Original Contribution

Transgenerational Effect of Neighborhood Poverty on Low Birth Weight Among African Americans in Cook County, Illinois

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Initially submitted July 21, 2008; accepted for publication December 5, 2008.

In perinatal epidemiology, transgenerational risk factors are defined as conditions experienced by one generation that affect the pregnancy outcomes of the next generation. The authors investigated the transgenerational effect of neighborhood poverty on infant birth weight among African Americans. Stratified and multilevel logistic regression analyses were performed on an Illinois transgenerational data set with appended US Census income information. Singleton African-American infants \( (n = 40,648) \) born in 1989–1991 were considered index births. The mothers of index infants had been born in 1956–1976. The maternal grandmothers of index infants were identified. Rates of infant low birth weight \( (<2,500 \text{ g}) \) rose as maternal grandmother’s residential environment during her pregnancy deteriorated, independently of mother’s residential environment during her pregnancy. In a multilevel logistic regression model that accounted for clustering by maternal grandmother’s residential environment, the adjusted odds ratio (controlling for mother’s age, education, prenatal care, cigarette smoking status, and residential environment) for infant low birth weight for maternal grandmother’s residence in a poor neighborhood (compared with an affluent neighborhood) equaled 1.3 (95% confidence interval: 1.1, 1.4). This study suggests that maternal grandmother’s exposure to neighborhood poverty during her pregnancy is a risk factor for infant low birth weight among African Americans.

African Americans; health status disparities; infant, low birth weight; poverty; residence characteristics; risk factors

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient.

The high rate of low birth weight \( (<2,500 \text{ g}) \) and consequent infant mortality among African Americans is a longstanding epidemiologic enigma. Emerging conceptual models emphasize the importance of African-American women’s in utero experiences as contributors to adult reproductive health (1). In perinatal epidemiology, transgenerational risk factors are defined as conditions experienced by one generation that affect the pregnancy outcomes of the next generation. In a seminal study, Lumey and Stein (2) investigated the Dutch Famine cohort and found that maternal grandmother’s exposure to extreme caloric restriction and social deprivation were negatively associated with mean infant birth weight, independently of maternal factors. Consistent with a transgenerational conceptual model of reproductive outcome, Emanuel (3) found that infant low birth weight was influenced more by the circumstances of the mother’s family during her childhood than by conditions experienced during pregnancy. The impact of transgenerational factors on the African-American infant’s birth weight disadvantage is poorly understood.

In the vast majority of metropolitan areas in the United States, the geographic separation of African Americans and whites is almost complete (4). Moreover, a disproportionately large percentage of African-American women reside in disadvantaged urban neighborhoods with concentrated poverty (4). Although it has been well documented that African-American mothers’ residence in impoverished neighborhoods is an independent risk factor for infant low birth weight (5–10), to our knowledge no published study has determined the extent to which the maternal grandmother’s exposure to neighborhood poverty during her
pregnancy is associated with infant low birth weight. This information may be particularly important for African Americans, a racial group with widespread exposure to urban impoverishment over generations.

Therefore, we designed a population-based study to determine the transgenerational effect of neighborhood poverty on infant low birth weight among African Americans in Cook County, Illinois.

**MATERIALS AND METHODS**

Illinois vital records have been computerized since 1956. A detailed description of the Illinois transgenerational data set has been previously published (11, 12). Briefly, birth certificate data tapes from the Illinois Department of Public Health for infants born in 1989–1991 were linked with the tapes of their mothers, who had been born in Illinois between 1956 and 1976. There were approximately 328,000 potentially matchable infants in the 1989–1991 cohort. On the basis of each mother’s maiden name (first and last) and exact date of birth, we successfully linked 267,303 (79%) infant birth records to mothers’ records. Failure to match records usually arose from minor spelling errors. After the linkage of maternal and infant birth certificates was complete, all identifying information on the individual mothers and their infants was removed, producing an anonymous transgenerational data set for analysis. In both generations, African-American race was defined by the mother’s race and origin (non-Hispanic) listed on the infant’s birth certificate. The study population was limited to Illinois-born singleton African-American infants of Illinois-born African-American mothers aged 15–35 years.

For 1956–1965 births to residents of Chicago (Cook County), Illinois, we appended 1960 US Census median family income data to each birth record by community area (1956–1960) or by census tract, for years for which valid tracts were available (1961–1965); for 1966–1976 births to Chicago residents, we appended 1970 US Census income data to each birth record by census tract. These values were used to estimate the environments maternal grandmothers had lived in when they had been pregnant with the mothers of index infants. Geographic codes were missing for the 1972 birth cohort, so they were excluded from this analysis. For the 1989–1991 births to Chicago residents, we appended 1990 US Census income information to each birth record according to the census tract of residence at birth; for births to women in suburban Cook County, outside of the Chicago city limits, we used the smallest available geographic unit (town, township, or village) to approximate neighborhood income. The neighborhood-level income value was used to estimate the mothers’ residential environments during their pregnancy with the index infants.

Thus, median family income in the urban community area or census tract or in the suburban town, township, or village was used to define residential environment, at the level of the smallest geographic unit available, for all Chicago-area births occurring across the 2 generations in our study. This continuous measure was initially divided into quartiles of the neighborhood income distribution for maternal grandmothers and mothers during their pregnancies, using values for women of all races. In the maternal grandmothers’ generation, median annual family income (adjusted for inflation to 1989 dollar amounts) for the lowest quartile was $10,048–$21,646; for the second quartile, it was $21,647–$27,427; for the third quartile, it was $27,428–$31,422; and for the highest quartile, it was $31,423–$104,904. In the mothers’ generation, median annual family income for the lowest quartile was $4,999–$23,425; for the second quartile, it was $23,426–$35,427; for the third quartile, it was $35,428–$45,871; and for the highest quartile, it was $45,872–$150,001. Neighborhoods in the first quartile of the distribution were empirically defined as “poor.” Neighborhoods in the second and third quartiles of the distribution were empirically defined as “medium.” Neighborhoods in the fourth quartile were empirically defined as “affluent.”

Because our primary emphasis was on the examination of neighborhood effects, we sought to avoid over-adjustment for individual characteristics. We chose maternal age, education, and prenatal-care variables because they were thought to be the major confounders and they are reliably reported on the birth certificate. We calculated the distributions of maternal age, education, and adequacy of prenatal-care utilization (13) among low birth weight and non-low birth weight infants.

The distributions of residential environments were determined among maternal grandmothers and mothers. As an initial step, to examine the relation between residence in poor neighborhoods across generations and infant birth weight, we calculated rates of infant low birth weight by maternal grandmother’s and mother’s residential environments and computed crude odds ratios and 95% confidence intervals.

To examine the relation between infant birth weight and maternal grandmother’s residence in a poor neighborhood (as compared with an affluent neighborhood), we used crossed random effects in a mixed-effects logistic regression model to simultaneously account for clustering of maternal grandmothers and mothers within neighborhoods; however, this model did not yield an estimable quantity. After accounting for clustering by neighborhood for maternal grandmothers, the SAS software that we used (PROC GLIMMIX) could not estimate the additional variance attributable to clustering at the neighborhood level for mothers and vice versa (14), probably because of the large number of unique neighborhoods at both time points (583 among maternal grandmothers and 786 among mothers).

Therefore, we constructed multilevel logistic regression models to account for the nesting of individual births (level 1) within either the mother’s (level 2) or the maternal grandmother’s (level 2) neighborhood. We first generated an intercept-only model to determine the intraclass correlation coefficient (ICC), or the proportion of the total variance in infant low birth weight that was accounted for by the maternal grandmother’s or mother’s neighborhood (level 2). The ICC was estimated from the multilevel logistic regression model using the latent variable method (15). We next examined the relation between infant birth weight and maternal grandmother’s residence in a poor neighborhood (as compared with an affluent neighborhood) in a crude
multilevel logistic regression model. Lastly, multivariable models controlling for maternal age, education, adequacy of prenatal-care utilization, and residential environment were fitted. We generated odds ratios and 95% confidence intervals from the final models by taking the antilogarithm of the beta coefficients for each independent variable and the confidence intervals for those coefficients. These analyses were conducted using PROC NLMIXED in SAS (14).

Approximately 14% (n = 5,648) of the mothers in our study population had more than one singleton pregnancy during the time period of index births (1989–1991); 5,225 mothers had 2 births, 417 had 3 births, and 6 had 4 births. Only 18% of the mothers with more than 1 birth had at least 1 low birth weight infant and 1 non-low birth weight infant. When we attempted to account for clustering of births within mothers, in addition to the clustering by mother’s and maternal grandmother’s residential environment using a 3-level mixed-effects model, the results in the model did not converge. To examine the effect of the nonindependence of successive pregnancies in the same woman, we reproduced multivariable mixed models in a restricted sample that included a randomly chosen birth from each mother who had multiple pregnancies during the generation 3 time period. These analyses were conducted using SAS PROC NLMIXED (14).

RESULTS

Table 1 shows the distribution of selected sociodemographic characteristics of African-American mothers (n = 40,648). Mothers of low birth weight infants (as compared with non-low birth weight infants) were less likely to have attended college and to have adequately utilized prenatal care.

Figure 1 shows the distribution of residential environments across generations for births to pregnant African-American women. Mother’s residential environment during her pregnancy was strongly tied to maternal grandmother’s residential environment during her pregnancy. The maternal grandmothers of approximately one-half of infants (n = 21,064) had resided in poor neighborhoods during their pregnancies; for approximately 56% of these infants (n = 11,775), the mothers had also lived in poor neighborhoods during their pregnancies. Nearly 12% of infants (n = 4,720) had maternal grandmothers who had resided in affluent neighborhoods during their pregnancies; however, fewer than 5% of these infants (n = 222) had mothers who had lived in affluent neighborhoods during their pregnancies.

Both maternal grandmother’s and mother’s residential environments were associated with rates of infant low birth weight (Figure 2). Rates of low birth weight declined as maternal grandmother’s residential environment during her pregnancy improved, regardless of mother’s residential environment during her pregnancy. Among infants with maternal grandmothers who had resided in affluent neighborhoods during pregnancy, rates of low birth weight did not increase very much as mother’s residential environment during pregnancy declined. We found no statistically significant interaction between maternal grandmother’s residential environment and mother’s residential environment when predicting infant low birth weight.

Table 2 shows the results from our multilevel regression models. In the model with maternal grandmother’s residential environment as the random effect, the crude and adjusted odds ratios (controlling for maternal age, education, prenatal-care usage, and residential environment) for infant low birth weight for maternal grandmother’s residence in a poor neighborhood (as compared with an affluent neighborhood) were 1.4 (95% confidence interval (CI): 1.3, 1.6) and 1.3 (95% CI: 1.1, 1.4), respectively. The ICC from the intercept-only model was 1.0%, indicating that a small proportion of the variance in infant low birth weight was explained at the level of the maternal grandmother’s neighborhood. In a separate multivariable, multilevel model from a restricted sample that included a randomly chosen

Table 1. Distribution (%) of Selected Maternal Characteristics Among Low Birth Weight and Non-Low Birth Weight Infants, Cook County, Illinois, 1989–1991

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>LBW Infants (n = 5,365)</th>
<th>Non-LBW Infants (n = 35,283)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age, years*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;20</td>
<td>23.1</td>
<td>26.1</td>
</tr>
<tr>
<td>20–35</td>
<td>76.9</td>
<td>73.9</td>
</tr>
<tr>
<td>Maternal education, years*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missing data</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td>&lt;12</td>
<td>39.5</td>
<td>32.5</td>
</tr>
<tr>
<td>12</td>
<td>37.0</td>
<td>37.6</td>
</tr>
<tr>
<td>&gt;12</td>
<td>22.5</td>
<td>29.0</td>
</tr>
<tr>
<td>Adequacy of prenatal-care utilization (13)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missing data</td>
<td>7.2</td>
<td>3.3</td>
</tr>
<tr>
<td>None or inadequate</td>
<td>31.6</td>
<td>29.5</td>
</tr>
<tr>
<td>Intermediate</td>
<td>15.3</td>
<td>23.6</td>
</tr>
<tr>
<td>Adequate</td>
<td>17.7</td>
<td>25.4</td>
</tr>
<tr>
<td>More than adequate</td>
<td>28.1</td>
<td>18.2</td>
</tr>
</tbody>
</table>

Abbreviation: LBW, low birth weight.
* P < 0.05.

Figure 1. Distribution of mother’s residential environment according to maternal grandmother’s residential environment, Cook County, Illinois, 1956–1976 and 1989–1991.

birth from each mother who had multiple pregnancies during the generation 3 time period, the crude and adjusted odds ratios for infant low birth weight for maternal grandmother’s residence in a poor neighborhood (as compared with an affluent neighborhood) were 1.4 (95% CI: 1.2, 1.5) and 1.2 (95% CI: 1.1, 1.4), respectively. The crude and adjusted odds ratios for maternal grandmother’s residence in a poor neighborhood and the ICC from the intercept-only model were unchanged when mother’s neighborhood was used as the level 2 variable.

DISCUSSION

This population-based investigation provides new information that maternal grandmother’s exposure to neighborhood poverty during pregnancy is a modest but stable risk factor for infant low birth weight among urban African Americans. Most strikingly, our stratified and multilevel logistic regression analyses showed that this association is independent of mother’s risk status. Further research is warranted to ascertain the mechanisms underlying the transgenerational effect of neighborhood poverty on infant birth weight.

In Cook County, Illinois, African-American mothers’ residential environments during pregnancy are tied to their own mothers’ residential environments during their pregnancies. Moreover, the percentage of infants born to African-American women who reside in affluent neighborhoods (as defined by median family census tract income in the highest quartile of the distribution) has remained very low across a generation. Given the extensive literature showing the association between mother’s residential environment during pregnancy and birth outcome (5–10), this finding has public health relevance to African-American women’s pregnancy disadvantage.

Few investigators have studied the impact of residential environment on female fetal reproductive outcomes. A study of survivors of the Dutch Famine showed that extreme caloric restriction and social deprivation among generation 1 women during pregnancy was negatively associated with the mean birth weight of generation 3 infants; measures of pathologic pregnancy outcome, such as rates of low birth weight, prematurity, and growth retardation, were not calculated (2).

The present study shows that maternal grandmother’s exposure to neighborhood poverty during her pregnancy is associated with a 20%–30% increased risk of infant low birth weight among African Americans. The underlying etiologic pathways are very unclear. Undernutrition during the maternal grandmother’s pregnancy and consequent aberrant female fetal (i.e., maternal) reproductive programming is a possible biologic mechanism (16–19). Alternatively, the stable association between maternal grandmother’s residential environment and infant low birth weight may reflect the presence of learned behaviors associated with low birth weight, such as poor diet, cigarette smoking, and alcohol intake (20, 21). Transgenerational exposures to environmental toxins and/or vertical transmission of abnormal genital tract flora are also plausible explanatory mechanisms (22, 23). Identification of the etiologic pathways underlying the association of maternal grandmother’s impoverishment and infant low birth weight will facilitate the development of effective public health strategies designed to improve the pregnancy outcomes of urban African-American women.


<table>
<thead>
<tr>
<th>Population (No. of Births) and Level 2 Variable</th>
<th>No. of Neighborhoods</th>
<th>Crude OR*</th>
<th>95% CI</th>
<th>Adjusted OR**</th>
<th>95% CI</th>
<th>ICC for Intercept-Only Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>All singleton births (n = 24,589)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grandmother’s neighborhood (403 neighborhoods)</td>
<td>403</td>
<td>1.4</td>
<td>1.3, 1.6</td>
<td>1.3</td>
<td>1.1, 1.4</td>
<td>0.010</td>
</tr>
<tr>
<td>Mother’s neighborhood (734 neighborhoods)</td>
<td>734</td>
<td>1.4</td>
<td>1.3, 1.6</td>
<td>1.3</td>
<td>1.1, 1.4</td>
<td>0.011</td>
</tr>
<tr>
<td>One randomly chosen singleton birth from each mother (n = 21,107)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grandmother’s neighborhood (403 neighborhoods)</td>
<td>403</td>
<td>1.4</td>
<td>1.2, 1.5</td>
<td>1.2</td>
<td>1.1, 1.4</td>
<td>0.0067</td>
</tr>
<tr>
<td>Mother’s neighborhood (728 neighborhoods)</td>
<td>728</td>
<td>1.4</td>
<td>1.2, 1.5</td>
<td>1.2</td>
<td>1.1, 1.4</td>
<td>0.0079</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient; OR, odds ratio.

* Odds ratios were obtained from multilevel logistic regression models.

** Results were controlled for maternal age, education, adequacy of prenatal-care utilization, and residential environment.
To our knowledge, no prior study has used a crossed random-effects model or a 3-level mixed-effects model of births within African-American women. Using a crossed random-effects model, we were unable to estimate the additional variance attributable to neighborhood clustering among mothers after maternal grandmothers’ neighborhood clustering was taken into account. We suspect that this was due to the large number of neighborhoods in each generation (583 among maternal grandmothers and 786 among mothers), since the crossed random-effects model is most appropriate when there are many levels of one of the random factors and relatively few levels of the other factor (24). In addition, maternal grandmothers’ and mothers’ residential environments were not mutually exclusive. A 3-level model that accounted for clustering of births within mothers, in addition to clustering by mother’s or maternal grandmother’s neighborhood of residence, did not converge, probably because of the lack of variability in the occurrence of low birth weight for multiple singleton births to the same woman. When the data allow, we encourage researchers to use the statistical methods available to account for individual and crossed random effects existing at multiple levels when examining the tenacious association between neighborhood factors and infant low birth weight.

The Illinois transgenerational vital record birth file with appended US Census income data is an unusually useful data set for assessing the transgenerational effects of residential environment on reproductive outcomes. However, it has certain intrinsic limitations. Firstly, vital records contain minimal clinical information, such as maternal weight and height. Maternal ponderal index and weight gain during pregnancy might account for our findings (20). Secondly, infants for whom maternal matches were unsuccessful were more likely to have been of low socioeconomic status and thus more prone to low birth weight (11). This would not have weakened our main finding: namely, that maternal grandmother’s impoverishment during pregnancy is a risk factor for infant low birth weight. However, it limits that conclusion somewhat in that it is based on observations confined to the more advantaged portion of the population. Similarly, our findings may not be generalizable to the US-born descendents of foreign-born women (25). Thirdly, the transgenerational data set contains no information on maternal grandmother’s or mother’s duration of exposure to neighborhood poverty. Consistent with prior studies (5–10), we assumed that women’s residential environment at the time of delivery was the same as that during pregnancy. Fourthly, residential environment was empirically defined by census tract median family income, and residence in the lowest quartile was operationalized to measure neighborhood poverty. Additional objective markers of neighborhood impoverishment, such as rates of violent crime, unemployment, and lead poisoning, may have affected our findings (8). Fifthly, because of migration patterns in Chicago during the 1970s, many women moved from the city to suburbs within Cook County. Therefore, mothers’ neighborhoods included suburbs that were within Cook County but outside of the city of Chicago, while maternal grandmothers’ neighborhoods were restricted to neighborhoods within the city. Lastly, there were too few impoverished white women across generations to allow us to directly examine the contribution of generational poverty to the racial disparity in rates of low birth weight.

In summary, maternal grandmother’s exposure to neighborhood poverty during her pregnancy is an independent risk factor for infant low birth weight among African Americans.

ACKNOWLEDGMENTS

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This study was funded by a research grant from the March of Dimes (12-FY04-45) to J. W. C.

Conflict of interest: none declared.

REFERENCES


