HHS Public Access
Author manuscript
*Soc Sci Med*. Author manuscript; available in PMC 2021 November 18.

Published in final edited form as:
*Soc Sci Med*. 2020 January ; 245: 112665. doi:10.1016/j.socscimed.2019.112665.

# Longitudinal measures of neighborhood poverty and income inequality are associated with adverse birth outcomes in Texas

**Catherine Cubbin**[a,*], **Yeonwoo Kim**[b], **Shetal Vohra-Gupta**[a], **Claire Margerison**[c]

[a]Steve Hicks School of Social Work, The University of Texas at Austin, 1925 San Jacinto Blvd, Austin, TX, 78712, USA

[b]School of Kinesiology, University of Michigan, 1402 Washington Heights, Ann Arbor, MI, 48109-2013, USA

[c]Department of Epidemiology and Biostatistics, College of Human Medicine, Michigan State University, 909 Wilson Road, Room B601, East Lansing, MI, 48824, USA

## Abstract

**Background:** Inequity in adverse birth outcomes between black and white women in the U.S. is persistent, despite decades of research and prevention efforts. Neighborhood environments are plausibly related to pre-pregnancy health and other risk factors for adverse birth outcomes and may help explain black/white inequities. Despite the fact that neighborhoods change over time, most prior work has relied upon cross-sectional measures of neighborhood economic contexts.

**Methods:** We used birth certificates for non-Hispanic black and white women in Texas (2009–2011, N = 470,896) to examine whether longitudinal measures of neighborhood economic context (poverty and income inequality, based on census tract data from 1990 to 2010) were associated with preterm birth, low birthweight and small-for-gestational-age (SGA) with hierarchical generalized linear models. We also tested whether (1) the longitudinal measures explained black/white inequities or (2) moderated the effect of race on the birth outcomes. Finally, we compared the models with longitudinal measures to models with cross-sectional measures of neighborhood economic context.

**Results:** Longitudinal measures of neighborhood economic context were associated with all three birth outcomes, but did not explain racial inequities. Except for income inequality and SGA, there was no evidence of moderation by race. Substituting cross-sectional measures of economic context for longitudinal ones resulted in similar findings.

**Conclusion:** Policies that either address structural neighborhood-level economic disadvantage or mitigate the effects of such disadvantage are warranted to improve the health of mothers and prevent adverse birth outcomes.

## 1. Introduction

The inequity in adverse birth outcomes (preterm birth, low birth weight, and small for gestational age) between non-Hispanic black (hereafter "black") and non-Hispanic white

*Corresponding author. ccubbin@austin.utexas.edu (C. Cubbin).

women (hereafter "white") in the U.S. is persistent, despite decades of research and prevention efforts. Vital statistics demonstrate that the percentage of preterm births (PTB) to Black women is about 50% higher compared with white women, and the percentages of low birth weight (LBW) and small-for-gestational age births (SGA) to Black women are about double compared with white women (Centers for Disease Control and Prevention, 2008; Martin et al., 2018). Given the tight link between these birth outcomes and infant mortality (Behrman and Butler, 2007; MacDorman, 2011), as well as links to adverse health outcomes during childhood and adulthood (Arpi and Ferrari, 2013; Bhutta et al., 2002; Evensen et al., 2009; Hack et al., 1995; Kajantie et al., 2015; Johnson and Schoeni, 2011; Saigal and Doyle, 2008; Van Lieshout et al., 2015; Vollsæter et al., 2013), the statistics are ethically troubling and constitute a major public health challenge.

Ecosocial theory (Krieger, 1994) guides the research in this study. The theory encompasses the concept of embodiment, or the ways in which social factors affect biology. A substantial body of work argues that adverse birth outcomes are primarily the result of psychosocial stress (Behrman and Butler, 2007; Cardwell, 2013; Hobel et al., 2008; Wadhwa et al., 2011; Witt et al., 2014; Yonkers et al., 2014). Stress is known to operate through multiple plausible pathways that could affect birth outcomes, including immune system function/susceptibility to infection (Segerstrom and Miller, 2004), the autonomic nervous system ("fight or flight" response) (Sandman et al., 1997; Su et al., 2015), and health behaviors (Lobel et al., 2008). Psychosocial stress is triggered by social and economic factors, such as disadvantaged neighborhood environments (Ross and Mirowsky, 2001), low socioeconomic status/position (Baum et al., 1999), and exposure to discrimination (Sawyer et al., 2012; Sellers et al., 2003). All of these are more prevalent on average among the black vs. white population (Williams and Sternthal, 2010), and could plausibly account for the higher prevalences of worse health status and adverse birth outcomes among the former (mediation hypothesis). In addition, because of the dramatically different social conditions that black and white populations experience, it is possible that the relationship between neighborhood economic disadvantage and adverse birth outcomes may vary by race (moderation hypothesis). For instance, an intersectionality framework would suggest that black women may be more impacted by their neighborhood environments because they have lower socioeconomic position and experience more racial discrimination on average compared with white women.

A body of population-based empirical studies has found relationships between economic indicators of neighborhoods and adverse birth outcomes (Braveman et al., 2015; Culhane and Elo, 2005; Elo et al., 2009; Kaufman et al., 2003; Masi et al., 2007; Margerison-Zilko et al., 2015; Messer et al., 2006; Metcalfe et al., 2011; O'Campo et al., 2007; Schempf et al., 2009). For example, Kaufman et al. (2003) found that higher income in a neighborhood was associated with lower risk of PTB for black, but not white, women. Schempf et al. (2009) found that higher neighborhood "risk" was associated with lower birth weight among a low-income sample, and that the relationship was mediated by maternal behaviors. Elo et al. (2009) found that neighborhood "deprivation" was associated with SGA both among black and white mothers.

Furthermore, high levels of racial segregation have had lasting impacts on the current residential conditions for black and white populations in the U.S, with the black population, on average, having far more health-challenging environments (economically disadvantaged, hazardous conditions) compared with the white population (Cubbin et al., 2001; Massey, 1990). For example, economically disadvantaged areas have lower access to high quality housing, education, employment, and information (Wilson, 1987, 1996; Massey, 1990; Kawachi and Berkman, 2003). These areas generally have lower political power and more unhealthy physical environments (Kraus, 2000; Hamilton, 1995; Pulido, 2017). For these and other reasons, neighborhood environments are considered upstream risk factors, leading both to lower socioeconomic attainment for their residents as well as more hazardous physical environments to attain good health (Gehlert et al., 2008). These environments, in turn, are plausibly related to pre-pregnancy health and other risk factors for adverse birth outcomes (Sheehan et al., 2017; Walsemann et al., 2017; Duncan and Kawachi, 2018). Thus, neighborhood-level economic disadvantage may be expected to impact birth outcomes for all women, but also to partially “explain” some of the racial disparity in them.

A limitation of prior studies–as with most neighborhood effects studies–is their reliance on cross-sectional indicators of neighborhood economic status, measured around the time of the birth. This is not surprising given the difficulty of measuring neighborhood environments over time for population-based studies. However, “static” measures of neighborhood economic environments ignore the fact that some neighborhoods are changing and that others have experienced similar conditions over an extended period, resulting in possibly extensive measurement error, as prior research has found (Margerison-Zilko et al., 2015). For instance, the cross-sectional measure of high neighborhood poverty (i.e., > 20%) in that study included neighborhoods that were high poverty over decades (40%), but also those that were changing in poverty levels over time (60%). This same study also found that among a representative sample of mothers in California, three different measures of neighborhood economic trajectories were each similarly and significantly associated with PTB, but that the cross-sectional (i.e., static) measure was not (Margerison-Zilko et al., 2015). Theoretically, neighborhoods with long-term poverty over decades may be different than those that had only recently become poor in terms of their built and social environments as a result of dynamic economic (e.g., private and public investment), social (e.g., perceived safety, social cohesion), and political forces (e.g., access to quality health care). Neighborhoods undergoing change, rather than being static over time, may also present certain stressors (e.g., rising rents/taxes, social isolation) or benefits (e.g., safer streets, better food). In support of this framework, a population-based study of women with young children in CA found that neighborhoods varied considerably in expected ways on built and social environmental characteristics, health behaviors, and norms based on their neighborhood poverty trajectory (Cubbin, unpublished data). If neighborhood changes are to be examined, they cannot be captured with cross-sectional measures.

This study builds on prior research on neighborhood change, health and gentrification. Using longitudinal residential history data available in the Panel Study of Income Dynamics (PSID), Do (2009) found that long-term neighborhood poverty exposure was a stronger predictor of self-rated health, and explained more of the black/white health disparity, than a single point-in-time measure. Wodtke et al. also used the PSID and found that long-term exposure to neighborhood disadvantage was associated with lower high school graduation, which is of course closely related to adult health (2011). Similarly, analyses of residential history data in the Multi-Ethnic Study of Atherosclerosis (MESA) also found that long-term measures of neighborhood poverty exposure were associated with subclinical atherosclerosis among women (Murray et al., 2010; Lemelin et al., 2009), and had stronger associations than single point-in-time measures (Murray et al., 2010). Another study of the MESA data found that people living in neighborhoods that experienced "adverse changes" were more likely to report depressive symptoms, and those living in neighborhoods that experienced "improved changes" were more likely to report fewer depressive symptoms, although the results were imprecisely estimated (Mair et al., 2015). Cantu et al. used the Geographic Research on Wellbeing (GROW) Study, and found that children who moved from a nonpoor to a poor neighborhood between birth and age 4–10 had higher odds of asthma compared to children who lived in non-poor neighborhoods throughout (Cantu et al., 2019). Using GROW and latent class analysis, Sheehan found that children who grew up in historically low or historically moderate poverty classes had lower odds of inadequate sleep duration compared with children who grew up in an historically high poverty class (Sheehan et al., 2018). They also found that the historical measure of neighborhood poverty remained significant, whereas the point-in-time measure of neighborhood poverty did not. Among women in GROW, Sheehan et al. found that living in or moving to neighborhoods that experienced historically low poverty was associated with lower odds of being obese relative to living in tracts characterized by historically high poverty (Sheehan et al., 2018). Finally, Walsemann et al. (2017) used GROW to examine psychosocial outcomes among women and found that women living in neighborhoods where poverty decreased over time had lower odds of depressive symptoms and a greater sense of control than women living in historically low-poverty neighborhoods. In addition, women living in historically high-poverty neighborhoods or in neighborhoods where poverty increased over time reported lower sense of control than women living in historically low-poverty neighborhoods.

We found several studies that specifically examined the impact of gentrification on health or health-related outcomes (Morenoff et al., 2007; Izenberg, Mujahid, & Yen, 2018a, 2018b), but only one study examined a birth outcome (Huynh and Maroko, 2014). Huynh and Maroko found that living in a very high gentrified neighborhood was associated with higher odds of PTB among black women, but was protective for white women, compared with those living in a very low gentrified neighborhood (Huynh and Maroko, 2014). Two studies by Izenberg et al. using data from the California Health Interview Survey found that gentrification was associated with health status among black, but not white, adults (Izenberg et al., 2018b), and that gentrification was associated with binge drinking, but only among those who lived in their neighborhood less than five years (Izenberg et al., 2018a). Finally, Morenoff et al. found that affluence/gentrification was negatively associated with hypertension among adults, and adjustment for the neighborhood context "explained" the black/white disparity, using data from Chicago (Morenoff et al., 2007).

Prior work on neighborhood change has measured economic context with absolute measures, most commonly poverty rates. There is a large body of literature demonstrating that relative measures, such as income inequality, are also important for health (Pickett and Wilkinson, 2015), including birth outcomes (Wallace et al., 2015). Both absolute measures and relative historical measures of economic context could plausibly be associated with adverse birth outcomes.

Therefore, in the current study, we build upon the earlier California study of a sample of births and extend it to *all* births among black and white women in Texas to examine (1) relationships between neighborhood economic trajectories (absolute and relative) on PTB and two additional adverse birth outcomes (LBW and SGA), (2) whether neighborhood economic trajectories "explain" black/white inequities in birth outcomes (mediation), (3) whether neighborhood economic trajectories impact birth outcomes differently for black and white women (moderation), and (4) whether findings were comparable with a cross-sectional measure of economic status. Our central hypothesis is that past neighborhood economic patterns (1990–2010) impact health-related characteristics of neighborhoods at the time of study (2009–2011) which in turn impact pregnancy outcomes of women living in those neighborhoods at the time of study. We predict that neighborhoods that experience long-term economic advantage will have the most positive birth outcomes compared with neighborhoods that experience change in economic advantage or long-term economic disadvantage.

## 2. Methods

### 2.1. Data

We obtained individual-level birth certificate data for all singleton births from 2009 to 2011 in Texas ($N$ = 1,127,624). These data include birth weight, length of gestation, maternal sociodemographic characteristics, paternal education, and geocode for address of residence. We restricted analyses to black and white women. Our initial sample included 513,148 births (black = 127,763; white = 385,385). We excluded records missing length of gestation or birth weight ($n$ = 9756), those with gestational age < 22 or > 44 weeks ($n$ = 4337), and those with implausible combinations of birth weight and gestational age ($n$ = 2275) (Alexander et al., 1996). We further excluded records missing geocodes ($n$ = 21,536), neighborhood poverty and income inequality rates between 1990 and 2010 ($n$ = 3954), and maternal characteristics (n = 394), resulting in 470,896 births (92% of the total).

Census tract-level data from 1990 to 2010 were obtained from the Neighborhood Change Database (NCDB) and were used as approximations of neighborhoods. The NCDB includes a comprehensive set of census variables from the U.S. Bureau of the Census (1970, 1980, 1990, 2000, and 2010 decennial censuses, and American Community Survey [ACS] 2006–2010), recalculated and weighted to correspond to census 2010 boundaries so that comparisons can be made on the same geographic boundaries over time. We included data beginning in 1990 because a quarter of TX census tracts (1277 out of 5265) had records missing economic indicators in either 1970 or 1980 (rural areas that had not yet been assigned to tracts). We used census tract-level poverty rates (percentage of persons below 100% of the federal poverty level) and income inequality rates (GINI index) for the years 1990 through 2010 as neighborhood-level economic status indicators. Census tract-level poverty and income inequality data for the years 1990 and 2000 came from decennial censuses and data for the final time period came from the ACS (2006–2010).

We linked individual-level birth certificate data to census tract-level data from 1990 to 2010 based on geocodes for residential addresses. These mothers lived in 5079 census tracts in Texas (out of a total of 5265), with an average of 92 mothers per tract (range = 1-1314).

Approximately 81% of the census tracts (4093 out of 5079) had at least 30 births, indicating substantial clustering by census tract.

### 2.2. Individual measures

Our primary outcome variables were: 1) PTB; 2) LBW; and 3) SGA. PTB was based on the birth certificate estimate of gestational age and defined as fewer than 37 weeks of completed gestation. LBW was defined as birth weight < 2500 g, and SGA was defined as < 10th percentile of birth weight for gestational age using published national reference guidelines (Oken et al., 2003). Other individual measures included maternal age at delivery, race, marital status, parity, education level, and prenatal care experience, and father's education level.

### 2.3. Neighborhood measures

We categorized all neighborhoods in TX by neighborhood poverty and inequality trajectories. For neighborhood poverty trajectories, we first created a cross-sectional measure of neighborhood poverty for each of the three time periods (1990, 2000, and 2006–2010), classifying census tracts with less than 5% poverty as low poverty, those with 5%−20% poverty as moderate poverty, and those with more than 20% poverty as high poverty. The cutoff was based on the U.S. Census definition of poverty areas (https://www.census.gov/prod/1/statbrief/sb95_13.pdf). Next, using those cross-sectional poverty measures (low, moderate, high) at all 3 time periods (1990, 2000, and 2006–2010), we categorized census tracts into 5 poverty trajectories defined *a priori* in past work (Margerison-Zilko et al., 2015): 1) long-term low poverty (all time periods were either low or a combination of low and moderate with no discernible pattern); 2) long-term moderate (all time periods were moderate); 3) long-term high (all time periods were either high or a combination or high and moderate with no discernible pattern); 4) increasing poverty (low or moderate poverty in 1990, became and remained moderate or high after 1990); and 5) decreasing poverty (high or moderate poverty in 1990, became and remained moderate or low after 1990).

For neighborhood inequality trajectories, we first created a cross-sectional measure of neighborhood income inequality by classifying census tracts with a GINI index less than 0.25 as low inequality, those with a GINI of 0.25–0.35 as moderate inequality, and those with a GINI of more than 0.35 as high inequality. The cutoff was based on Luebker's (2010) classification. Using cross-sectional inequality categories (low, moderate, and high), we classified census tracts into 4 inequality trajectories in a similar way to poverty trajectories: long-term low/moderate; long-term high; increase; and decrease. Because of a small proportion of long-term low inequality (1.2%) tracts, we combined long-term low inequality with long-term moderate inequality.

Population density was also included as a confounding variable, operationalized as population per square mile and entered into models after a log transformation because of non-normality.

### 2.4. Statistical analyses

We first examined the distribution of the variables and prevalence of the dependent variables (PTB, LBW, SGA) overall and by individual- and neighborhood-level characteristics. Next, we estimated two separate sets of hierarchical generalized linear models (HGLM) to examine the relationship between neighborhood trajectories (one set using poverty trajectories and the other set using inequality trajectories) and each dependent variable. Multilevel modeling analysis was conducted in this study because (1) births were nested within neighborhoods; and (2) we were interested in testing associations between neighborhood-level variables and each dependent variable net of individual-level sociodemographic variables. Multilevel models were built sequentially, using a series of models, to determine the 'final' model: (a) an unconditional model; (b) bivariate models; (c) a combined model; (d) a random coefficient model; and (e) a cross-level interaction model (if applicable). The HGLM was estimated using Laplace based on a binomial distribution and logit link function which allowed us to assess model fit by examining the change in the negative two log likelihood (−2LL) between models via a chi-square test (Hox, 2010; Wang et al., 2012). To determine whether Black/White disparities are explained by neighborhood categories, we estimated models that included all the individual-level variables but without any neighborhood variable. These models yielded a measure of the Black/White disparity in each outcome not explained by neighborhood context, which was compared to the Black/White disparity in the 'neighborhood' models. Finally, we estimated the models to examine the association between neighborhood poverty (or inequality) based on cross-sectional data from the ACS (2006–2010) and each dependent variable, after adjusting for individual-level sociodemographic characteristics and neighborhood-level population density.

Additionally, as sensitivity analyses, we estimated the models among the subset of neighborhoods (n = 4,363, or 86% of the 5079 neighborhoods in the study) where at least one black mother and one white mother gave birth, so that we were examining the same set of neighborhoods for both groups. We also ran a sensitivity analysis among the neighborhoods where over 10 births had occurred to exclude neighborhoods with sparse data. We used SAS software version 9.4 for all analyses.

## 3. Results

### 3.1. Descriptive statistics

Population characteristics are listed in Table 1. The majority of mothers were 20–34 years old, three quarters were white, and more than 60% were married. According to the longitudinal method of categorizing neighborhood poverty trajectories, 39% had long-term moderate poverty, followed by poverty increase (21%), poverty decrease (14%), long-term high poverty (14%), and long-term low poverty (12%). Regarding neighborhood inequality trajectories based on the longitudinal data, a third of neighborhoods had long-term low/moderate inequality, followed by long-term high inequality (31%), inequality increase (20%), and inequality decrease (16%).

Ten percent of births were classified at PTB, 7% were LBW, and 11% were SGA. Prevalence of adverse birth outcomes were highest for mothers living in neighborhoods which experienced high poverty or inequality. Fig. 1 shows the prevalence of adverse birth outcomes by neighborhood-level poverty and inequality histories combined by race and stratified by race. Black mothers exhibited higher prevalence of adverse birth outcomes in all categories of neighborhood poverty and inequality trajectories. Prevalence of adverse birth outcomes was the highest among both black and white mothers living in neighborhoods categorized by long-term high poverty or inequality.

### 3.2. Development of the multilevel model

We first examined an unconditional model to assess how much total variation in adverse birth outcomes was between neighborhoods. The percentage of variation between neighborhoods in PTB, LBW, and SGA (the pseudo intra-class correlation, or ICC) was 2–4% and were significant ($\tau_{00}$ = 0.08 to 0.14, $p < .001$) (Hox, 2010; Snijders and Bosker, 2012). Although the pseudo ICCs are low, variance between neighborhoods implied that our decision to use multilevel modeling is appropriate.

Second, random intercept models for each dependent variable showed that adding each independent variable in the model improved the model fit, and those variables were significantly associated with each dependent variable. Our next model included all 7 individual-level sociodemographic variables. Third, we added 2 neighborhood-level variables in combined models. The difference in −2LL between these models and the individual-level model (level-1 model) showed that model fit significantly improved based on a chi-square distribution (Δ −2LL = 26 to 78 and Δ df = 3 or 4 depending on the model, $p < .001$) in all cases except the PTB/inequality model.

Fourth, random coefficient models assessed whether the slopes for race had a significant variance component. Although the effect of race varied across neighborhoods, subsequent cross-level interaction models showed insignificant interactions between race and neighborhood-level poverty or inequality trajectories–with the exception of neighborhood inequality trajectories for SGA. Thus, in order to have parsimonious models, we decided to include race as a fixed factor in the neighborhood poverty and inequality models for PTB and LBW and for the neighborhood poverty model for SGA. For the neighborhood inequality model for SGA, we included race as a random factor and a cross-level interaction between race and neighborhood inequality trajectories.

### 3.3. Neighborhood economic trajectories and PTB

In Table 2, living in neighborhoods characterized by long-term moderate poverty, long-term high poverty, poverty increase, or poverty decrease (vs. neighborhoods with long-term low poverty) was associated with increased odds of PTB (ORs [CIs] = 1.10 [1.06–1.14], 1.17 [1.12–1.23], 1.07 [1.02–1.12], and 1.08 1.03–1.14], respectively). Living in neighborhoods characterized by long-term high inequality (vs. living neighborhoods with long-term low inequality) was associated with increased odds of PTB (OR [CI] = 1.07 [1.04–1.10]). Neighborhood-level variables did not reduce the odds of PTB associated with being black (vs. white). Models 3 (poverty) and 4 (inequality) explained 31.5% and 31.8% of the between-neighborhood variance in PTB (Hox, 2010).

### 3.4. Neighborhood economic trajectories and LBW

As shown in Table 3, living in neighborhoods which experienced long-term moderate poverty, long-term high pove rty, poverty increase, or poverty decrease (vs. neighborhoods with long-term low poverty) was associated with increased odds of LBW (ORs [CIs] = 1.13 [1.08–1.19], 1.22 [1.16–1.29], 1.11 [1.05–1.16], and 1.12 [1.06–1.18], respectively). Living in neighborhoods with long-term high inequality (vs. neighborhoods with long-term low inequality) was associated with increased odds of LBW (OR [CI] = 1.08 [1.05–1.12]). Neighborhood-level variables did not reduce the odds of LBW associated with being black (vs. white). Models 3 and 4 explained 11.0% (poverty) and 11.4% (inequality) of the between-neighborhood variance in LBW (Hox, 2010).

### 3.5. Neighborhood economic trajectories and SGA

Table 4 shows that living in neighborhoods which experienced long-term moderate poverty, long-term high poverty, poverty increase, and poverty decrease (vs. neighborhood with long-term low poverty) was associated with increased odds of SGA (ORs [CIs] = 1.11 [1.07–1.15], 1.19 [1.14–1.25], 1.10 [1.06–1.15], and 1.09 [1.04–1.14], respectively). In the inequality trajectories model, the increased odds of SGA for black vs. white women in neighborhoods with increasing or decreasing inequality were dampened. Neighborhood-level variables did not reduce the odds of SGA associated with being black (vs. white). Models 3 and 4 explained 11.8% (poverty) and 14.1% (inequality) of the between-neighborhood variance in SGA (Hox, 2010).

### 3.6. Cross-sectional neighborhood economic status and adverse birth outcomes

Table 5 presents the association between a cross-sectional measure of neighborhood poverty (or inequality) and each dependent variable. Living in neighborhoods with moderate or high poverty in 2006–2010 (vs. neighborhoods with low poverty) was associated with increased odds of PTB, LBW, and SGA. Living in neighborhoods with moderate inequality was associated with increased odds of LBW and SGA. Finally, living in neighborhoods with high inequality was associated with increased odds of all three outcomes.

### 3.7. Findings of sensitivity analysis

We analyzed the same HGLM among mothers living in neighborhoods where at least one black and one white mother were included in this study (results not shown). Similar results were found. In addition, similar results were found in the HGLM among the neighborhoods with over 10 births (results not shown).

## 4. Discussion

Neighborhood economic trajectories, measured both in absolute and relative ways, were associated with PTB, LBW, and SGA in TX. However, surprisingly, these neighborhood economic trajectories did not appear to “explain” black/white inequities net of individual-level variables. Except for the association between inequality trajectories and SGA, race did not moderate the relationships between neighborhood economic trajectories and birth outcomes, suggesting that the associations between the trajectories and birth outcomes operate in similar ways for both black and white mothers. In contrast to prior work in

CA (Margerison-Zilko et al., 2015), the findings were comparable with a cross-sectional measure of economic status (although weaker in magnitude). This may suggest that developing more complex measures of neighborhood histories in population-based studies may not be necessary. But if the interest is in capturing neighborhoods experiencing change, as our study did with significant results, cross-sectional measures are insufficient.

Interestingly, both absolute (poverty) and relative (income inequality) measures of neighborhood economic trajectories were associated with adverse birth outcomes. The absolute measure is consistent with prior work that examined cross-sectional measures of neighborhood disadvantage (Kaufman et al., 2003; Schempf et al., 2009; Elo et al., 2009) or neighborhood income inequality (Auger et al., 2009; Nkansah-Amankra et al., 2010) and birth outcomes. In addition to the expected higher odds associated with long-term moderate and high poverty conditions, we also found that neighborhoods that experienced *change* in poverty (either increasing or perhaps most interestingly, decreasing), were also associated with higher odds of adverse birth outcomes. Huynh and Maroko (2014) used a broader measure of gentrification (poverty, education, income) in New York City, and found that black women had higher odds of PTB in gentrifying neighborhoods, but that white women had lower odds of PTB in gentrifying neighborhoods. If you consider decreasing poverty to be an indicator of gentrification, our study found that women regardless of race also had higher odds of PTB, suggesting that there is something about economic changes that are associated with birth outcomes.

To our knowledge, this is the first study to examine a relative measure of economic status at the neighborhood level and to do so as a longitudinal measure. While more research is needed to elucidate the specific mechanisms, it appears that a long-term unequal neighborhood income distribution—in addition to a long-term absolute level of neighborhood poverty-has a negative association with birth outcomes compared with a long-term equal neighborhood income distribution.

The strengths of our study include observing the entire population of births in a large state, employing more conceptually rigorous measures of economic context (i.e historical trends and comparing associations to analyses with more conventional cross-sectional measures) and testing both absolute and relative measures of neighborhood economic context. However, our limitations include having no knowledge of how long the women resided in their neighborhood before they have birth, or if they previously resided in a similar one if they recently moved. Existing studies have found that 12–30% of women move during pregnancy (Fell et al., 2004; Lupo et al., 2010; Sundquist et al., 2011) and, according to the 2010 ACS, 17% of all females aged 1 year or over moved in the past year in TX. Only one study was identified that examined *socioeconomic* mobility during pregnancy and found that 63% of women remained in their neighborhood throughout pregnancy and, among those that did move, the large majority moved to similar neighborhoods in terms of poverty levels (Saadeh et al., 2013). Longitudinal designs would be required to examine residential histories neighborhood exposures (Kane and Margerison-Zilko, 2017). Although selection effects are always important to consider in cross-sectional observational neighborhood effects studies, evidence suggests that neighborhood effects are indeed causal, for at least some health outcomes (Sampson et al., 2008; Cantu et al., 2019). We hypothesized that neighborhood economic trajectories would influence current physical and social conditions of neighborhoods at the time of the births. However, we cannot rule out that our findings are due to compositional effects since physical and social conditions have not been directly measured, even though we controlled for multiple markers of individual-level socioeconomic status. In this study, we only examine neighborhood economic context, and neighborhood environments have many other characteristics that could be important to examine, such as racial composition, built environments, etc. Another study is currently underway to examine the relationships between racial/ethnic composition trajectories and adverse birth outcomes. In addition, we only examined Black/White disparities; our findings cannot be generalized to other groups at this time, although a future study is pending approval that would include births to Latinas, taking nativity into account. Finally, it should be noted that our outcome measures are not independent: 39% of the PTB births are also LBW; 11% of PTB births are also SGA; and 57% of the LBW births are also SGA.

Understanding how past and present policies influence neighborhood economic context provides a more robust path to mitigating adverse birth outcomes. The long-term economic impact of intentional segregation by race and class resulted in the creation of advantaged and disadvantaged neighborhoods, whereby wealthy neighborhoods benefit from resources, political power, and opportunities for upward mobility while low income neighborhoods are relatively lacking in such things (Rothstein, 2017; Turner and Gourevitch, 2017).

Policies that either address structural neighborhood-level economic disadvantage or mitigate its effects are warranted to improve the health of mothers and prevent adverse birth outcomes. Policy considerations for Texas and its municipalities could include: (1) incentives to increase voucher-affordable housing in low poverty, high opportunity neighborhoods (Metzger and Webber, 2018; Mazzara and Knudsen, 2019), and for the state to hold property managers accountable for discriminating against voucher holders (denying housing to voucher holders is currently legal in the state); (2) preserving affordable housing in gentrifying communities and improving upon the neighborhoods where families using vouchers already live (Mazzara and Knudsen, 2019); (3) increasing teacher-to-child ratios for childcare centers and wages for child care educators, along with increased funding for early childhood education programs to improve early childcare education and later academic outcomes (Powell, 2014); (4) addressing barriers to higher education (e.g., college readiness and vocational training programs); (5) redesigning asset-building mechanisms for low income families (e.g., greater access to credit); and (6) removing the state preemption that denies municipalities from raising the minimum wage. These policies, among others, have the potential benefit of improving many health outcomes for the entire population, in addition to birth outcomes.

## Acknowledgments

This work was supported by a Grant from the St. David's Center for Health Promotion and Disease Prevention in Underserved Populations to C. Cubbin and by a grant (Grant No. P2CHD042849) awarded to the Population Research Center at The University of Texas at Austin by the Eunice Kennedy Shriver National Institute of Child Health and Human Development.

## References


Alexander GR, Himes JH, Kaufman RB, Mor J, Kogan M, 1996. A United States national reference for fetal growth. Obstet. Gynecol 87 (2), 163–168. 10.1016/0029-7844(95)00386-X. [PubMed: 8559516]

Arpi E, Ferrari F, 2013. Preterm birth and behaviour problems in infants and pre-school-age children: a review of the recent literature. Dev. Med. Child Neurol 55 (9), 788–796. [PubMed: 23521214]

Auger N, Giraud J, Daniel M, 2009. The joint influence of area income, income inequality, and immigrant density on adverse birth outcomes: a population-based study. BMC Public Health 9 (1), 237. [PubMed: 19602256]

Baum A, Garofalo JP, Yali AM, 1999. Socioeconomic status and chronic stress: does stress account for SES effects on health? Ann. N. Y. Acad. Sci 896 (1), 131–144. [PubMed: 10681894]

Behrman RE, Butler AS, 2007. Preterm Birth: Causes, Consequences, and Prevention. The National Academies Press, Washington, DC.

Bhutta AT, Cleves MA, Casey PH, Cradock MM, Anand KJ, 2002. Cognitive and behavioral outcomes of school-aged children who were born preterm: a meta-analysis. J. Am. Med. Assoc 288 (6), 728–737.

Braveman PA, Heck K, Egerter S, Marchi KS, Dominguez TP, Cubbin C, et al. , 2015. The role of socioeconomic factors in black–white disparities in preterm birth. Am. J. Publ. Health 105 (4), 694–702.

Cantu P, Kim Y, Sheehan C, Powers D, Margerison-Zilko C, Cubbin C, 2019. Downward neighborhood poverty mobility during childhood is associated with child health: evidence from the Geographic Research on Wellbeing (GROW) Survey. J. Urban Health 10.1007/s11524-019-00356-2.

Cardwell MS, 2013. Stress: pregnancy considerations. Obstet. Gynecol. Surv 68 (2), 119–129. [PubMed: 23417218]

Centers for Disease Control and Prevention, 2008. QuickStats: percentage of small-for-gestational-age births, by race and Hispanic ethnicity—United States, 2005. MMWR (Morb. Mortal. Wkly. Rep.) 57 (50), 1359.

Cubbin C, Hadden WC, Winkleby MA, 2001. Neighborhood context and cardiovascular disease risk factors: the contribution of material deprivation. Ethn. Dis 11 (4), 687–700. [PubMed: 11763293]

Cubbin C Unpublished data from the Georgraphic Research on Wellbeing Study..

Culhane JF, Elo IT, 2005. Neighborhood context and reproductive health. Am. J. Obstet. Gynecol 192 (5), S22–S29. [PubMed: 15891708]

Do DP, 2009. The dynamics of income and neighborhood context for population health: do long-term measures of socioeconomic status explain more of the black/white health disparity than single-point-in-time measures? Soc. Sci. Med 68 (8), 1368–1375. 10.1016/j.socscimed.2009.01.028. [PubMed: 19278767]

Duncan DT, Kawachi I (Eds.), 2018. Neighborhoods and Health. Oxford University Press, New York.

Elo IT, Culhane JF, Kohler IV, O'campo P, Burke JG, Messer LC, et al. , 2009. Neighbourhood deprivation and small-for-gestational-age term births in the United States. Paediatr. Perinat. Epidemiol 23 (1), 87–96. [PubMed: 19228318]

Evensen KAI, Steinshamn S, Tjønna AE, Stølen T, Høydal MA, Wisløff U, et al. , 2009. Effects of preterm birth and fetal growth retardation on cardiovascular risk factors in young adulthood. Early Hum. Dev 85 (4), 239–245. [PubMed: 19013031]

Fell DB, Dodds L, King WD, 2004. Residential mobility during pregnancy. Paediatr. Perinat. Epidemiol 18, 408–414. 10.1111/j.1365-3016.2004.00580.x. [PubMed: 15535816]

Gehlert S, Sohmer D, Sacks T, Mininger C, Mcclintock M, Olopade O, 2008. Targeting health disparities: a model linking upstream determinants to downstream interventions. Health Aff. 27 (2), 339–349. 10.1377/hlthaff.27.2.339.

Hack M, Klein NK, Taylor HG, 1995. Long-term developmental outcomes of low birth weight infants. Future Child. 5 (1), 176–196. [PubMed: 7543353]

Hamilton JT, 1995. Testing for environmental racism: prejudice, profits, political power? J. Policy Anal. Manag 14 (1), 107–132.

Hobel CJ, Goldstein AMY, Barrett ES, 2008. Psychosocial stress and pregnancy outcome. Clin. Obstet. Gynecol 51 (2), 333–348. [PubMed: 18463464]

Hox JJ, 2010. Multilevel Analysis: Techniques and Applications, second ed. Routledge, New York, NY.

Huynh M, Maroko AR, 2014. Gentrification and preterm birth in New York City, 2008–2010. J. Urban Health : Bull. N. Y. Acad. Med 91 (1), 211–220. 10.1007/s11524-013-9823-x.

Izenberg JM, Mujahid MS, Yen IH, 2018a. Gentrification and binge drinking in California neighborhoods: it matters how long you've lived there. Drug Alcohol Depend. 188, 1–9. 10.1016/j.drugalcdep.2018.03.018. [PubMed: 29709759]

Izenberg JM, Mujahid MS, Yen IH, 2018b. Health in changing neighborhoods: a study of the relationship between gentrification and self-rated health in the state of California. Health Place 52, 188–195. 10.1016/j.healthplace.2018.06.002. [PubMed: 29957396]

Johnson RC, Schoeni RF, 2011. The influence of early-life events on human capital, health status, and labor market outcomes over the life course. B. E. J. Econ. Anal. Policy 11 (3), 2521.

Kajantie E, Strang-Karlsson S, Hovi P, Wehkalampi K, Lahti J, Kaseva N, et al. , 2015. Insulin sensitivity and secretory response in adults born preterm: the Helsinki Study of Very Low Birth Weight Adults. J. Clin. Endocrinol. Metab 100 (1), 244–250. [PubMed: 25303493]

Kane JB, Margerison-Zilko C, 2017. Theoretical insights into preconception social conditions and perinatal health: the role of place and social relationships. Popul. Res. Policy Rev 36 (5), 639–669. [PubMed: 29398741]

Kawachi I, Berkman LF, 2003. Neighborhoods and Health. Oxford University Press, Oxford.

Kaufman JS, Dole N, Savitz DA, Herring AH, 2003. Modeling community-level effects on preterm birth. Ann. Epidemiol 13 (5), 377–384. [PubMed: 12821277]

Kraus N, 2000. Race, Neighborhoods, and Community Power: Buffalo Politics, 1934–1997. State University of New York Press, Albany.

Krieger N, 1994. Epidemiology and the web of causation: has anyone seen the spider? Soc. Sci. Med 39 (7), 887–903. 10.1016/0277-9536(94)90202-x. [PubMed: 7992123]

Lemelin ET, Diez Roux AV, Franklin TG, Carnethon M, Lutsey PL, Ni H, et al. , 2009. Life-course socioeconomic positions and subclinical atherosclerosis in the multi-ethnic study of atherosclerosis. Soc. Sci. Med 68 (3), 444–451. 10.1016/j.socscimed.2008.10.038. [PubMed: 19081660]

Lobel M, Cannella DL, Graham JE, DeVincent C, Schneider J, Meyer BA, 2008. Pregnancy-specific stress, prenatal health behaviors, and birth outcomes. Health Psychol. 27 (5), 604–615. [PubMed: 18823187]

Luebker M, 2010. Inequality, Income Shares and Poverty: the Practical Meaning of Gini Coefficients. International Labour Office, Geneva, Switzerland TRAVAIL Policy Brief No. 3.

Lupo PJ, Symanski E, Chan W, Mitchell LE, Waller DK, Canfield MA, Langlois PH, 2010. Differences in exposure assignment between conception and delivery: the impact of maternal mobility. Paediatr. Perinat. Epidemiol 24, 200–208. 10.1111/j.1365-3016.2010.01096.x. [PubMed: 20415777]

MacDorman MF, 2011. Race and ethnic disparities in fetal mortality, preterm birth, and infant mortality in the United States: an overview. Semin. Perinatol 35 (4), 200–208. [PubMed: 21798400]

Mair C, Diez Roux AV, Golden SH, Rapp S, Seeman T, Shea S, 2015. Change in neighborhood environments and depressive symptoms in New York city: the multi-ethnic study of atherosclerosis. Health Place 32, 93–98. 10.1016/j.healthplace.2015.01.003. [PubMed: 25665936]

Margerison-Zilko C, Cubbin C, Jun J, Marchi K, Fingar K, Braveman P, 2015. Beyond the cross-sectional: neighborhood poverty histories and preterm birth. Am. J. Publ. Health 105 (6), 1174–1180.

Martin JA, Hamilton BE, Osterman MJ, Driscoll AK, Drake P, 2018. 8. Births: Final Data for 2017. National Vital Statistics Reports, vol. 67 National Center for Health Statistics, Hyattsville, MD 2018.

Masi CM, Hawkley LC, Piotrowski ZH, Pickett KE, 2007. Neighborhood economic disadvantage, violent crime, group density, and pregnancy outcomes in a diverse, urban population. Soc. Sci. Med 65 (12), 2440–2457. [PubMed: 17765371]

Massey DS, 1990. American apartheid: segregation and the making of the underclass. Am. J. Sociol 96 (2), 329–357.

Mazzara A, Knudsen B, 2019. Where Families with Children Use Housing Vouchers: A Comparative Look at the 50 Largest Metropolitan Areas. Center on Budget and Policy Priorities: Poverty and Race Research Action Council. Retrieved on 2/3/2019 from. https://www.cbpp.org/research/housing/where-families-with-children-use-housing-vouchers.

Messer LC, Kaufman JS, Dole N, Savitz DA, Laraia BA, 2006. Neighborhood crime, deprivation, and preterm birth. Ann. Epidemiol 16 (6), 455–462. [PubMed: 16290179]

Metcalfe A, Lail P, Ghali WA, Sauve RS, 2011. The association between neighbourhoods and adverse birth outcomes: a systematic review and meta-analysis of multilevel studies. Paediatr. Perinat. Epidemiol 25 (3), 236–245. [PubMed: 21470263]

Metzger M, Webber H, 2018. Facing Segregation: Housing Policy Solutions for a Stronger Society. Oxford University Press, New York, NY.

Morenoff JD, House JS, Hansen BB, Williams DR, Kaplan GA, Hunte HE, 2007. Understanding social disparities in hypertension prevalence, awareness, treatment, and control: the role of neighborhood context. Soc. Sci. Med 65 (9), 1853–1866. 10.1016/j.socscimed.2007.05.038. [PubMed: 17640788]

Murray ET, Diez Roux AV, Carnethon M, Lutsey PL, Ni H, O'Meara ES, 2010. Trajectories of neighborhood poverty and associations with subclinical atherosclerosis and associated risk factors: the multi-ethnic study of atherosclerosis. Am. J. Epidemiol 171 (10), 1099–1108. 10.1093/aje/kwq044. [PubMed: 20423931]

Nkansah-Amankra S, Dhawain A, Hussey JR, Luchok KJ, 2010. Maternal social support and neighborhood income inequality as predictors of low birth weight and preterm birth outcome disparities: analysis of South Carolina Pregnancy Risk Assessment and Monitoring System survey, 2000–2003. Matern. Child Health J 14 (5), 774–785. [PubMed: 19644741]

Oken E, Kleinman KP, Rich-Edwards J, Gillman MW, 2003. A nearly continuous measure of birth weight for gestational age using a United States national reference. BMC Pediatr. 3 (1), 6. 10.1186/1471-2431-3-6. [PubMed: 12848901]

O'Campo P, Burke JG, Culhane J, Elo IT, Eyster J, Holzman C, et al. , 2007. Neighborhood deprivation and preterm birth among non-Hispanic Black and White women in eight geographic areas in the United States. Am. J. Epidemiol 167 (2), 155–163. [PubMed: 17989062]

Pickett KE, Wilkinson RG, 2015. Income inequality and health: a causal review. Soc. Sci. Med 128, 316–326. [PubMed: 25577953]

Powell J, 2014. Six Policies to Reduce Economic Inequality. Retrieved 1/20/2019 from. https://haasinstitute.berkeley.edu/six-policies-reduce-economic-inequality.

Pulido L, 2017. Geographies of race and ethnicity II: environmental racism, racial capitalism and state-sanctioned violence. Prog. Hum. Geogr 41 (4), 524–533. 10.1177/0309132516646495.

Ross CE, Mirowsky J, 2001. Neighborhood disadvantage, disorder, and health. J. Health Soc. Behav 42 (3), 258–276. [PubMed: 11668773]

Rothstein R, 2017. The Color of Law. Liveright Publishing, New York, NY.

Saadeh FB, Clark MA, Rogers ML, et al., 2013. Matern. Child Health J 17, 330. 10.1007/s10995-012-0978-y. [PubMed: 22415811]

Saigal S, Doyle LW, 2008. An overview of mortality and sequelae of preterm birth from infancy to adulthood. The Lancet 371 (9608), 261–269.

Sampson RJ, Sharkey P, Raudenbush SW, 2008. Durable effects of concentrated disadvantage on verbal ability among African-American children. Proc. Natl. Acad. Sci 105 (3), 845–852. [PubMed: 18093915]

Sandman CA, Wadhwa PD, Chicz-DeMet A, Dunkel-Schetter C, Porto M, 1997. Maternal stress, HPA activity, and fetal/infant outcome. Ann. N. Y. Acad. Sci 814 (1 Neuropeptides), 266–275. 10.1111/j.1749-6632.1997.tb46162.x. [PubMed: 9160976]

Sawyer PJ, Major B, Casad BJ, Townsend SS, Mendes WB, 2012. Discrimination and the stress response: psychological and physiological consequences of anticipating prejudice in interethnic interactions. Am. J. Publ. Health 102 (5), 1020–1026.

Schempf A, Strobino D, O'Campo P, 2009. Neighborhood effects on birthweight: an exploration of psychosocial and behavioral pathways in Baltimore, 1995–1996. Soc. Sci. Med 68 (1), 100–110. [PubMed: 18995941]

Segerstrom SC, Miller GE, 2004. Psychological stress and the human immune system: a meta-analytic study of 30 years of inquiry. Psychol. Bull 130 (4), 601–630. [PubMed: 15250815]

Sellers RM, Caldwell CH, Schmeelk-Cone KH, Zimmerman MA, 2003. Racial identity, racial discrimination, perceived stress, and psychological distress among African American young adults. J. Health Soc. Behav 44 (3), 302–317. [PubMed: 14582310]

Sheehan CM, Cantu PA, Powers DA, Margerison-Zilko CE, Cubbin C, 2017. Long term neighborhood poverty trajectories and obesity in a sample of California mothers. Health Place 7 (46), 49–57.

Sheehan C, Powers D, Margerison-Zilko C, McDevitt T, Cubbin C, 2018. Historical neighborhood poverty trajectories and child sleep. Sleep health 4 (2), 127–134. 10.1016/j.sleh.2017.12.005. [PubMed: 29555124]

Snijders TAB, Bosker R, 2012. Multilevel Analysis: an Introduction to Basic and Advanced Multilevel Modeling, second ed. Sage Publications, Thousand Oaks, CA.

Su Q, Zhang H, Zhang Y, Zhang H, Ding D, Zeng J, et al. , 2015. Maternal stress in gestation: birth outcomes and stress-related hormone response of the neonates. Pediatr. Neonatol 56 (6), 376–381. [PubMed: 26363772]

Sundquist J, Sundquist K, Johansson S, et al. , 2011. Mothers, places and small for gestational age births: a cohort study. Arch. Dis. Child 96, 380–385. [PubMed: 21127005]

Turner M, Gourevitch R, 2017. How Neighborhoods Affect the Social and Economic Mobility of Their Residents. US Partnership on Mobility from Poverty, Urban Institute, Washington D.C Retrieved on 2/3/2019 from. https://www.urban.org/research/publication/place-and-opportunity-using-federal-fair-housing-data-examine-opportunity-across-us-regions-and-populations/view/full_report.

Van Lieshout RJ, Boyle MH, Saigal S, Morrison K, Schmidt LA, 2015. Mental health of extremely low birth weight survivors in their 30s. Pediatrics 135 (3), 452–459. [PubMed: 25667243]

Vollsæter M, Røksund OD, Eide GE, Markestad T, Halvorsen T, 2013. Lung function after preterm birth: development from mid-childhood to adulthood. Thorax 68 (8), 767–776. [PubMed: 23749815]

Wadhwa PD, Entringer S, Buss C, Lu MC, 2011. The contribution of maternal stress to preterm birth: issues and considerations. Clin. Perinatol 38 (3), 351–384. [PubMed: 21890014]

Wallace ME, Mendola P, Liu D, Grantz KL, 2015. Joint effects of structural racism and income inequality on small-for-gestational-age birth. Am. J. Publ. Health 105, 1681–1688.

Walsemann KM, Child S, Heck K, Margerison-Zilko C, Braveman P, Marchi K, Cubbin C, 2017. Are the poverty histories of neighbourhoods associated with psychosocial well-being among a representative sample of California mothers? An observational study. J. Epidemiol. Community Health 71 (6), 558–564. [PubMed: 28130392]

Wang J, Xie H, Fisher JH, 2012. Multilevel Models: Applications Using SAS. Higher Education Press, Boston, MA.

Williams DR, Sternthal M, 2010. Understanding racial-ethnic disparities in health: sociological contributions. J. Health Soc. Behav 51 (1_Suppl. 1), S15–S27. 10.1177/0022146510383838. [PubMed: 20943580]

Wilson WJ, 1987. The Truly Disadvantaged: the Inner City, the Underclass, and Public Policy. University of Chicago Press, Chicago.

Wilson WJ, 1996. When Work Disappears: the World of the New Urban Poor. Knopf, New York, NY.

Witt WP, Cheng ER, Wisk LE, Litzelman K, Chatterjee D, Mandell K, Wakeel F, 2014. Maternal stressful life events prior to conception and the impact on infant birth weight in the United States. Am. J. Publ. Health 104 (S1), S81–S89.

Yonkers KA, Smith MV, Forray A, Epperson CN, Costello D, Lin H, Belanger K, 2014. Pregnant women with posttraumatic stress disorder and risk of preterm birth. JAMA Psychiatr. 71 (8), 897–904.

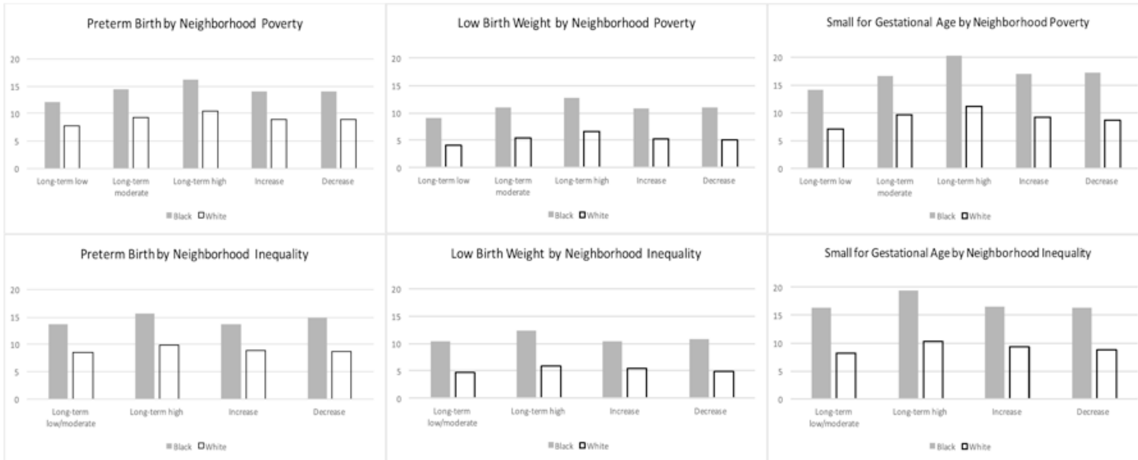


**Fig. 1.**

Prevalence of adverse birth outcomes by neighborhood-level poverty and inequality trajectories, Texas natality files, 2009–2011, N = 470,896.

**Table 1**

Descriptive statistics, Texas natality files, 2009–2011, N = 470,896.

| Characteristics | n | % | Preterm birth (%) | Low birth weight (%) | Small for gestational age (%) |
|---|---|---|---|---|---|
| Total Sample | | | 10.4 | 6.8 | 11.3 |
| Child sex | | | | | |
| Male | 240,966 | 51.2 | 10.8 | 6.1 | 8.9 |
| Female | 229,930 | 48.8 | 10.0 | 7.5 | 13.8 |
| Mother's age | | | | | |
| 12–19 years of age | 45,218 | 9.6 | 12.7 | 9.5 | 16.9 |
| 20–34 years of age | 367,029 | 77.9 | 9.9 | 6.4 | 11.0 |
| 35 or above | 58,649 | 12.5 | 11.7 | 6.9 | 9.1 |
| Mother's race | | | | | |
| Black | 118,723 | 25.2 | 14.6 | 11.3 | 17.7 |
| White | 352,173 | 74.8 | 9.0 | 5.3 | 9.1 |
| Parity | | | | | |
| First child | 205,044 | 43.5 | 10.1 | 7.7 | 13.2 |
| Second-fourth child | 260,042 | 55.2 | 10.5 | 6.0 | 9.8 |
| Fifth child or more | 5810 | 1.2 | 16.2 | 9.5 | 12.8 |
| Mother's marital status | | | | | |
| Married | 294,943 | 62.6 | 9.0 | 5.2 | 8.6 |
| Not married | 175,953 | 37.4 | 12.8 | 9.5 | 15.8 |
| Mother's education level | | | | | |
| Less than high school | 53,769 | 11.4 | 14.4 | 10.5 | 17.7 |
| High school/GED | 113,348 | 24.1 | 11.8 | 8.3 | 14.0 |
| Some college | 154,516 | 32.8 | 10.5 | 6.7 | 10.9 |
| College graduate or more | 149,263 | 31.7 | 7.9 | 4.4 | 7.4 |
| Father's education level | | | | | |
| Less than high school | 34,974 | 7.4 | 12.5 | 8.8 | 15.1 |
| High school/GED | 107,120 | 22.8 | 11.2 | 7.6 | 12.6 |
| Some college | 126,439 | 26.9 | 9.8 | 5.9 | 9.7 |
| College graduate or more | 130,515 | 27.7 | 7.5 | 4.1 | 7.2 |

| Characteristics | n | % | Preterm birth (%) | Low birth weight (%) | Small for gestational age (%) |
|---|---|---|---|---|---|
| Missing | 71,848 | 15.3 | 14.5 | 10.9 | 17.6 |
| Mother's prenatal care experience | | | | | |
| First trimester care | 300,544 | 63.8 | 10.0 | 6.0 | 9.6 |
| No first trimester care | 170,352 | 36.2 | 11.1 | 8.1 | 14.2 |
| Neighborhood poverty (2006–2010) | | | | | |
| Low poverty | 97,662 | 20.7 | 8.5 | 4.8 | 8.2 |
| Moderate poverty | 259,203 | 55.0 | 10.1 | 6.5 | 10.8 |
| High poverty | 114,031 | 24.2 | 12.7 | 9.2 | 15.0 |
| Neighborhood inequality (2006–2010) | | | | | |
| Low inequality | 22,721 | 4.8 | 8.1 | 4.3 | 7.2 |
| Moderate inequality | 228,760 | 48.6 | 9.6 | 6.0 | 10.0 |
| High inequality | 219,415 | 46.6 | 11.5 | 7.9 | 13.0 |
| Neighborhood poverty trajectories | | | | | |
| Long-term low | 55,404 | 11.8 | 8.1 | 4.6 | 7.9 |
| Long-term moderate | 181,366 | 38.5 | 10.3 | 6.5 | 11.0 |
| Long-term high | 66,015 | 14.0 | 13.3 | 9.7 | 15.7 |
| Increase | 100,713 | 21.4 | 10.6 | 7.1 | 11.8 |
| Decrease | 67,398 | 14.3 | 9.6 | 5.8 | |
| Neighborhood inequality trajectories | | | | | |
| Long-term low/moderate | 153,331 | 32.6 | 9.5 | 5.8 | 9.7 |
| Long-term high | 147,239 | 31.3 | 11.8 | 8.1 | 13.4 |
| Increase | 94,329 | 20.0 | 10.3 | 7.0 | 11.6 |
| Decrease | 75,997 | 16.1 | 9.8 | 5.9 | 10.1 |

## Table 2

Associations between neighborhood economic trajectories and preterm birth, Texas natality files, 2009–2011, N = 470,896.

| Characteristics | Model 1 (unadjusted) | | Model 2 (level-1 model) | | Model 3 (full model-poverty trajectories) | | Model 4 (full model-inequality trajectories) | |
|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| ***Fixed Effects*** | | | | | | | | |
| Mother's age | | | | | | | | |
| 12–19 years of age | 1.25 *** | 1.21–1.29 | 0.96 * | 0.93–1.00 | 0.96 * | 0.93–1.00 | 0.96 * | 0.93–1.00 |
| 20–34 years of age | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| 35 or above | 1.27 *** | 1.24–1.31 | 1.40 *** | 1.36–1.44 | 1.41 *** | 1.37–1.45 | 1.40 *** | 1.36–1.45 |
| Mother's race | | | | | | | | |
| Black | 1.70 *** | 1.66–1.73 | 1.50 *** | 1.46–1.53 | 1.48 *** | 1.45–1.52 | 1.49 *** | 1.46–1.53 |
| White | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Mother's marital status | | | | | | | | |
| Married | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Not married | 1.41 *** | 1.38–1.43 | 1.05 *** | 1.02–1.08 | 1.05 *** | 1.02–1.08 | 1.05 *** | 1.03–1.08 |
| Parity | | | | | | | | |
| First child | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Second-fourth child | 1.04 *** | 1.02–1.06 | 1.02 | 1.00–1.04 | 1.01 | 0.99–1.04 | 1.01 | 0.99–1.04 |
| Fifth child or more | 1.63 *** | 1.52–1.75 | 1.30 *** | 1.20–1.40 | 1.29 *** | 1.19–1.38 | 1.29 *** | 1.20–1.39 |
| Mother's education level | | | | | | | | |
| Less than high school | 1.87 *** | 1.81–1.94 | 1.46 *** | 1.40–1.52 | 1.44 *** | 1.38–1.50 | 1.45 *** | 1.39–1.51 |
| High school/GED | 1.51 *** | 1.47–1.55 | 1.23 *** | 1.19–1.27 | 1.22 *** | 1.18–1.26 | 1.22 *** | 1.18–1.27 |
| Some college | 1.34 *** | 1.31–1.38 | 1.16 *** | 1.12–1.19 | 1.15 *** | 1.12–1.18 | 1.15 *** | 1.12–1.19 |
| College graduate or more | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Father's education level | | | | | | | | |
| Less than high school | 1.70 *** | 1.63–1.77 | 1.36 *** | 1.30–1.42 | 1.34 *** | 1.28–1.40 | 1.35 *** | 1.28–1.41 |
| High school/GED | 1.52 *** | 1.47–1.56 | 1.30 *** | 1.26–1.35 | 1.28 *** | 1.24–1.33 | 1.29 *** | 1.25–1.34 |
| Some college | 1.32 *** | 1.28–1.36 | 1.21 *** | 1.17–1.25 | 1.20 *** | 1.16–1.23 | 1.20 *** | 1.16–1.24 |
| College graduate or more | 1.00 | | 1.00 | | 1.00 | | 1.00 | |

| Characteristics | Model 1 (unadjusted) | | Model 2 (level-1 model) | | Model 3 (full model-poverty trajectories) | | Model 4 (full model-inequality trajectories) | |
|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Missing | 1.99*** | 1.93–2.06 | 1.50*** | 1.44–1.57 | 1.48*** | 1.42–1.54 | 1.49*** | 1.43–1.55 |
| Mother's prenatal care experience | | | | | | | | |
| First trimester care | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| No first trimester care | 1.06*** | 1.04–1.08 | 1.10*** | 1.07–1.12 | 1.10*** | 1.08–1.12 | 1.10*** | 1.07–1.12 |
| Population density (logged) | 1.02*** | 1.01–1.02 | | | 1.00 | 0.99–1.01 | 1.00 | 0.99–1.01 |
| Neighborhood poverty trajectories | | | | | | | | |
| Long-term low | 1.00 | | | | 1.00 | | | |
| Long-term moderate | 1.30*** | 1.24–1.36 | | | 1.10*** | 1.06–1.14 | | |
| Long-term high | 1.72*** | 1.64–1.81 | | | 1.17*** | 1.12–1.23 | | |
| Increase | 1.34*** | 1.28–1.41 | | | 1.07** | 1.02–1.12 | | |
| Decrease | 1.21*** | 1.15–1.27 | | | 1.08*** | 1.03–1.14 | | |
| Neighborhood inequality trajectories | | | | | | | | |
| Long-term low/moderate | 1.00 | | | | | | 1.00 | |
| Long-term high | 1.27*** | 1.23–1.31 | | | | | 1.07*** | 1.04–1.10 |
| Increase | 1.10*** | 1.06–1.14 | | | | | 0.99 | 0.96–1.03 |
| Decrease | 1.05* | 1.01–1.09 | | | | | 1.03 | 0.99–1.06 |
| ***Random Effects*** | | | | | | | | |
| Level-2 Intercept | | | 0.03*** | | 0.03*** | | 0.03*** | |
| Model fit | | | | | | | | |
| −2LL | | | 309,145 | | 309,089 | | 309,156 | |
| AIC | | | 309,177 | | 309,131 | | 309,156 | |
| BIC | | | 309,282 | | 309,269 | | 309,287 | |

OR = Odds ratio; CI = Confidence interval.

* $p < .05$

** $p < .01$

*** $p < .001$.

## Table 3

Association between neighborhood economic trajectories and low birth weight, Texas natality files, 2009–2011, N = 470,896.

| Characteristics | Model 1 (unadjusted) | | Model 2 (level-1 model) | | Model 3 (full model-poverty trajectories) | | Model 4 (full model-inequality trajectories) | |
|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| ***Fixed Effects*** | | | | | | | | |
| Mother's age | | | | | | | | |
| 12–19 years of age | 1.40*** | 1.35–1.45 | 0.83*** | 0.80–0.86 | 0.83*** | 0.80–0.87 | 0.83*** | 0.80–0.86 |
| 20–34 years of age | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| 35 or above | 1.15*** | 1.11–1.19 | 1.43*** | 1.38–1.48 | 1.44*** | 1.39–1.49 | 1.43*** | 1.38–1.49 |
| Mother's race | | | | | | | | |
| Black | 2.24*** | 2.18–2.30 | 1.87*** | 1.83–1.92 | 1.84*** | 1.79–1.89 | 1.86*** | 1.81–1.91 |
| White | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Mother's marital status | | | | | | | | |
| Married | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Not married | 1.78*** | 1.74–1.83 | 1.13*** | 1.09–1.16 | 1.12*** | 1.09–1.16 | 1.12*** | 1.09–1.16 |
| Parity | | | | | | | | |
| First child | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Second-fourth child | 0.75*** | 0.73–0.77 | 0.72*** | 0.70–0.74 | 0.72*** | 0.70–0.73 | 0.72*** | 0.70–0.74 |
| Fifth child or more | 1.13** | 1.04–1.24 | 0.81*** | 0.74–0.89 | 0.80*** | 0.73–0.88 | 0.81*** | 0.74–0.89 |
| Mother's education level | | | | | | | | |
| Less than high school | 2.35*** | 2.26–2.45 | 1.63*** | 1.55–1.71 | 1.60*** | 1.52–1.68 | 1.61*** | 1.53–1.69 |
| High school/GED | 1.84*** | 1.78–1.91 | 1.36*** | 1.30–1.41 | 1.34*** | 1.28–1.40 | 1.35*** | 1.29–1.41 |
| Some college | 1.49*** | 1.45–1.54 | 1.20*** | 1.15–1.25 | 1.19*** | 1.14–1.24 | 1.19*** | 1.15–1.24 |
| College graduate or more | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Father's education level | | | | | | | | |
| Less than high school | 2.15*** | 2.05–2.25 | 1.46*** | 1.38–1.55 | 1.44*** | 1.36–1.52 | 1.45*** | 1.37–1.54 |
| High school/GED | 1.85*** | 1.78–1.92 | 1.40*** | 1.34–1.46 | 1.38*** | 1.32–1.44 | 1.39*** | 1.33–1.45 |
| Some college | 1.43*** | 1.38–1.49 | 1.21*** | 1.16–1.26 | 1.20*** | 1.15–1.25 | 1.21*** | 1.16–1.26 |
| College graduate or more | 1.00 | | 1.00 | | 1.00 | | 1.00 | |

| Characteristics | Model 1 (unadjusted) | | Model 2 (level-1 model) | | Model 3 (full model-poverty trajectories) | | Model 4 (full model-inequality trajectories) | |
|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Missing | 2.63*** | 2.54–2.74 | 1.57*** | 1.49–1.65 | 1.54*** | 1.47–1.62 | 1.56*** | 1.48–1.64 |
| Mother's prenatal care experience | | | | | | | | |
| First trimester care | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| No first trimester care | 1.28*** | 1.25–1.31 | 1.06*** | 1.03–1.08 | 1.06*** | 1.03–1.08 | 1.06*** | 1.03–1.08 |
| Population density (logged) | 1.04*** | 1.03–1.05 | | | 1.00 | 1.00–1.01 | 1.00 | 1.00–1.01 |
| Neighborhood poverty trajectories | | | | | | | | |
| Long-term low | 1.00 | | | | 1.00 | | | |
| Long-term moderate | 1.46*** | 1.38–1.54 | | | 1.13*** | 1.08–1.19 | | |
| Long-term high | 2.19*** | 2.06–2.32 | | | 1.22*** | 1.16–1.29 | | |
| Increase | 1.06*** | 1.51–1.70 | | | 1.11*** | 1.05–1.16 | | |
| Decrease | 1.31*** | 1.23–1.40 | | | 1.12*** | 1.06–1.18 | | |
| Neighborhood inequality trajectories | | | | | | | | |
| Long-term low/moderate | 1.00 | | | | | | 1.00 | |
| Long-term high | 1.39*** | 1.34–1.45 | | | | | 1.08*** | 1.05–1.12 |
| Increase | 1.20*** | 1.15–1.26 | | | | | 1.03 | 0.99–1.06 |
| Decrease | 1.03 | 0.98–1.09 | | | | | 1.01 | 0.97–1.05 |
| ***Random Effects*** | | | | | | | | |
| Level-2 Intercept | | | 0.02*** | | 0.01*** | | 0.02*** | |
| Model fit | | | | | | | | |
| −2LL | | | 225,583 | | 225,522 | | 225,557 | |
| AIC | | | 225,615 | | 225,564 | | 225,597 | |
| BIC | | | 225,720 | | 225,702 | | 225,728 | |

OR = Odds ratio; CI = Confidence interval.

* $p < .05$

** $p < .01$

*** $p < .001$.

## Table 4

Associations between neighborhood economic trajectories and small for gestational age, Texas natality files, 2009–2011, N = 470,896.

| Characteristics | Model 1 (unadjusted) | | Model 2 (level-1 model) | | Model 3 (full model- poverty trajectories) | | Model 4 (full model-inequality trajectories) | |
|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| ***Fixed Effects*** | | | | | | | | |
| Mother's age | | | | | | | | |
| 12–19 years of age | 1.53*** | 1.48–1.57 | 0.88*** | 0.85–0.91 | 0.88*** | 0.85–0.91 | 0.88*** | 0.85–0.91 |
| 20–34 years of age | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| 35 or above | 0.86*** | 0.84–0.89 | 1.07*** | 1.04–1.11 | 1.08*** | 1.05–1.12 | 1.08*** | 1.04–1.11 |
| Mother's race | | | | | | | | |
| Black | 2.08*** | 2.03–2.12 | 1.71*** | 1.67–1.75 | 1.70*** | 1.66–1.73 | 1.82*** | 1.75–1.90 |
| White | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Mother's marital status | | | | | | | | |
| Married | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Not married | 1.87*** | 1.83–1.91 | 1.17*** | 1.14–1.20 | 1.17*** | 1.14–1.20 | 1.17*** | 1.14–1.20 |
| Parity | | | | | | | | |
| First child | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Second-fourth child | 0.70*** | 0.69–0.72 | 0.70*** | 0.68–0.71 | 0.69*** | 0.68–0.71 | 0.69*** | 0.68–0.71 |
| Fifth child or more | 0.86*** | 0.80–0.94 | 0.69*** | 0.64–0.75 | 0.68*** | 0.63–0.74 | 0.69*** | 0.63–0.75 |
| Mother's education level | | | | | | | | |
| Less than high school | 2.49*** | 2.41–2.57 | 1.67*** | 1.61–1.74 | 1.64*** | 1.58–1.71 | 1.65*** | 1.59–1.72 |
| High school/GED | 1.92*** | 1.87–1.98 | 1.42*** | 1.37–1.47 | 1.40*** | 1.35–1.45 | 1.40*** | 1.36–1.45 |
| Some college | 1.49*** | 1.45–1.53 | 1.21*** | 1.18–1.25 | 1.20*** | 1.17–1.24 | 1.21*** | 1.17–1.24 |
| College graduate or more | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| Father's education level | | | | | | | | |
| Less than high school | 2.16*** | 2.08–2.24 | 1.30*** | 1.24–1.36 | 1.27*** | 1.22–1.33 | 1.28*** | 1.22–1.34 |
| High school/GED | 1.77*** | 1.72–1.82 | 1.21*** | 1.17–1.26 | 1.19*** | 1.15–1.24 | 1.20*** | 1.16–1.24 |
| Some college | 1.35*** | 1.31–1.39 | 1.08*** | 1.04–1.11 | 1.06*** | 1.03–1.10 | 1.07*** | 1.04–1.11 |
| College graduate or more | 1.00 | | 1.00 | | 1.00 | | 1.00 | |

| Characteristics | Model 1 (unadjusted) | | Model 2 (level-1 model) | | Model 3 (full model- poverty trajectories) | | Model 4 (full model-inequality trajectories) | |
|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Missing | 2.52*** | 2.44–2.59 | 1.33*** | 1.28–1.39 | 1.31*** | 1.26–1.36 | 1.32*** | 1.26–1.37 |
| Mother's prenatal care experience | | | | | | | | |
| First trimester care | 1.00 | | 1.00 | | 1.00 | | 1.00 | |
| No first trimester care | 1.46*** | 1.43–1.49 | 0.82*** | 0.81–0.84 | 0.82*** | 0.81–0.84 | 0.82*** | 0.81–0.84 |
| Population density (logged) | 1.03*** | 1.02–1.03 | | | 0.99 | 0.99–1.00 | 1.00 | 0.99–1.00 |
| Neighborhood poverty trajectories | | | | | | | | |
| Long-term low | 1.00 | | | | 1.00 | | | |
| Long-term moderate | 1.47*** | 1.40–1.54 | | | 1.11*** | 1.07–1.15 | | |
| Long-term high | 2.14*** | 2.03–2.25 | | | 1.19*** | 1.14–1.25 | | |
| Increase | 1.60*** | 1.52–1.68 | | | 1.10*** | 1.06–1.15 | | |
| Decrease | 1.31*** | 1.24–1.38 | | | 1.09*** | 1.04–1.14 | | |
| Neighborhood inequality trajectories | | | | | | | | |
| Long-term low/moderate | 1.00 | | | | | | 1.00 | |
| Long-term high | 1.42*** | 1.37–1.46 | | | | | 1.10*** | 1.06–1.13 |
| Increase | 1.22*** | 1.17–1.27 | | | | | 1.08*** | 1.04–1.12 |
| Decrease | 1.07** | 1.02–1.11 | | | | | 1.07*** | 1.03–1.11 |
| Race × Neighborhood inequality trajectories | | | | | | | | |
| Black × Long-term low/moderate | | | | | | | 1.00 | |
| Black × Long-term high | | | | | | | 0.95 | 0.90–1.00 |
| Black × Increase | | | | | | | 0.89*** | 0.84–0.95 |
| Black × Decrease | | | | | | | 0.87*** | 0.81–0.94 |
| ***Random Effects*** | | | | | | | | |
| Level-2 Intercept | | | 0.01*** | | 0.01*** | | 0.01*** | |
| Race | | | | | | | 0.01*** | |
| Model fit | | | | | | | | |
| −2LL | | 320,062 | 319,984 | 319,994 | | | | |
| AIC | | 320,094 | 320,026 | 320,042 | | | | |
| BIC | | 320,199 | 320,163 | 320,198 | | | | |

OR = Odds ratio; CI = Confidence interval.

* $p < .05$

** $p < .01$

*** $p < .001$.

## Table 5

Associations between cross-sectional measures of neighborhood economic context and adverse birth outcomes, Texas natality files, 2009–2011, N = 470,896.

| Characteristics | Preterm birth | | Low birth weight | | Small for gestational age | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| A. Neighborhood poverty (2006–2010) | | | | | | |
| Unadjusted model | | | | | | |
| Low poverty | 1.00 | | 1.00 | | 1.00 | |
| Moderate poverty | 1.22*** | 1.18–1.27 | 1.37*** | 1.32–1.43 | 1.38*** | 1.33–1.43 |
| High poverty | 1.58*** | 1.53–1.64 | 1.98*** | 1.89–2.07 | 1.95*** | 1.87–2.02 |
| Full model [a] | | | | | | |
| Low poverty | 1.00 | | 1.00 | | 1.00 | |
| Moderate poverty | 1.07*** | 1.03–1.10 | 1.10*** | 1.06–1.14 | 1.08*** | 1.05–1.12 |
| High poverty | 1.13*** | 1.09–1.17 | 1.17*** | 1.13–1.22 | 1.15*** | 1.12–1.19 |
| B. Neighborhood inequality (2006–2010) | | | | | | |
| Unadjusted model | | | | | | |
| Low inequality | 1.00 | | 1.00 | | 1.00 | |
| Moderate inequality | 1.21*** | 1.13–1.29 | 1.43*** | 1.31–1.55 | 1.46*** | 1.36–1.57 |
| High inequality | 1.46*** | 1.37–1.56 | 1.88*** | 1.72–2.04 | 1.93*** | 1.79–2.07 |
| Full model [a] | | | | | | |
| Low inequality | 1.00 | | 1.00 | | 1.00 | |
| Moderate inequality | 1.03 | 0.97–1.09 | 1.08* | 1.01–1.16 | 1.09** | 1.03–1.15 |
| High inequality | 1.07* | 1.01–1.13 | 1.15*** | 1.07–1.24 | 1.16*** | 1.09–1.23 |

OR = Odds ratio; CI = Confidence interval.

* $p < .05$

** $p < .01$

*** $p < .001$.

[a] Covariates in Models 3–4 of Tables 2-4 were adjusted.