separately, as opposed to prior literature that created a combination variable of economic deprivation (Masi et al., 2007; Papacek et al., 2002). Although creation of composite variables may be statistically robust, it is often difficult for public health providers to disentangle these scores and utilize them to design programs.

Another limitation of this study was the measurement of violent crime rate in each block group using the rate of ambulance pickups, rather than using police records of violent crimes which were not available at the time of this study. Unfortunately, the ambulance data were only available from 2001 through 2007 instead of our entire study period. Although we believe that our estimate of the average violent crime-related ambulance pickups per block group was a reasonable estimate of the relative safety, it is nonetheless a limitation of this study. Our conservative estimate of violent crime was not significant in the models; however, this underestimation may hide a true association between violent crime and adverse birth outcomes which had been found by other researchers (Collins & David, 1997; Masi et al., 2007; Messer et al., 2006).

In conclusion, this research illuminates individual and community risk factors associated with adverse birth outcomes. These results are important to understanding the mechanisms of poor birth outcomes in relation to the social environment of the mother. Existing literature suggests that perinatal disparities cannot not be fully explained by individual factors. This study attempted to evaluate selected community and individual level factors that influence birth outcomes (Alio et al., 2010). This understanding will allow the development of strategies aimed at improving health based upon the complex relationships of individuals and their environment (Diez-Roux, 2001).

In addition to the well-known individual level factors, this study investigated the influence of less explored community level factors including poverty and violence that are ravaging our inner city communities. This study demonstrates that preterm birth is influenced by social factors and requires multidisciplinary solutions. Although great strides have been made in developing state-of-the-art clinical interventions, the medical framework alone cannot address the root causes of these problems. To successfully eliminate disparities, it is important to engage stakeholders in urban development to address these community level issues. Further, public health programs should target the modifiable risk factors such as smoking, drug abuse, and poverty identified by this study and design interventions to improve pregnancy outcomes. Public health programs should also recognize the spatial impact that influences adverse birth incomes and its differential effect on African American mothers. Furthermore, poverty is a factor that requires multisectoral collaborations (Maso et al., 2011). It is important and timely to create forums bringing together different sectors such as housing authorities, urban
planners, public transportation, education, and health to address the issue of preterm birth in urban settings.

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