



# SCHS Studies

A Special Report Series by the State Center for Health Statistics  
1908 Mail Service Center, Raleigh, N.C. 27699-1908  
[www.schs.state.nc.us/SCHS/](http://www.schs.state.nc.us/SCHS/)

No. 148

November 2005

## Neighborhood-Level Characteristics as Predictors of Preterm Birth: Examples from Wake County, North Carolina

by

Lynne C. Messer, Paul A. Buescher, Barbara A. Laraia, Jay S. Kaufman

### ABSTRACT

**Objectives:** This study uses recent North Carolina data to demonstrate that multiple factors influence preterm birth risk, and particularly to show the effect of neighborhood context on the incidence of preterm birth. Previous studies have shown that neighborhood environments influence health, even after adjustment for individual characteristics and behaviors.

**Methods:** Approximately 24,300 1999-2001 singleton live birth records for white non-Hispanic and African American non-Hispanic residents of Wake County, North Carolina were used in the analysis. Addresses from the birth certificates were geo-coded to census tracts and tract-level variables from the 2000 U.S. Census were used as measures of the neighborhood environment. Four neighborhood indexes were created from the census tract measures: neighborhood education, residential stability, neighborhood poverty, and neighborhood deprivation. A random effects multivariate regression model was used to estimate the effect of these neighborhood-level factors on preterm birth, controlling for three individual-level characteristics: maternal age, education, and marital status.

**Results:** White women residing in a census tract with the lowest level of education had an odds of preterm birth 1.47 times that for white women residing in a census tract with the highest level of education. This relationship was statistically significant at the 95 percent confidence level and independent of the three individual-level risk factors that were controlled in the regression model. Other results showed a significantly higher odds of preterm birth among African Americans who live in neighborhoods with higher poverty levels, and a significantly higher odds of preterm birth among whites who reside in neighborhoods with the highest level of deprivation.

**Conclusions:** Disadvantaged neighborhoods are associated with a higher odds of preterm birth, even after adjusting for individual risk factors. Neighborhoods are units where interventions can be targeted. Improving women's health through neighborhood interventions can be an effective way to reduce adverse birth outcomes. Structural changes may have a stronger effect on health than programs designed to modify individual behaviors or risk factors.

---

*Note:* Paul Buescher works at the State Center for Health Statistics. The other three authors are affiliated with the Carolina Population Center at the University of North Carolina at Chapel Hill. This paper is one product of the collaborative North Carolina Birth Outcomes Project (NC-BOP), funded by the federal Maternal and Child Health Bureau.



NORTH CAROLINA DEPARTMENT OF HEALTH AND HUMAN SERVICES

## Introduction

Low birth weight is a major contributor to infant mortality in North Carolina. Among low birth weight babies (under 2,500 grams, or under 5 lb. 9 oz.) the infant death rate is 66 deaths per 1,000 live births. This compares to an infant death rate of 2.4 among normal birth weight babies (2,500 grams or more). During the past decade in North Carolina, the percentage of births that are low birth weight has increased, from 8.7 percent in 1993 to 9.0 percent in 2003.

The major cause of low birth weight is preterm delivery, usually defined as a delivery at less than 37 weeks gestation. In North Carolina in 2003, more than 13 percent of live births were delivered at less than 37 weeks gestation. Previous studies have shown that a number of individual-level risk factors are strong predictors of a preterm birth, e.g., low maternal education, late initiation of prenatal care, and being unmarried. Also, African American women have a much higher rate of preterm birth than white women, independently of other measured risk factors. Traditionally protective factors such as college education and access to quality prenatal care do not provide the same level of protection against adverse birth outcomes for African American women as for white women. African American and white women at high levels of education (i.e., college and beyond) have a larger gap in the rate of adverse birth outcomes than African American and white women at lower educational levels.<sup>1-3</sup>

Most studies of preterm birth and other adverse birth outcomes have focused on individual-level risk factors. This is partly because these risk factors are easily derived from information collected on live birth certificates and captured in electronic data bases. Researchers estimate that 25-30 percent of preterm births in developed countries can be “explained” by known risk factors,<sup>4</sup> but many of these risk indicators offer limited guidance for preventive measures. However, there is increasing awareness that the **neighborhood environment** of women of childbearing age also influences reproductive outcomes, independently of individual risk factors.

Perinatal research demonstrates modest but consistent effects of neighborhood-level socioeconomic deprivation on pregnancy outcomes.<sup>4-7</sup> Lower birth

weights have been associated with higher rates of neighborhood poverty,<sup>8-10</sup> higher unemployment,<sup>10,11</sup> lower median rent costs,<sup>8</sup> and lower neighborhood educational and income levels.<sup>8,10,12</sup> Differences in neighborhood-level exposures may partially account for the disparity between African American and white women’s preterm birth rates, beyond individual risk factors. For example, in one study African American women residing in wealthier neighborhoods were found to have a reduced risk of preterm birth.<sup>13</sup> Another study showed that the association of early prenatal care initiation with better birth weights was weaker in neighborhoods with high unemployment rates.<sup>11</sup>

There is good evidence that neighborhood environments influence health, even after adjustment for individual characteristics and behaviors.<sup>8-10,11,13</sup> Neighborhoods can influence health through social, socioeconomic, physical infrastructure, and community resource mechanisms.<sup>14</sup> Neighborhood stability and collective efficacy (or social capital), for example, may be protective mechanisms that improve individual birth outcomes.<sup>15</sup> Neighborhood deprivation or concentrated poverty may lead to poor birth outcomes. Neighborhoods can contain resources, such as parks, clinics, and grocery stores, that promote good health. As stated by Pickett and Pearl,<sup>16</sup> “by drawing public health attention to the health risks associated with the social structure and ecology of neighborhoods, innovative approaches to community level interventions may ensue.”

The purpose of the present study is to use recent North Carolina data to demonstrate that multiple factors influence preterm birth risk, and particularly to show the effect of neighborhood context on the incidence of preterm birth.

## Methods

We used 1999-2001 singleton live birth records for residents of Wake County, North Carolina. Less than one percent of these records were missing information on gestational age so that preterm birth status could not be determined. These records were excluded from the analysis. The address on the birth certificate record was used to geo-code the record to a specific census tract. The census tract level of aggregation was chosen to

ensure a rough approximation of each woman's immediate neighborhood. Census tracts are small, relatively permanent statistical subdivisions of counties, designed to be relatively homogenous with respect to sociodemographic characteristics and living conditions, and contain on average 4,000 residents.<sup>17</sup> Previous research confirms the validity of the census tract unit of aggregation in birth outcome research.<sup>18</sup>

Tract-level data from the 2000 Census were merged with each live birth record. Census variables are aggregated individual characteristics used to approximate the neighborhood sociodemographic environment. Examples of the census-tract measures that were merged with the birth records are: percent of households below the 1999 federal poverty level, percent of households on public assistance, percent of households that are female-headed with dependent children, percent of households with owner/renter expenses greater than 50 percent of household income, percent of males and females who are unemployed, percent of persons with less than a high school degree, percent of households with income less than \$30,000, percent of families who own their home, percent of families in same house since 1995, and median value of owner-occupied house.

This paper illustrates results for the effects of neighborhood-level education, residential stability, poverty, and deprivation. These neighborhood measures were selected because of their potential as modifiable neighborhood conditions that may influence health through policy-relevant pathways. These neighborhood-level influences are estimated separately in a random effects multivariate logistic regression model, controlling for three individual-level characteristics: maternal age, education, and marital status. Odds ratios and ninety-five percent confidence intervals for preterm birth are shown for categories of the predictor variables, with the lowest risk category of each variable as a reference group (odds ratio = 1.00). If the confidence interval does not include 1.00, then the odds ratio is statistically different from 1.00 at the 95 percent confidence level.

The single-item census variable, percent of households with individuals earning less than a high school degree, was used to approximate neighborhood education level. A composite measure for neighborhood residential

stability was constructed from two census tract variables: percent of the population over age 64 and percent of households in the same house since 1995. Higher values on these variables indicate more stability. The neighborhood poverty index is a composite measure that incorporates six census tract variables: percent of total population in poverty, percent of households that are female-headed with dependent children, percent of households with income less than \$30,000, percent of households on public assistance, percent of households with no vehicle, and percent of households with no telephone.

The neighborhood deprivation index is a composite measure of neighborhood health that incorporates ten census tract measures representing four sociodemographic domains. The domain of poverty is represented by the percent of households below the 1999 federal poverty level, percent of households on public assistance, percent of households that are female-headed with dependent children, percent of households with income less than \$30,000, percent of households with owner/renter expenses in excess of 50 percent of income, percent of home owners with no car, and percent of home owners with no telephone. The housing domain is represented by the median household value. The education domain is represented by the percent of individuals who did not complete high school, and the employment domain is represented by the unemployment rate. These measures were selected from many highly correlated census variables using principal components analysis. This is a statistical technique used to identify underlying dimensions within a set of variables and assign weights for each of the variables that comprise a dimension.

For neighborhood-level education, residential stability, poverty, and deprivation, the census tract proportions were categorized into four groups (quartiles). The 4th quartile indicates the worst neighborhood category (e.g., highest tract proportions of individuals with less than 12 years of education) and the 1st quartile indicates the best neighborhood category.

Analyses were stratified by race and limited to non-Hispanic whites and non-Hispanic African Americans, due to the small numbers of women of other races and ethnicities. A multilevel logistic modeling approach was undertaken to explore the contribution of the

neighborhood environment to preterm birth in addition to that of individual-level predictors, and to account for any clustering of the birth outcomes. The multilevel model used a fixed slope to estimate the constant effect of neighborhood attributes across the neighborhoods and a random intercept to allow the intercept, or baseline risk, to vary across the census tracts. Odds ratios for preterm birth are shown for categories of the predictor variables, with the lowest risk category of each variable as a reference group (odds ratio = 1.00). An odds ratio of 1.50 for women living in census tracts characterized by lower education, for example, indicates that the odds of preterm birth is 50 percent higher for this group compared to the reference group of census tracts with the highest education levels (the 1st quartile). Analyses were conducted in Stata 8.2.

## Results

Table 1 shows the range of values and the mean value on a number of variables for the 115 census tracts in Wake County. These results show a wide variety of

neighborhood characteristics across these geographic areas of the county. While the average census tract population in Wake County is about 4,000, the census tract populations range from 34 to 13,944.

Table 2 shows the distribution of selected individual and neighborhood characteristics within the sample of Wake County singleton live births during 1999-2001. There were 17,983 non-Hispanic white births in the sample and 6,304 non-Hispanic African American births in this three-year period.

For non-Hispanic whites, 6.9 percent of singleton live births were preterm, compared to 12.4 percent for non-Hispanic African Americans. African American mothers were much more likely to be under age 20 and much less likely to be age 30 and older, compared to white mothers. African Americans had lower education levels and were much more likely to be unmarried. African American women were more likely to reside in census tracts characterized by lower education levels, lower residential stability, higher levels of poverty, and more neighborhood deprivation.

**Table 1:** Range and Mean Value for Selected Census-Based Neighborhood Traits for 115 Wake County Census Tracts

Census-based Neighborhood Traits	Range	Mean
% Families below 1999 poverty level	0.0-67.9	9.5
% Families on public assistance	0.0-22.4	2.1
% Female-headed household with children	0.0-68.4	10.8
% Owner/renter expenses > 50% of income	0.0-100.0	22.3
% Families with income < \$30,000	0.0-89.3	20.1
% No vehicle	0.0-56.5	2.8
Median owner occupied house value	\$57,300-738,800	\$165,697
% Unemployed	0.0-62.8	4.3
% Not high school graduates	0.0-55.8	13.1
% Families own residence	1.0-100.0	65.1
% Families in same house since 1995	14.8-75.3	45.0
% White non-Hispanic	0.0-100.0	70.4

**Table 2:** Percentage Distributions of Selected Individual and Neighborhood Characteristics for 1999-2001 Wake County, North Carolina Singleton Live Births, by Race of Mother

	Non-Hispanic White	Non-Hispanic African American
	Percent	Percent
<b>Individual characteristics</b>		
Preterm birth	6.9	12.4
<i>Maternal age</i>		
<20 years	2.7	12.8
20-24 years	10.2	12.8
25-29 years	27.2	26.3
30-34 years	38.1	19.9
35+ years	21.8	12.2
<i>Maternal education</i>		
> high school	82.8	51.2
= high school	13.0	31.4
< high school	4.2	17.4
<i>Maternal marital status</i>		
Not married	8.7	55.4
Married	91.3	44.6
<b>Neighborhood characteristics</b>		
4th quartile < 12 years education (highest)	26.6	40.1
3rd quartile < 12 years education	29.9	36.1
2nd quartile < 12 years education	32.4	14.9
1st quartile < 12 years education (lowest)	11.1	8.9
4th quartile residential stability (lowest stability)	13.2	21.1
3rd quartile residential stability	25.7	22.5
2nd quartile residential stability	29.6	33.3
1st quartile residential stability (highest stability)	31.6	23.0
4th quartile poverty (highest)	7.9	42.7
3rd quartile poverty	24.0	29.3
2nd quartile poverty	31.0	19.7
1st quartile poverty (lowest)	37.1	8.3
4th quartile (high deprivation)	7.1	42.3
3rd quartile	25.6	27.8
2nd quartile	32.7	22.3
1st quartile (low deprivation)	34.7	7.6

Tables 3, 4, 5, and 6 present the results from the logistic regression models for the neighborhood measures of low education, residential stability, poverty, and neighborhood deprivation, adjusted for maternal age, education, and marital status.

Table 3 shows that white women residing in a census tract with the lowest level of education had an odds of preterm birth 1.47 times that for white women residing in a census tract with the highest level of education. This relationship was statistically significant at the 95 percent confidence level. This relationship of neighborhood education level with preterm birth is independent of the individual-level risk factors that are controlled in the logistic regression model (maternal age, education, and marital status). For African American women, neighborhood education level was not significantly associated with preterm birth. Table 3 also shows that the odds of preterm birth increase steadily with age for African American women and that lower education (at the individual level) and being

unmarried significantly increase the odds of preterm birth for African American women.

Tables 4, 5, and 6 indicate a similar pattern of relationships between the individual risk factors and preterm birth. Residential stability is a neighborhood characteristic hypothesized to be protective against ill health and adverse birth outcomes. However, these data show no statistically significant association between residential stability and preterm birth. A significantly higher odds of preterm birth among African American women who live in neighborhoods with higher poverty levels was observed, while for white women the odds ratio was 1.24 but not quite statistically significant. High levels of neighborhood deprivation were associated with an increased odds of preterm birth among white women. The magnitude of the association between high neighborhood deprivation and preterm birth was greater for African American women (odds ratio = 1.48), but did not quite achieve statistical significance.

**Table 3: Adjusted Odds Ratios<sup>1</sup> and 95% Confidence Intervals for Preterm Birth: Neighborhood-level Education (1999-2001 Wake County, North Carolina Singleton Live Births)**

Predictor variables	Non-Hispanic Whites	Non-Hispanic African Americans
4th quartile < 12 years education (highest)	1.47* (1.20, 1.81)	1.21 (0.88, 1.67)
3rd quartile < 12 years education	1.22* (1.04, 1.44)	1.26 (0.92, 1.72)
2nd quartile < 12 years education	1.08 (0.92, 1.28)	1.01 (0.71, 1.45)
1st quartile < 12 years education (lowest)	1.00 (reference group)	1.00 (reference group)
<20 years	1.10 (0.76, 1.60)	0.69* (0.52, 0.92)
20-24 years	1.00 (reference group)	1.00 (reference group)
25-29 years	1.19 (0.95, 1.49)	1.30* (1.04, 1.62)
30-34 years	1.01 (0.81, 1.26)	1.65* (1.30, 2.10)
35+ years	1.15 (0.91, 1.46)	2.05* (1.57, 2.69)
> high school	1.00 (reference group)	1.00 (reference group)
= high school	1.28* (1.07, 1.52)	1.36* (1.13, 1.64)
< high school	1.25 (0.92, 1.71)	1.89* (1.48, 2.41)
Not married	1.20 (0.96, 1.50)	1.49* (1.24, 1.79)
Married	1.00 (reference group)	1.00 (reference group)

<sup>1</sup> An asterisk (\*) denotes that the odds ratio is statistically different from 1.00 at the 95% confidence level.

**Table 4:** Adjusted Odds Ratios<sup>1</sup> and 95% Confidence Intervals for Preterm Birth: Residential Stability (1999-2001 Wake County, North Carolina Singleton Live Births)

Predictor variables	Non-Hispanic Whites	Non-Hispanic African Americans
4th quartile stability (unstable)	0.89 (0.71, 1.07)	1.25 (0.99, 1.57)
3rd quartile stability	1.13 (0.97, 1.32)	1.04 (0.82, 1.33)
2nd quartile stability	1.08 (0.88, 1.19)	1.01 (0.81, 1.26)
1st quartile stability (stable)	1.00 (reference group)	1.00 (reference group)
<20 years	1.08 (0.75, 1.57)	0.69* (0.52, 0.92)
20-24 years	1.00 (reference group)	1.00 (reference group)
25-29 years	1.18 (0.95, 1.47)	1.30* (1.04, 1.62)
30-34 years	0.99 (0.79, 1.23)	1.64* (1.29, 2.08)
35+ years	1.18 (0.88, 1.41)	2.04* (1.56, 2.67)
> high school	1.00 (reference group)	1.00 (reference group)
= high school	1.33* (1.12, 1.58)	1.37* (1.14, 1.65)
< high school	1.33 (0.98, 1.82)	1.90* (1.50, 2.41)
Not married	1.22 (0.97, 1.52)	1.48* (1.23, 1.78)
Married	1.00 (reference group)	1.00 (reference group)

<sup>1</sup>An asterisk (\*) denotes that the odds ratio is statistically different from 1.00 at the 95% confidence level.

**Table 5:** Adjusted Odds Ratios<sup>1</sup> and 95% Confidence Intervals for Preterm Birth: Neighborhood Poverty (1999-2001 Wake County, North Carolina Singleton Live Births)

Predictor variables	Non-Hispanic Whites	Non-Hispanic African Americans
4th quartile poverty (highest)	1.24 (0.99, 1.55)	1.53* (1.08, 2.16)
3rd quartile poverty	1.14 (0.98, 1.34)	1.34 (0.95, 1.93)
2nd quartile poverty	1.03 (0.89, 1.20)	1.50* (1.04, 2.16)
1st quartile poverty (lowest)	1.00 (reference group)	1.00 (reference group)
<20 years	1.09 (0.75, 1.59)	0.70* (0.52, 0.93)
20-24 years	1.00 (reference group)	1.00 (reference group)
25-29 years	1.18 (0.95, 1.48)	1.30* (1.04, 1.62)
30-34 years	1.00 (0.80, 1.25)	1.67* (1.31, 2.12)
35+ years	1.13 (0.89, 1.44)	2.08* (1.58, 2.72)
> high school	1.00 (reference group)	1.00 (reference group)
= high school	1.31* (1.10, 1.56)	1.35* (1.12, 1.63)
< high school	1.31 (0.95, 1.49)	1.86* (1.46, 2.36)
Not married	1.19	1.46* (1.21, 1.75)
Married	1.00 (reference group)	1.00 (reference group)

<sup>1</sup>An asterisk (\*) denotes that the odds ratio is statistically different from 1.00 at the 95% confidence level.

**Table 6:** Adjusted Odds Ratios<sup>1</sup> and 95% Confidence Intervals for Preterm Birth: Neighborhood Deprivation (1999-2001 Wake County, North Carolina Singleton Live Births)

Predictor variables	Non-Hispanic Whites	Non-Hispanic African Americans
4th quartile deprivation (highest)	1.28* (1.01, 1.61)	1.48 (1.00, 2.18)
3rd quartile deprivation	1.10 (0.94, 1.29)	1.37 (0.93, 2.04)
2nd quartile deprivation	1.05 (0.90, 1.22)	1.39 (0.93, 2.08)
1st quartile deprivation (lowest)	1.00 (reference group)	1.00 (reference group)
<20 years	1.09 (0.75, 1.59)	0.69* (0.52, 0.92)
20-24 years	1.00 (reference group)	1.00 (reference group)
25-29 years	1.19 (0.95, 1.48)	1.30* (1.04, 1.62)
30-34 years	1.00 (0.80, 1.44)	1.66* (1.30, 2.11)
35+ years	1.13 (0.89, 1.44)	2.07* (1.57, 2.72)
> high school	1.00 (reference group)	1.00 (reference group)
= high school	1.31* (1.10, 1.56)	1.36* (1.12, 1.64)
< high school	1.31 (0.96, 1.78)	1.87* (1.46, 2.39)
Not married	1.19 (0.95, 1.49)	1.46* (1.21, 1.76)
Married	1.00 (reference group)	1.00 (reference group)

<sup>1</sup>An asterisk (\*) denotes that the odds ratio is statistically different from 1.00 at the 95% confidence level.

## Discussion

This study shows that neighborhood disadvantage is significantly associated with a higher odds of preterm birth, even after adjusting for individual risk factors. Another way of stating this is that if there were two groups of mothers with similar individual characteristics (age, education, marital status) living in different neighborhoods, the group living in a more disadvantaged neighborhood would have a higher risk of preterm birth. Therefore, the social and economic context in which mothers live is an important determinant of birth outcomes.

We explored the contribution of the neighborhood environment to preterm birth in addition to that of individual-level predictors. We used a multilevel logistic modeling approach to account for any clustering of the birth outcomes. While there was not evidence of any substantial clustering of the birth outcomes in this particular study, in general it is important to use the appropriate multilevel modeling techniques when combining geographic and individual-level variables in order to produce statistically valid results.

Neighborhoods are more than the aggregation of individuals who reside in them. Neighborhood characteristics such as income inequality or the quality of a school system are contextual features that go beyond the characteristics of the individuals in the neighborhood. One cannot learn about all of the important health effects by limiting research to individual risk factors.

According to Shaw and McKay’s classic 1942 work, the same socioeconomically disadvantaged areas in 21 United States cities continued to experience high delinquency rates over the span of several decades, despite changes in racial and ethnic composition. This demonstrates persistent contextual effects of these disadvantaged communities, regardless of what populations experienced them.<sup>19</sup> This work suggests that neighborhoods exert independent effects on the populations who reside in them.

Neighborhoods are units where interventions can be **targeted**. Finding a cluster of adverse birth events in a specific neighborhood could lead to locating a satellite health clinic nearby or establishing a social support



program for pregnant women there. Identifying crime hotspots in neighborhoods with many women of reproductive age could lead to increased crime patrols, the introduction of a neighborhood watch, or other neighborhood building processes. Improving women's health through neighborhood interventions can be an effective way to reduce adverse birth outcomes. Structural changes may have a stronger effect on health than programs designed to modify individual behaviors or risk factors.<sup>20</sup>

A recent March of Dimes study (2003) found that a large proportion of the population (~60%) hold women responsible for their preterm birth outcomes.<sup>21</sup> This study expands considerations of causality (and blame) away from women (or groups of women) and into the broader social and physical structures that influence health.

## References

1. Gould JB, LeRoy S. Socioeconomic status and low birth weight: a racial comparison. *Pediatrics* 1988;82:896-904.
2. Kleinman J, Kessel S. Racial differences in low birth weight. Trends and risk factors. *New England Journal of Medicine* 1987;317:749-753.
3. Starfield B, Shapiro S, Weiss J, et al. Race, family income, and low birth weight. *American Journal of Epidemiology* 1991;134:1167-1174.
4. Kramer M. Determinants of low birth weight: methodological assessment and meta-analysis. *Bulletin of the World Health Organization* 1987;65:663-737.
5. Kogan M. Social causes of low birth weight. *Journal of the Royal Society of Medicine* 1995;88:611-615.
6. Parker J, Schoendorf K, Kiely J. Associations between measures of socioeconomic status and low birth weight, small for gestational age, and premature delivery in the United States. *Annals of Epidemiology* 1994;4:271-278.
7. Wilcox M, Smith S, Johnson I, Maynard P, Chilvers C. The effect of social deprivation on birthweight, excluding physiological and pathological effects. *British Journal of Obstetrics and Gynaecology* 1995;102:918-924.
8. Roberts EM. Neighborhood social environments and the distribution of low birthweight in Chicago. *American Journal of Public Health* 1997;87:597-603.
9. Rauh V, Andrews H, Garfinkel R. The contribution of maternal age to racial disparities in birthweight: a multilevel perspective. *American Journal of Public Health* 2001;91:1808-1814.
10. Pearl M, Braveman P, Abrams B. The relationship of neighborhood socioeconomic characteristics to birthweight among 5 ethnic groups in California. *American Journal of Public Health* 2001;91:1808-1814.
11. O'Campo P, Xue S, Wang M-C, Caughy MOB. Neighborhood risk factors for low birth weight in Baltimore: a multilevel analysis. *American Journal of Public Health* 1997;87:1113-1118.
12. Ahern J, Pickett K, Selvin S, Abrams B. Preterm birth among African American and white women: a multilevel analysis of socioeconomic characteristics and cigarette smoking. *Journal of Epidemiology and Community Health* 2003;57:606-611.
13. Kaufman JS, Dole N, Savitz DA, Herring A. Modeling community-level effects on preterm birth. *Annals of Epidemiology* 2003;13.
14. Macintyre S, Ellaway A, Cummins S. Place effects on health: how can we conceptualise, operationalise and measure them? *Social Science and Medicine* 2002;55:125-139.
15. Morenoff JD. Neighborhood mechanisms and the spatial dynamics of birthweight. *American Journal of Sociology* 2003;108:976-1017.
16. Pickett KE, Pearl M. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. *Journal of Epidemiology and Community Health* 2001; 55:111-122.
17. U.S. Census Bureau. Census 2000 Summary File 1 Technical Documentation: Appendix A. Census 2000 Geographic Terms and Concepts, 2003.
18. Krieger N, Chen J, Waterman P, Soobader M-J, Subramanian S, Carson R. Choosing area based socioeconomic measures to monitor social inequalities in low birth weight and childhood lead poisoning: the Public Health Disparities Geocoding Project (US). *Journal of Epidemiology and Community Health* 2003;57:186-199.
19. Shaw C, McKay H. *Juvenile delinquency and urban areas: a study of the rates of delinquents in relation to differential characteristics of local communities in American cities*. Chicago: University of Chicago Press, 1942.
20. Yen I, Syme S. The social environment and health: a discussion of the epidemiologic literature. *Annual Review of Public Health* 1999;20:287-308.
21. Massett HA, Greenup M, Ryan CE, Staples DA, Green NS, Maibach EW. Public perceptions about prematurity: a national survey. *American Journal of Preventive Medicine* 2003;24:120-127.

**State of North Carolina**  
Michael F. Easley, Governor

**Department of Health and Human Services**  
Carmen Hooker Odom, Secretary

**Division of Public Health**  
Leah Devlin, D.D.S., M.P.H., State Health Director

**State Center for Health Statistics**  
Paul A. Buescher, Ph.D., Director

[www.schs.state.nc.us/SCHS/](http://www.schs.state.nc.us/SCHS/)



The NC Department of Health and Human Services does not discriminate on the basis of race, color, national origin, sex, religion, age or disability in employment or the provision of services.

500 copies of this public document were printed at a cost of \$176.49 or 35¢ per copy. 11/05



---

Department of Health and Human Services  
State Center for Health Statistics  
1908 Mail Service Center  
Raleigh, NC 27699-1908  
919-733-4728