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Low Birth Weight Across Generations: The Effect of Economic Environment

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Abstract To determine whether economic environment across generations underlies the association of maternal low birth weight (<2,500 g, LBW) and infant LBW including its preterm (<37 weeks) and intrauterine growth retardation (IUGR) components. Stratified and multilevel logistic regression analyses were performed on an Illinois transgenerational dataset of White and African-American infants (1989–1991) and their mothers (1956–1976) with appended US census income data. Population Attributable Risk percentages were calculated to estimate the percentage of LBW births attributable to maternal LBW. Among Whites, former LBW mothers ($N = 651$) had an infant LBW rate of 7.1% versus 3.9% for former non-LBW mothers ($N = 11{,}505$); RR = 1.8 (1.4–2.5). In multilevel logistic regression models that controlled for economic environment and individual maternal risk factors, the adjusted OR of infant LBW, preterm birth, and intrauterine growth retardation for maternal LBW (compared to non-LBW) equaled 1.8 (1.3–2.5), 1.3 (1.0–1.8), and 1.8 (1.5–2.3), respectively. Among African-Americans, former LBW mothers ($N = 3{,}087$) had an infant LBW rate of 19.5% versus 13.3% for former non-LBW mothers ($N = 18{,}558$); RR = 1.5 (1.3–1.6). In multilevel logistic models of African-Americans, the adjusted OR of infant LBW, preterm birth, and IUGR for maternal LBW (compared to non-LBW) were 1.6 (1.4–1.8), 1.3 (1.2–1.5), and 1.6 (1.5–1.8), respectively. In both races, approximately five percent of LBW infants with mothers and maternal grandmother who resided in high-income neighborhoods were attributable to maternal LBW. A similar generational transmission of LBW including its component pathways of preterm birth and intrauterine growth retardation occurs in both races independent of economic environment across generations.

Keywords Preterm birth · Prematurity · Maternal low birth weight · Infant low birth weight · Economic environment · Racial disparity · Transgenerational

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Introduction

Infant mortality in the United States has two striking characteristics: it is very high compared to other developed nations, and the mortality rate for African-Americans is more than twice that of Whites [1–4]. Unfortunately, our nation will not achieve the *Healthy People 2010* federal health objectives to substantially decrease overall infant mortality rates and eliminate the racial disparity in infant mortality rates [5]. Most pertinent, low birth weight (<2,500 g, LBW) is a leading determinant of first year mortality risk and the primary factor driving the racial disparity in infant mortality rates [2, 4].

For unclear reasons, African-Americans have a long standing twofold greater rate of LBW than Whites [1–6]. Interestingly, the available data suggest an independent relationship between maternal birth weight, across the entire birth weight spectrum, and pathologic reproductive outcome as measured by rates of infant LBW and its component pathways of preterm birth and intrauterine growth retardation [7–10]. The mechanisms underlying the association of LBW across generations are incompletely understood and may help us better understand the perplexing racial disparity in the rates of LBW, preterm birth, and intrauterine growth retardation.

Environmental, epigenetic, or genetic mechanisms may explain the association of LBW across generations. Maternal place of residence as listed on vital records is a well described surrogate of maternal residential environment during pregnancy [11–16]. Most pertinent, maternal exposure to neighborhood poverty during pregnancy is an independent risk factor for infant LBW [11–14]. As such, economic environment may follow a familial pattern across generations, impacting both maternal and infant LBW rates [11–16]. Alternatively, aspects of mother's social environment may have subjected her to influences during fetal life that resulted both in her slowed growth in utero and also programmed her reproductive physiology via an epigenetic mechanism to have small children [17–19]. Lastly, infants may inherit genes from their mothers that limit or promote intrauterine growth [20–24].

We, therefore, performed a population-based study of cross-sectional data at two time points to determine whether economic environment across generations underlies the association between maternal and infant LBW including its preterm and intrauterine growth retardation components. We will then consider the relevance of the findings to the racial disparity in infant outcome.

Methods

Study Population

A detailed description of the Illinois transgenerational dataset, including the linkage procedure, has been previously published [25]. Briefly, the birth certificate data tapes for 1989–1991 from the Illinois Department of Public Health were linked to those of their mothers who were 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 mother's records. This analysis was restricted to non-Hispanic White and African-American women whose mothers lived in Chicago at the time of their own birth and who later lived in Chicago or suburban Cook County at the time they delivered their singleton infants ($N = 72{,}555$).

Economic Environment

For 1956–1965 births to Chicago (Cook County), IL residents, based on maternal place of residence listed on the birth certificates, we appended 1960 US census median family income to each birth record by community area (1956–1960) or census tract for years where valid tracts were available (1961–1965) [12, 15, 25]; for the 1966–1976 births to Chicago residents, we appended the 1970 US census income to each birth record by census tract [12, 15, 25]. These values were used to estimate the economic environment of maternal grandmothers when they were 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 used the same methodology to append 1990 US census income information to each birth record according to the census tract of the residence at birth; for births to women in suburban Cook County, outside the Chicago city limits, we used the smallest available geographic unit (town, township or village) to approximate neighborhood income [12, 15, 25]. The neighborhood-level income value was used to estimate the economic environment of mothers during their pregnancy with index infants.

The continuous neighborhood income measure was divided into tertiles separately for mother's and maternal grandmother's pregnancies. Infants with mothers and maternal grandmothers with a neighborhood income in the second tertile during their pregnancies were excluded from this analysis.

Infant LBW, Maternal LBW and Economic Environment Across Generations

In both races, the distribution of mother's and maternal grandmother's neighborhood income category during their pregnancies and maternal age, education, marital status, parity, adequacy of prenatal care utilization [26], and cigarette smoking status were determined among LBW and non-LBW infants.

Next, we calculated race-specific rates of infant LBW, preterm (<37 weeks) birth, and intrauterine growth retardation (weight for gestational age <10th percentile, IUGR) by maternal birth weight and generational neighborhood income category; crude relative risk (RR) and 95% confidence intervals (95% CI) were computed. Multivariable logistic regression models were then performed within each neighborhood income category [27]. For each race, the adjusted odds ratio (OR) of infant LBW, preterm birth, and IUGR for LBW (compared to non-LBW) mothers were determined within each neighborhood income category by taking the antilogarithm of the Beta-coefficients; 95% CIs were estimated from the standard errors of those coefficients.

To more fully examine the relationship between infant birth weight, maternal birth weight, and generational economic environment, we constructed race-specific multilevel logistic regression models to account for the nesting of individual births (level 1) within mother's neighborhood (level 2) [28].

To estimate the percentage of LBW infants attributable to maternal LBW, we calculated the population attributable risk percent (PAR%): PAR% = Pe (RR−1)/[1 + Pe (RR − 1)], where Pe was the proportion of infants born to former LBW mothers [29]. To estimate the percentage of LBW, preterm, and IUGR infants attributable to maternal and maternal grandmother residence in low-income neighborhoods among former non-LBW women, we calculated the population attributable risk percent (PAR%): PAR% = Pe (RR − 1)/[1 + Pe (RR − 1)], where Pe was the proportion of infants with former non-LBW mothers who lived in low-income neighborhoods at birth (i.e. during maternal grandmothers pregnancies) and during adulthood (i.e. during their pregnancies) [29].

Results

Within the White population (*N* = 12,156) the LBW rate was 7.1% for infants of former low birth weight mothers (*N* = 651) versus 3.9% among infants of former non-low birth weight mothers (*N* = 11,505), RR = 1.8 (1.4–2.5); the preterm birth rate was 8.6% for infants of former low birth weight mothers versus 6.2% among infants of former non-low birth weight mothers, RR = 1.4 (1.1–1.8); the IUGR rate was 15.1% for infants of former low birth weight mothers versus 8.7% among infants of former non-low birth weight mothers, RR = 1.7 (1.4–2.1).

Within the African-American population (*N* = 21,645) the LBW rate was 19.5% among infants of former low birth weight mothers (*N* = 3,087) versus 13.3% among infants of former non-low birth weight mothers (*N* = 18,558), RR = 1.5 (1.3–1.6); the preterm birth rate was 21.1% for infants of former low birth weight mothers versus 17.0% among infants of former non-low birth weight mothers, RR = 1.2 (1.1–1.3); the IUGR rate was 17.2% for infants of former low birth weight mothers versus 11.4% among infants of former non-low birth weight mothers, RR = 1.5 (1.4–1.6).

The prevalence of LBW among White mothers born to women (i.e. maternal grandmothers) who resided in low-income neighborhoods equaled 10.2%. The prevalence of LBW among African-American mothers born to women (i.e. maternal grandmothers) who resided in low-income neighborhoods equaled 14.8%.

In both races, a greater percentage of LBW (compared to non-LBW) infants had mothers and maternal grandmothers who lived in low-income neighborhoods during their pregnancies; they also had a greater percentage of mothers with high risk individual-level characteristics (Table 1).

Table 2 shows race-specific birth outcomes according to race, maternal birth weight, and generational economic environment. White infants with former LBW mothers and with both mothers and maternal grandmothers who resided in low-income neighborhoods during their pregnancies had rates of LBW, preterm birth, and IUGR of 15, 20, and 30%, respectively. African-American infants with former LBW mothers and with both mothers and maternal grandmothers who resided in low-income neighborhoods during their pregnancies had rates of LBW, preterm birth, and IUGR of 20.3, 21.5, and 17.6%, respectively. Former LBW White and African-American mothers who resided in high-income neighborhoods at birth and during adulthood had approximately a two-fold greater rate of delivering a LBW infant compared to their former non-LBW counterparts; RR = 2.1 (1.5–2.9) and 1.9 (1.0–3.6), respectively. Similarly, former LBW White and African-American mothers who resided in high-income neighborhoods at birth and during adulthood had approximately a two-fold greater rate of delivering an IUGR infant compared to their former non-LBW counterparts; RR = 1.8 (1.5–2.3) and 2.0 (1.0–3.9), respectively.

Table 3 shows the results of our multivariable logistic regression analyses for infants in each generational neighborhood income category. Former LBW White mothers (*N* = 10,072) who resided in high-income neighborhoods at birth and during adulthood had a 2.1-fold greater odds of delivering a LBW infant compared to their former non-LBW counterparts independent of selected individual-level risk factors. Former LBW African-American mothers (*N* = 16,356) who resided in low-income neighborhoods at birth and during adulthood had a 1.6-fold greater odds of delivering a LBW infant compared to their non-LBW counterparts. The results were similar in each of the other generational neighborhood income categories with adequate sample sizes and the interaction between maternal LBW and neighborhood income was not significant for each of the infant outcomes.

Table 4 shows the results of our multilevel logistic regression models with mother's neighborhood of residence as the random effect. Former LBW White mothers had an 80% greater odds of LBW, a 30% greater odds of preterm birth, and an 80% odds of IUGR than non-LBW White mothers. Former LBW African-American mothers had a 60% greater odd LBW, a 30% greater odds of preterm birth, and a 60% greater odds of IUGR than non-LBW African-American mothers. The results were minimally changed when sensitivity analysis was performed and the

Table 1 Distribution of generational economic environment and maternal individual-level characteristics by race and maternal low birth weight (<2,500 g, LBW), Cook County, IL, 1956–1976, 1989–1991

	African-American infants ($N = 21,645$)		White infants ($N = 12,156$)	
	LBW ($N = 3,076$)%	non-LBW ($N = 18,569$)%	LBW ($N = 489$)%	non-LBW ($N = 11,667$)%
Generational economic environment				
Maternal GM[a] low-income/ mother low-income	83.2	77.3	5.1	1.9
Maternal GM high-income/ mother low-income	10.0	12.6	11.5	7.2
Maternal GM low-income/ mother high-income	5.1	7.7	7.8	6.5
Maternal GM high-income/ mother high-income	1.7	2.4	75.7	84.4
Maternal age (years)				
<20	22.5	26.1	8.4	4.6
20–35	77.5	73.9	91.6	95.4
Education (years)				
<12	44.3	38.0	15.6	7.7
12	36.5	37.6	38.6	34.5
>12	19.1	24.5	45.8	57.8
Marital status				
Unmarried	88.5	81.7	23.9	12.0
Married	11.5	18.3	76.1	88.0
Parity				
Primiparous	21.5	26.5	35.6	36.9
1–2 previous livebirths	41.2	45.8	49.5	50.8
3 or more previous livebirths	37.4	27.7	14.9	12.3
Prenatal Care (PNC) Utilization				
No PNC/inadequate	35.9	32.9	13.2	7.4
Intermediate/adequate	36.3	49.7	34.8	69.6
Adequate plus	27.9	17.3	52.0	22.9
Cigarette smoking status				
Smoker	33.7	20.4	29.5	16.0
Non-smoker	66.3	79.6	70.6	84.0

Note: With the exception of parity for Whites, all variables differed between LBW and non-LBW infants ($P < 0.0001$)

[a] *GM* grandmother

models were re-run with maternal grandmother's neighborhood as the level 2 variable and when the sample was restricted to one random birth per mother.

Among White ($N = 10,072$) infants with mothers and maternal grandmothers who resided in high-income neighborhoods during their pregnancies, a small percentage of LBW, preterm, and IUGR infants were attributable to maternal LBW; the PAR% of LBW, preterm birth, and IUGR for maternal low birth weight were 5.1, 1.8, and 4.1%, respectively. A similar pattern occurred among African-Americans ($N = 489$): 4.5, 2.0, and 6.6%, respectively.

Among former non-LBW White mothers ($N = 11,328$), a small percentage of LBW, preterm, and IUGR infants were attributable to maternal and maternal grandmother residence in low-income areas; the PAR% of LBW, preterm birth, and IUGR were 3.4, 2.0, and 2.2%, respectively. In contrast, among former non-LBW African-American ($N = 17,947$) mothers, a large percentage of LBW, preterm, and IUGR infants were attributable to maternal and maternal grandmother residence in low-income areas; the PAR% of LBW, preterm birth, and IUGR were 25.8, 9.8, and 25.6%, respectively.

Table 2 Rates of infant low birth weight (<2,500 g, LBW), preterm birth (<37 weeks), and intrauterine growth retardation (IUGR) by race, maternal birth weight, and generational economic environment, Cook County, IL, 1956–1976, 1989–1991

Infant outcome	Generational residential environment	African-American mothers Former LBW $N = 2,498$ (%)	African-American mothers Former non-LBW $N = 18,558$ (%)	African-American mothers RR (95% CI)	White mothers Former LBW $N = 651$ (%)	White mothers Former non-LBW $N = 11,505$ (%)	White mothers RR (95% CI)
Low birth weight	Maternal GM[a] low/ mother low	20.3	14.2	1.4 (1.3, 1.6)	15.0	9.5	1.6 (0.5, 4.8)
	Maternal GM high/ mother low	15.9	11.0	1.4 (1.1, 1.9)	**	6.6	**
	Maternal GM low/ mother high	15.4	9.1	1.7 (1.2, 2.4)	10.9	4.3	2.5 (1.1, 5.8)
	Maternal GM high/ mother high	18.2	9.4	1.9 (1.0, 3.6)	7.1	3.4	2.1 (1.5, 2.9)
Preterm birth	Maternal GM[a] low/ mother low	21.5	17.5	1.2 (1.1, 1.3)	20.0	11.7	1.7 (0.7, 4.4)
	Maternal GM high/ mother low	20.9	16.7	1.3 (1.0, 1.6)	9.2	10.0	0.9 (0.4, 2.0)
	Maternal GM low/ mother high	14.9	12.9	1.2 (0.8, 1.7)	12.7	6.1	2.1 (1.0, 4.4)
	Maternal GM high/ mother high	23.6	15.2	1.6 (0.9, 2.6)	7.7	5.7	1.3 (1.0, 1.8)
IUGR	Maternal GM[a] low/ mother low	17.6	12.1	1.5 (1.3, 1.6)	30.0	18.2	1.7 (0.8, 3.4)
	Maternal GM high/ mother low	14.4	9.8	1.5 (1.1, 2.0)	15.4	14.5	1.1 (0.6, 1.9)
	Maternal GM low/ mother high	16.4	7.6	2.2 (1.5, 3.1)	14.6	8.8	1.7 (0.8, 3.3)
	Maternal GM high/ mother high	16.4	8.1	2.0 (1.0, 3.9)	14.5	8.0	1.8 (1.5, 2.3)

RR relative risk (95% confidence interval), with former non-LBW mothers as the reference group

[a] *GM* grandmother

** Not estimated—less than 3 LBW mothers delivered a LBW infant

Discussion

Our population-based study provides new information that the generational transmission of LBW and its component pathways of preterm birth and intrauterine growth retardation is the same in both races independent of economic environment across generations. In multilevel logistic models that accounted for the clustering of women within economic environments, we found that former low birth weight White and African-American women have nearly a two-fold greater odds of infant LBW than their former non-low birth weight counterparts. In both races, only a small percentage of LBW, preterm, and IUGR infants are attributable to maternal LBW. Most striking, approximately 25% of LBW infants born to former non-low birth weight African-American mothers are attributable to generational residence in low-income neighborhoods, a proportion six times greater than that seen in non-low birth weight White mothers.

Our data show that economic environments (as measured by income) across generations does not explain the association of LBW across generations. The remarkable consistency of the magnitude of the association between maternal and infant LBW (and its preterm birth and IUGR components) across generational economic environments independent of traditional individual level risk factors (i.e. maternal age, education, marital status, parity, prenatal care usage, and cigarette smoking) in both races is most consistent with either an epigenetic or primary genetic inheritance pattern. However, unmeasured contextual factors may underlie the association of maternal and infant LBW [11, 30–34]. Since the association of LBW across generations occurs over a wide range of risk factors among Whites and African-Americans in the present investigation and earlier studies [7–10], individual-level factors such as cultural practices, exercise, or limited access to advances in medical care, which were not measured in the present study, seem less likely to account for this phenomenon.

Table 3 Multivariable logistic regression models for the relationship between maternal low birth weight and infant low birth weight (<2,500 g), preterm (<37 weeks) birth, and intrauterine growth retardation (IUGR), stratified by generational economic environment and race, Cook Country, IL, 1956–1976, 1989–1991

		African-American mothers		White mothers	
Infant outcome	Generational economic environment	*N*	OR[a] (95% CI)	*N*	OR[a] (95% CI)
Low birth weight	Maternal GM low-income/mother low-income	16,350	1.6 (1.4, 1.7)	239	1.0 (0.2, 6.0)
	Maternal GM high-income/mother low-income	2,541	1.6 (1.2, 2.3)	863	*
	Maternal GM low-income/mother high-income	1,543	1.8 (1.2, 2.8)	786	2.5 (0.9, 6.7)
	Maternal GM high-income/mother high-income	489	1.6 (0.6, 3.9)	10,072	2.1 (1.4, 3.0)
Preterm birth	Maternal GM low-income/mother low-income	16,278	1.3 (1.2, 1.5)	239	1.4 (0.3, 6.5)
	Maternal GM high-income/mother low-income	2,534	1.4 (1.0, 1.9)	860	0.8 (0.3, 2.1)
	Maternal GM low-income/mother high-income	1,540	1.2 (0.7, 1.8)	785	2.0 (0.8, 4.9)
	Maternal GM high-income/mother high-income	485	1.1 (0.5, 2.6)	10,067	1.3 (0.9, 1.9)
IUGR	Maternal GM low-income/mother low-income	16,262	1.6 (1.4, 1.8)	239	1.9 (0.6, 6.1)
	Maternal GM high-income/mother low-income	2,533	1.5 (1.0, 2.1)	860	1.3 (0.6, 2.7)
	Maternal GM low-income/mother high-income	1,540	2.3 (1.5, 3.6)	785	2.1 (0.9, 4.7)
	Maternal GM high-income/mother high-income	485	2.0 (0.8, 4.8)	10,067	1.9 (1.5, 2.5)

GM grandmother

OR odds ratio (95% confidence interval), with former non-low birth weight mothers as the reference group

[a] Controlling for maternal age, education, marital status, parity, adequacy of prenatal care utilization, and cigarette smoking status

* Not estimated—inadequate sample size for exposed cases

Table 4 Multilevel logistic regression models for the relationship between maternal low birth weight (<2,500 g, LBW) and infant low birth weight, preterm birth, and intrauterine growth retardation (IUGR), stratified by race, Cook County, IL, 1956–1976, 1989–1991

Infant outcome	Race group	# Infants	# Neighborhoods	Beta	SE	OR[b] (95% CI)
Low birth	African American	20,923	518	0.44	0.05	1.6 (1.4, 1.8)
Weight	White	11,960	448	0.58	0.17	1.8 (1.3, 2.5)
Preterm	African American	20,837	518	0.27	0.05	1.3 (1.2, 1.5)
Birth	White	11,951	448	0.29	0.16	1.3 (1.0, 1.8)
IUGR	African American	20,820	518	0.47	0.06	1.6 (1.5, 1.8)
	White	11,951	448	0.61	0.12	1.8 (1.5, 2.3)

OR odds ratio (95% confidence interval), with former non-LBW mothers as the reference group

[a] Referent group = Maternal non-LBW

[b] Controlling for economic environment across generations, maternal age, education, marital status, parity, adequacy of prenatal care utilization, and cigarette smoking status

Low birth weight is a strong proxy of aberrant fetal programming with respect to adult health status [35]. Fetal programming acts at the level of the DNA, in a phenomenon called epigenetics. Gene expression can be turned up or down, switched on or off, by methylating or demethylating DNA. Two women with the same genetic code can have very different levels of stress reactivity, based on whether their DNA's are methylated or demethylated [36]. This may predispose female fetuses to deliver LBW infants during their adulthood [32, 37]. This epigenetic phenomenon has a lot to do with whether or not their mothers were stressed during pregnancy [38]. For example, maternal grandmothers' exposure to neighborhood poverty during their pregnancies is a suspected chronic stressor associated with poor birth outcomes as measured by LBW rates [11–14], and maternal LBW is a subsequent risk factor for infant LBW.

Two subgroups of White women are particularly interesting because of their elevated rates of poor reproductive outcome and provide evidence of a possible epigenetic inheritance pattern of LBW. The prevalence of LBW among White mothers born to women who resided in low-income neighborhoods is high at 10.2%. Moreover, when these former LBW White women grow up and live in low-income neighborhoods during their own pregnancies, they experience rates of LBW, preterm birth, and IUGR of 15, 20, and 30%, respectively. Although the number of White women in these subgroups is small compared to the overall population, their childbearing experience makes it clear that the combination of maternal LBW and generational residence in low-income neighborhoods is associated with elevated rates of pathologic birth outcomes. Moreover, a similar pattern occurs among a much larger sample African-Americans. Further research is needed to better delineate the epigenetic and/or primary genetic mechanisms underlying the association of maternal and infant LBW.

For transgenerational mechanisms in LBW to have relevance to racial disparities in birth outcome these factors must contribute to the total burden of adverse birth outcomes and have a different prevalence between racial groups. Our calculated PAR% takes into account the strength of the association between maternal and infant LBW (i.e. the RR of infant LBW) and the prevalence of maternal LBW. It demonstrates the proportion of LBW infants that could potentially have been avoided if all former LBW women had been born non-LBW. The population-wide impact of the tenacious association of maternal and infant LBW on the racial disparity in infant mortality rates appears minimal given the equally small proportion of LBW, preterm, and IUGR White and African-American infants attributable to maternal LBW among successive generations residing in high-income neighborhoods.

Independent of the mechanisms underlying the association of LBW across generations, former non-LBW women are uniquely suited to address the public health implications of generational exposure to adverse economic environments. Reflecting the stark racial disparity in both maternal grandmother's and mother's economic environments during their pregnancies, 25.8% of LBW African-American infants compared to only 3.4% of LBW White infants born to former non-LBW mothers are attributable to generational residence in low (compared to) high-income neighborhoods. Former non-LBW African-American mothers also possess a five to tenfold greater proportion of preterm and growth retarded births attributable to generational residence in low-income neighborhoods than former non-LBW White mothers. These findings strongly suggest that public health and social programs that improve the economic environment of former non-LBW African-American women can substantially reduce the number of LBW, preterm, and IUGR infants in subsequent generations.

Studies that link vital records of all births in a population to additional social data from the census or other sources allow preliminary investigations into the relative importance of environmental and genetic factors in racial disparities in birth outcomes. The Illinois transgenerational birth file with appended US census income data allows for longitudinal research on perinatal outcomes [25]. However, it has certain intrinsic limitations. First, the dataset has a small but demonstrable skew toward more educated women compared to the general birth population of Illinois, which could limit the generalizability of the study's findings. However, the rates of infant outcome in the file are virtually identical to the state as a whole, so the impact of this distortion is minimal [25]. Second, economic environment was empirically defined by census tract median family income; and residence in the lowest tertile was operationalized to measure low-income. Additional objective markers of residential environment (such as rates of violent crimes, unemployment, and familial poverty) may affect our findings [11, 12]. Third, because a large percentage of maternal vital records were missing gestational age data, we could not evaluate the relation of maternal preterm and IUGR to birth outcome [25]. Fourth, the races were exposed to the opposite extremes of economic environments. This limited the ability of our stratified and multivariate logistic analyses to fully examine the association of LBW across generations among Whites with a generational residence in low-income neighborhood and among African-Americans with generational residence in high-income neighborhoods. However, our multilevel regression models demonstrate significant associations of maternal and infant LBW in both races independent of generational economic environments. Fifth, we did not disentangle the impact of generational migration patterns versus generational neighborhood economic change on birth outcomes [34]. Lastly, due to the 1970s migration patterns in Chicago, many women moved from the city to suburbs within Cook County. Therefore, mothers' neighborhoods included suburbs within Cook County but outside of the city of Chicago, while maternal grandmother's neighborhoods were restricted to neighborhoods within the city.

In summary, our analyses show that maternal LBW is a risk factor for infant LBW, preterm birth, and IUGR regardless of economic environments across generations. This generational transmission works the same in both races. Perhaps more useful for informing the development of public health programs to reduce racial disparities in birth outcome, we find that former non-LBW African-American mothers have a sixfold greater proportion of LBW infants attributable to generational residence in low-income neighborhoods than former non-LBW White mothers.

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