ASSOCIATIONS BETWEEN AREA-LEVEL DEPRIVATION AND PRETERM BIRTH IN THE BIBB (BIOSOCIAL IMPACT ON BLACK BIRTHS) STUDY

By

Jazib Gohar

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ABSTRACT

Evidence suggests that neighborhood deprivation may be associated with an increased risk of preterm birth (PTB, <37 weeks completed gestation). Black women, specifically, are more likely to have PTB and reside in deprived neighborhoods than their white counterparts. Few prior studies have examined this relationship in a cohort comprised solely of Black women and at multiple spatial levels. Our objective was to examine the association between area-level deprivation and the odds of PTB at the county, minor civil division (MCD), and census tract level in a Black cohort, and to determine if this association is modified by individual-level maternal characteristics. Women consented to participate in the BIBB study during a prenatal care visit and were surveyed to obtain addresses and individual-level data on age, income, and education among other covariates (n=1,239). Prenatal and hospital birth records of women who participated were abstracted to obtain multiple measures from which to categorize PTB. After exclusion for spontaneous abortion, therapeutic abortion, stillborn, or fetal death (n=17); women with missing gestational age data (n=47); missing residential address data (n-63); or lived in a Census tract that could not be linked to Census data (n=1); 1,112 women remained in the final sample size. Addresses from participants were geocoded and linked to data from the American Community Survey 5-year estimates. Six individual area-level characteristics were selected *a priori* for analyses: percent of population identifying as Black, unemployment rate, median household income, percent of population that is college educated, vacant housing rate, and percent on public assistance. An area-level deprivation index (ADI) was developed from a principal components analysis of the variables at the 3 aforementioned spatial levels. To examine the association between the ADI and the odds of PTB, odds ratios and 95% confidence intervals were estimated with sequentially-built generalized estimating equations (GEE). Models with the

best fit were selected using the quasilikelihood information criterion (QIC). Effect modification by individual-level maternal characteristics, such as income and education, was also assessed using GEE. After controlling for maternal age, annual household income, and education level, no association was found between the ADI and the odds of PTB at the county and Census tract levels. At the MCD level, however, living in the most deprived neighborhood quartile, compared to living in the upper three quartiles, was found to be slightly protective of PTB (OR = 0.90, 95% CI: 0.84, 0.96). There was statistically significant effect modification of the association with PTB by maternal annual household income at all three spatial levels. Among women who resided in the highest quartile of area-level deprivation, women who were low income (< $30,000/year) were less likely to have PTB than their high-income (≥ $30,000/year) counterparts. We simultaneously examined effect modification by maternal annual household income and education level in a two two-way interaction model at the Census tract level. Among those with an annual household income of over $30,000 and who were not college educated, living in a high deprivation Census tract was associated with a 5-times increase in odds of PTB compared to those living in a low deprivation Census tract. Conversely, among those with a household annual household income of less than $30,000 and who were college educated, living in a high deprivation Census tract was associated with a 59% decrease in odds of PTB compared to those residing in a low deprivation Census tract. Area-level deprivation is a multidimensional construct that may influence a woman's odds of PTB in several ways, and the impact it has on odds of PTB may vary across different spatial levels. Future research should further examine the association between area-level deprivation at multiple spatial levels and PTB risk, and further explore how this relationship may be moderated by various individual-level characteristics.

This dissertation is dedicated to my mother and father.
Thank you for every sacrifice you made to help me get here.
I am forever grateful.

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TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

Preterm birth (PTB), defined as birth prior to 37 completed weeks gestational age, is the leading cause of neonatal morbidity and mortality worldwide.[1] Within the U.S. there are marked racial/ethnic disparities as 14.4 percent of Black women had PTB in 2019, compared to 9.3 percent of white women.[2] High rates of PTB among Black women may be related to the residential neighborhood environment.[3] Neighborhoods can be characterized with regard to area-level variation (e.g., education, household income, poverty, racial/ethnic makeup of the community). Compared to white women, Black women are more likely to live in disadvantaged residential neighborhood environments that exhibit higher rates of crime, lower performing schools, and higher rates of poverty.[4-12] Even higher socioeconomic status Black women are more likely than their similar-SES White counterparts to live in disadvantaged neighborhoods or on the periphery of those neighborhoods. These inequalities are a consequence of long-standing patterns of residential racial segregation.[13] Further, individual-level sociodemographic characteristics of a mother may operate in tandem with area-level factors to increase the risk of PTB, potentially exacerbating, or attenuating the risk of untoward features of the environment in which a woman resides. In one of the few studies examining cross-level interactions, Sealy-Jefferson reported that mother's education level significantly modified the relationship between perceived residential environment and PTB despite a statistically insignificant association between residential environment and preterm delivery.[14] Research on residential neighborhood environments and birth outcomes, especially studies on risk among Black mothers, needs to further explore how individual-level characteristics intersect with area-level exposures.

This dissertation aims to describe how a Black mother's residential neighborhood environment may contribute to the risk of her infant being born preterm. We analyzed data collected from Black women participating in the Biosocial Impact on Black Births (BIBB) study in prenatal clinics in metropolitan Detroit, Michigan; Columbus, Ohio; and Orlando, Florida. Using available geocoded addresses of where the woman lived at the time of completing the questionnaire, we joined area-level characteristics from the American Community Survey 5-Year Estimates data at three spatial scales: 1) county, 2) minor civil division (MCD), and 3) Census tract. The area-level characteristics were as follows: proportion of the population that identifies as Black, proportion of the population with a high school education, median household income, unemployment rate, proportion of the population on public assistance, and proportion of housing that is vacant. These were examined individually and jointly in relation to a mother's PTB risk. Jointly, an area-level deprivation index was constructed using principal components analysis (PCA) at each of the three spatial domains. Subsequently, questionnaire data collected in late first/early second trimester were used as individual-level effect modifiers of the relationship. Generalized estimating equations (GEEs) were sequentially built to investigate the association between area-level deprivation and the odds of PTB. GEE accounts for the fact that the data are correlated due to clustering, as multiple women may be nested within the same spatial unit.[15]

Aim 1 of this study is to assess the relationship between area-level deprivation and the odds of PTB at the three aforementioned spatial units. Aim 2 of this study is to determine whether the relationship in Aim 1 is modified by individual-level maternal characteristics, specifically maternal annual household income and maternal education level. This research has contributed to our understanding of how a woman's residential neighborhood environment contributes to her risk of PTB, and whether a woman's individual-level characteristics exacerbate or attenuate the adverse impact of the neighborhood environment on PTB. By analyzing multiple and nested levels of the area-level environment, we have also contributed to the growing knowledge regarding the degree to which area-level exposures operate at various spatial scales. Continued efforts in understanding area-level environments as an underlying driver of health will inform future programmatic interventions and health policy to invest in disadvantaged neighborhoods.

BIBLIOGRAPHY

1) Purisch SE, Gyamfi-Bannerman C. Epidemiology of preterm birth. Semin Perinatol. 2017 Nov;41(7):387-391. doi: 10.1053/j.semperi.2017.07.009. Epub 2017 Sep 1. PMID: 28865982.

2) Martin JA, Hamilton BE, Sutton PD, et al. Births: Final data for 2019. National Vital Statistics Reports; vol 70 no 2. Hyattsville, MD: National Center for Health Statistics. 2021. DO: https://dx.doi.org/10.15620/cdc:100472.

3) Lorch, S., Enlow, E. The role of social determinants in explaining racial/ethnic disparities in perinatal outcomes. *Pediatr Res* 79, 141–147 (2016). https://doi.org/10.1038/pr.2015.199

4) De La Roca, J., Ellen, I.G., O'Regan, K.M., 2014. Race and neighborhoods in the 21st century: What does segregation mean today?. Regional Science and Urban Economics 47, 138–151.. doi:10.1016/j.regsciurbeco.2013.09.006

5) Masho SW, Cha S, Chapman DA, Chelmow D. Understanding the role of violence as a social determinant of preterm birth. Am J Obstet Gynecol. 2017 Feb;216(2):183.e1-183.e7. doi: 10.1016/j.ajog.2016.10.001. Epub 2016 Oct 8. PMID: 27729255.

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

7) Xu X, Qu K, Pang Q, Wang Z, Zhou Y, Liu C. Association between telomere length and survival in cancer patients: a meta-analysis and review of literature. Frontiers of medicine. 2016:1-13.

8) Margerison-Zilko, Claire, et al. "Beyond the Cross-Sectional: Neighborhood Poverty Histories and Preterm Birth." *American Journal of Public Health*, vol. 105, no. 6, 2015, pp. 1174-1180. *ProQuest*, http://ezproxy.msu.edu/login?url=https://www-proquest-com.proxy2.cl.msu.edu/scholarly-journals/beyond-cross-sectional-neighborhood-poverty/docview/1683336238/se-2?accountid=12598.

9) Pickett KE, Ahern JE, Selvin S, Abrams B. Neighborhood socioeconomic status, maternal race and preterm delivery: a case-control study. Ann Epidemiol. 2002 Aug;12(6):410-8. doi: 10.1016/s1047-2797(01)00249-6. PMID: 12160600.

10) Ahern J, Pickett KE, Selvin S, Abrams B. Preterm birth among African American and white women: a multilevel analysis of socioeconomic characteristics and cigarette smoking. J Epidemiol Community Health. 2003 Aug;57(8):606-11. doi: 10.1136/jech.57.8.606. PMID: 12883067; PMCID: PMC1732558.

11) Ma X, Fleischer NL, Liu J, Hardin JW, Zhao G, Liese AD. Neighborhood deprivation and preterm birth: an application of propensity score matching. Ann Epidemiol. 2015

Feb;25(2):120-5. doi: 10.1016/j.annepidem.2014.11.021. Epub 2014 Nov 28. PMID: 25523896.

12) Janevic T, Stein CR, Savitz DA, Kaufman JS, Mason SM, Herring AH. Neighborhood deprivation and adverse birth outcomes among diverse ethnic groups. Ann Epidemiol. 2010 Jun;20(6):445-51. doi: 10.1016/j.annepidem.2010.02.010. PMID: 20470971; PMCID: PMC3410674.

13) Braveman, P. A., Heck, K., Egerter, S., Marchi, K. S., Dominguez, T. P., Cubbin, C., Fingar, K., Pearson, J. A., & Curtis, M. (2015). The role of socioeconomic factors in Black-White disparities in preterm birth. *American journal of public health*, *105*(4), 694–702. https://doi.org/10.2105/AJPH.2014.302008

14) Sealy-Jefferson S, Giurgescu C, Helmkamp L, Misra DP, Osypuk TL. Perceived Physical and Social Residential Environment and Preterm Delivery in African-American Women. Am J Epidemiol. 2015;182(6):485-493.

15) James A. Hanley, Abdissa Negassa, Michael D. deB. Edwardes, Janet E. Forrester, Statistical Analysis of Correlated Data Using Generalized Estimating Equations: An Orientation, *American Journal of Epidemiology*, Volume 157, Issue 4, 15 February 2003, Pages 364–375, https://doi.org/10.1093/aje/kwf215

CHAPTER 2: LITERATURE REVIEW

In the United States, Black women have the highest rate of preterm birth (PTB) among all racial/ethnic groups.[1] Further, Black women are more likely to reside in communities with fewer resources than their white counterparts.[1-3] The significance in this study lies in the intersection of area-level deprivation and individual-level risk factors to predict PTB among Black women. Specific pathways that are less well understood include: a) the independent influence of area-level deprivation exposure on PTB risk; b) the association between area-level characteristics and PTB at three different spatial scales (i.e. census tract, MCD, county); c) and how individual-level characteristics moderate area-level factors on PTB risk. To address these significant gaps in scientific knowledge, we will analytically investigate the role that area-level characteristics and deprivation may have on PTB risk among Black women at three different spatial scales. Further, we will consider and examine the potential moderating role that individual-level characteristics may have on the association between area-level deprivation and PTB. As will be seen in this review of the literature, there are few studies that have addressed these gaps.

This literature review focuses on 19 studies that examine the association between area-level deprivation and PTB (Table 1). Studies were identified via search engine using key terms "preterm birth," "birth outcomes," "neighborhood," "neighborhood deprivation," "neighborhood disadvantage," and "neighborhood characteristics" using PubMed, selecting papers from January 2000 to February 2024. Criteria for inclusion were based on the outcomes and exposures studied. Studies including PTB as the outcome and that focused on some form of objective neighborhood characteristic, be it specific area-level Census measures or area-level deprivation indices constructed from a set of specific Census measures that capture the neighborhood environment, as the predictors were included. Excluded studies did not analyze PTB as their primary outcome of interest or considered only subjective measures of neighborhood deprivation. Studies conducted outside of the United States were also excluded as objective measures based on linkage to the Census would not be possible. We included only studies that estimated effects of the current (cross-sectional) environment of the neighborhood (see Discussion for consideration of longitudinal neighborhood factors and life course experiences.) Finally, studies that did not perform race-stratified or single race (Black, African-American) analyses were excluded from this literature review. We first review the overall results and later summarize the race-specific results. Furthermore, we denote the area level of the characteristics (county, minor civil division, Census tract, Census block group, other).

Cross sectional measures of neighborhood environment and PTB.

Crime.[1,4-5] Gun violence rates and violent crime counts were individually examined as area-level measures in three reports examining area-level crime measures.[1, 4-5] Matoba et al. found a 21% increased odds of PTB among those who resided in the neighborhoods with in highest tertile of gun violence rates compared to those who lived in the lowest tertile, even after adjusting for both individual characteristics (i.e., age, education, marital status) and other Census tract socioeconomic characteristics (adjusted odds ratio (aOR) = 1.21, 95% confidence interval (CI): 1.11, 1.32).[1] Messer et al. found high violent crime rates to be associated with an increased odds of delivering preterm among a sample of 11,749 women (7,372 non-Hispanic white, 4,377 non-Hispanic Black).[4] Adjusting for neighborhood-level deprivation (rather than modeling it as a predictor variable as seen in other studies) and individual-level characteristics (i.e., race, age, education, marital status), both non-Hispanic white and non-Hispanic Black women who lived in block groups in the highest quartile of violent crime rates had a 50% and 40%, respectively, increased odds of PTB compared to their counterparts who lived in the lowest quartile of violent crime rates.[4] In an all-Black cohort of 72 women Giurgescu et al. did not find a statistically significant relationship between violent crime and PTB, however factors that may contribute to these discrepancies include differences in violent crime measures (Giurgescu et al. used counts; Messer et al. used rates), violent crime definitions, city of study site (Giurgescu et al. Chicago IL vs. Messer et al. Raleigh NC), and sample size differences.[5]

Built environment.[5-7] Three studies reported on three different dimensions of built environment as potential exposures of interest: median housing development year;[6] vacant land and housing;[5] and neighborhood walkability.[7] Wood et al. categorized as high risk those Census tracts with the median housing development year being prior to 1975 and with greater than 20% of the individuals below the Federal poverty line.[6] Women residing in high-risk Census tracts had a slightly higher odds of PTB than women who lived in other Census tracts (OR = 1.07, 95% CI: 1.04, 1.09). Kash et al. used walk score rankings (from walkscore.com, a website that measures walkability using an algorithm that awards points based on distances to amenities to examine how walkability may be associated with PTB risk in neighborhoods of Philadelphia.[7] Higher walkability of a neighborhood was found to be associated with a 10% decreased odds of only medically-induced preterm births and not all preterm births.[4] Giurgescu et al. used a unique approach to area level with measures taken based on half mile radius of residence rather than Census tracts.[5] Objective neighborhood physical disorder, defined as an average z-score of vacant housing, vacant land, and industrial land use in a 0.5-mile radius of one's household, was strongly associated with PTB risk in an all-Black cohort (OR = 2.64, 95% CI: 1.07, 6.53).[5]

Sociodemographic characteristics.[8-11] These factors reflect the economic, educational, and racial composition of a neighborhood, including median household income, proportion of residents living in poverty, unemployment rate, high school graduation rates, and proportion of

Black residents. As a secondary analysis of the Bogalusa Heart Study, Wallace et al. examined the effect of living in a high poverty block group (defined as greater than 27% of the households in a block group at below the federal poverty line; or, the upper quartile of the sample distribution) has on risk of PTB compared to living in a low poverty block group (the lower three quartiles of the sample distribution), stratified by race.[8] Using white women who lived in a low poverty block group as the referent group, there was an increased, however not statistically significant, odds of PTB among Black or white women living in high poverty block groups. A statistically significant increased odds of PTB among Black women who lived in low poverty neighborhoods was seen compared to white women, independent of individual-level socioeconomic position.[8] While we might expect the Black-white disparity in PTB odds to reduce in low poverty relative to high poverty communities, we see the opposite pattern. This suggests that while poverty has deleterious effects on PTB risk regardless of race, higher neighborhood socioeconomic position does not reduce the disproportionate burden of adverse outcomes experienced by Black women relative to white women in the same neighborhoods.[8] Work done by Pickett et al. revealed that the relationship between area-level characteristics and PTB risk may not be linear.[9] Statistically significant quadratic relationships were identified for proportion of unemployed adult men, median household income, and 1980-1990 change in neighborhood proportion of African American residents on PTB risk among Black women in the study.[9] Additionally, among white women in the study, a quadratic relationship was found between change in male unemployment and PTB.[9] Not only does this suggest that the relationship between area-level deprivation and PTB risk may not be linear, but also that area-level characteristics have varying impacts on a woman's risk to deliver preterm across racial groups. Looking at birth data from Maternal and Infant Health Assessment (MIHA) in

California, Margerison et al. estimated associations between PTB and neighborhood poverty measures.[10] Using cross-sectional (at the time of the infant's birth) measures, a statistically significant relationship was reported between living in a neighborhood with high (compared to low) poverty (OR = 1.29; 95% CI: 1.12, 1.50). However, this association was no longer significant after adjusting for maternal characteristics (OR = 1.08; 95% CI: 0.91, 1.28).[10] Using birth certificate data in Texas from 2009-2011 Cubbin et al. examined the association between neighborhood poverty and PTB, and neighborhood inequality, defined by cutpoints of a Census tract's GINI index score (a measure of wealth inequality across a population), and PTB.[11] Even after adjusting for individual-level covariates and neighborhood-level population density, Cubbin et al. found significant associations between neighborhood poverty and PTB odds (OR = 1.13; 95% CI: 1.09, 1.17) and between neighborhood inequality and PTB odds (OR = 1.07; 95% CI: 1.01, 1.13).[11]

Neighborhood Deprivation Index.[2-4,12-15] Studies have also examined how maternal exposure measured by a global index of neighborhood environment, rather than a disaggregated or singular (local-level) neighborhood measure as described above, may relate to PTB risk. To create a measure that captures the neighborhood environment as a whole, neighborhood deprivation indices (NDI) have been created, often by means of principal components analysis (PCA), to create a composite measure of neighborhood quality from several individual measured characteristics. Six of the 24 studies included in this literature review created their own NDI using US Census and American Community Survey (ACS) data.[2-4,12-14] Common area-level variables that were included in several of the deprivation indices include: poverty rate, high school graduation rate, unemployment rate, median household income, percent on public assistance, and proportion of males in management occupations.

Two of the six studies reported that Black women lived in neighborhoods with greater levels of deprivation compared to white women.[4,12] In these studies, those who lived in block groups with the greatest levels of deprivation had an increased odds of PTB compared to women who lived in neighborhoods with the least amount of deprivation. In particular, as seen in a study examining neighborhood deprivation and PTB risk among diverse ethnic groups, Janevic et al. found a 12% increased odds of PTB among Black women who lived in the highest quartile of deprivation compared to Black women who lived in the lowest quartile.[13] Other studies, however, found more mixed results when examining the association between neighborhood deprivation and PTB. Comparing those living in the highest quintile of deprivation to those living in the lowest quintile, O'Campo et al. found an increased risk of PTB among white women living in 7 out of 8 neighborhoods included in the study.[2] Conversely, this same association was found among Black women only in 2 of the 8 neighborhoods, with a more attenuated effect than the ones seen among white women. Others have also found a null association in the odds of PTB between those who lived in the most deprived neighborhoods in comparison to those living in the least deprived.[3,14]

One study, however, did not perform PCA on US Census or ACS data to create a composite measure of neighborhood quality.[15] Berkowitz et al. utilized the California Healthy Places Index (HPI), a publicly available, multi-dimensional characterization of census tracts in California to examine the association between neighborhood quality and PTB in a cohort of all-Black women delivering in Oakland, California between 2007 and 2011.[15] The HPI contains 25 indicators that fall under one of eight policy action domains (economics, education, healthcare access, housing, neighborhood conditions, pollution/clean environment, social environment, and transportation), and weighted domain scores for each Census tract were summed to create the

HPI score.[15] In fully adjusted models, women who lived in neighborhoods in the highest quartile of HPI scores (indicating the highest quality neighborhoods) had a 38% reduced risk of PTB compared to women living in neighborhoods in the lowest quartile of HPI scores (indicating the lowest quality neighborhoods).[15]

Black Women.

The experience that Black women have may be markedly different than that of any other racial group, thus warranting the investigation of this association among Black women alone. Black women experience higher rates of PTB in comparison to their white counterparts and are more likely to reside in neighborhoods with greater disorder than white women. In fact, the study of neighborhood deprivation and PTB risk arose out of efforts to explain the racial disparities that individual-level variables, such as maternal education and poverty, could not explain. Seventeen of the 19 studies either performed a race-stratified analysis (10 studies) or had a study population comprising of Black women only (7 studies).

Among the 10 studies that performed race-stratified analyses, all but two reported heterogeneity in the associations across racial groups.[7,11] Kash et al. did not find that race moderate the relationship between neighborhood walkability and the odds of PTB, and Cubbin et al. found that race did not moderate the relationship between neighborhood-level poverty and income trajectories and PTB risk.[7,11] The remaining 7 studies, however, found statistically significant relationships between area-level characteristics and PTB in race-stratified models.[1-2,4,8-9,12-13,19] Three of the studies found an increased odds of PTB comparing Black women who lived in neighborhoods with the highest deprivation to their counterparts that lived in neighborhoods with the lowest deprivation.[4,12-13] One study found significant quadratic relationships between area-level characteristics and PTB risk that varied by race.[9] Wallace et al.

found that, compared to white women who lived in low poverty neighborhoods, Black women who also lived in low poverty neighborhoods had over 2.5 times the odds of PTB (OR = 2.56, 95% CI: 1.19, 5.49) but there were no increased odds of PTB among Black or white women who lived in high poverty neighborhoods.[8] Braverman et al. estimated Black-White disparities in PTB odds within subgroups of different socioeconomic categories, such as family poverty status (=< 100% poverty; > 100% poverty), maternal education (< high-school graduate; >= high school graduate), paternal occupation (not working; lower status; higher status), and Census tract-level poverty (>= 25%; 25%).[19] Among women in each of the relatively more advantaged subgroups, Black women experienced significantly elevated odds of PTB compared to their white counterparts.[19] There were not, however, significant differences in PTB odds between Black and white women among those in the most disadvantaged subgroups.[19] Lastly, O'Campo et al. found increased odds of PTB among white women who lived in the highest quintile of deprivation compared to the lowest across 7 out of 8 different geographic regions.[2] Comparing this to the same association studied in Black women in the study, significantly increased odds of PTB were only found in 2 of the 8 geographic regions.

Seven of the 19 studies focused on shedding light on factors that specifically influence a Black woman's risk of PTB by recruiting only Black women.[3,5,14-18] Phillips et al. found no statistically significant associations between area-level characteristics and PTB risk overall but reported an increased odds of medically induced PTB among unmarried women who lived in low-SES neighborhoods compared to unmarried women in high-SES neighborhoods.[3] Berkowitz et al. found that residing in the highest quality neighborhood, compared to the lowest quality neighborhood, was associated with a 38% reduced risk of PTB.[15] Two studies by Giurgescu et al. included only Black women. They found that objective physical disorder and psychological distress predicted PTB risk, and that psychological distress mediated the effects of perceived neighborhood conditions on PTB risk.[5,16] In a series of papers using data from the Life-course Influences on Fetal Environments Study (LIFE; 2009-2011), also a Black only cohort, Sealy-Jefferson et al. did not find an association between area-level characteristics and PTB risk. However, they were able to find evidence of effect modification by individual maternal characteristics.[14,17-18] These will be further outlined in the subsequent section.

Two of the 19 studies did not perform race-stratified analyses or had all-Black cohorts but did look at race as potential predictors of PTB.[6,10] Both Margerison-Zilko et al. and Wood et al. found an increased odds of PTB among Black women, compared to white women.[6,10]

Effect Modification.

The impact of neighborhood environment on PTB may be moderated by the mother's personal sociodemographic characteristics. Other than assessment of moderation by maternal race (see above), studies have rarely explored other individual-level sociodemographic characteristics (e.g., maternal educational attainment, annual household income). In a series of three papers using data from the Life-course Influences on Fetal Environments Study (LIFE; 2009-2011) of 1410 pregnant Black women, Sealy-Jefferson et al. examined how the association between various area-level characteristics and PTB are moderated by maternal characteristics.[14,17-18] Among all three of these papers, no statistically significant associations were identified between the neighborhood-level exposures (tax foreclosures, eviction rates, and neighborhood deprivation index score) and PTB risk.[14,17-18] What was found, however, was a statistically significant modification of the association by individual-level characteristics. Thus, analyses of moderation unmasked important associations of area-level characteristics with PTB risk for subgroups. Those with greater than 12 years of education who lived in high tax foreclosure Census tracts had a statistically significantly lower risk of PTB than their counterparts in low tax foreclosure tracts (adjusted rate ratio (RR) = 0.74, 95% confidence interval (CI): 0.55, 0.98).[17] A higher risk of PTB was found among women who were married/cohabiting with the father of the baby living in neighborhoods with high eviction rates compared to their counterparts living in areas with low eviction rates (adjusted RR: 1.25, 95% CI: 1.06, 1.47).[18] Lastly, among women who infrequently asked others for prayer, there was a greater prevalence of PTB among those who resided in more disadvantaged neighborhoods compared to those who resided in less disadvantaged neighborhoods (adjusted prevalence ratio = 1.29, 95% CI: 1.01, 1.63).[14] In summary, while none of the papers found an association between objective neighborhood environment and PTB, all were able to demonstrate the effect modifying role that individual-level characteristics played in the relationship between neighborhood and PTB risk. Notably, these findings were derived from analyses of a Black only cohort of women delivering at a metro Detroit hospital.

Strengths.

The papers in this literature review exhibited many strengths in design and analysis. First, the assessment of exposure data, particularly US Census and American Community Survey (ACS) data used 10-year US Census and 5-Year ACS estimates as opposed to single year estimates. Multi-year estimates provide a more stable representation of the area-level environment, whereas a single year estimate may be more prone to drastic changes that may not accurately reflect the environment during the study period.

Second, the use of composite measures of neighborhood deprivation, in contrast to single neighborhood measures, was a strength of seven of the 19 studies. NDIs are a more comprehensive reflection of the area environment, incorporating several individual characteristics into a single measure that captures several dimensions of the neighborhood. Singular measures, on the other hand, only capture one dimension of the area-level environment and thus may miss valuable information regarding the deprivation of the neighborhood. While the inclusion of specific variables in the deprivation index was not uniform across papers, the methodology in its development was consistent across all studies that utilized an NDI. Principal components analysis was utilized by every study in developing their NDIs and is considered as the gold standard methodology.

Third, with the use of birth certificate records, clinical notes, and hospital data, nearly all of the studies utilized high quality methods to determine PTB status among study participants. Only one study exhibited a weakness in the determination of PTB status, asking participants to self-report PTB. With the use of clinical and birth records to determine PTB status for each woman, there was little risk for measurement error in the outcome of PTB for the other studies.

For the six papers that focused on cohorts of Black women only, there is a significant strength in that these studies examined within-group variations of neighborhood deprivation on PTB risk among this group at highest-risk for PTB.[14] In the series of papers using data from the LIFE study, Sealy-Jefferson et al. had the largest all-Black cohort with over 1,400 Black women in the study.[14,17-18] Black women are understudied when it comes to identifying specific risk and preventive factors that influence PTB risk, and several of these studies were able to identify novel associations that may guide future research.

Several studies noted that their large sample size was a strength in their studies. Other studies used city- and state-level birth registry data, allowing them to analyze tens, even hundreds of thousands of individuals.[1-2,4,6,10-13,19] With nearly every study having at least a thousand individuals, and several having substantially more, statistical power for testing hypotheses was likely sufficient with the prevalence of the PTB outcome and exposures.

Weaknesses.

Several gaps in the literature are evident and underscore the need for the proposed study. Many of the studies compared outcomes between Black and white women. Only a handful of studies recruited only Black women. In order to understand the risk factors that contribute to PTB risk specifically among Black women, studies must focus on recruiting more Black women into their study cohorts in order to perform analyses of sufficient power that examine these risk factors. While six studies recruited all-Black cohorts, the study population sizes in half of these studies were at most 100 women and recruited from one or two hospitals.

All of the studies included examined area-level characteristics at the Census tract or block group levels. While these spatial units have frequently been used for neighborhood-level analyses, none of these studies compared findings across multiple different spatial units or examined spatial units of greater scale (i.e. township, county). This reveals a gap in the literature that may provide insight on the role of deprivation at various spatial units may play in a woman's risk of PTB. While county- and minor civil division (MCD)-level deprivation may not be entirely representative of a woman's immediate surroundings, it could serve as grounds to explore policy-level changes at various governances that may have downstream effects at the Census tract and block group levels. Furthermore, comparing the level of deprivation across spatial levels may reveal discordances between spatial levels that could reveal an unequal distribution of deprivation (i.e., if a Census tract's deprivation is substantially higher than the MCD and county within which it is nested in). The unequal distribution of deprivation may be targets of policy interventions that aim to reduce disparities among more deprived Census tracts nested within their respective MCDs and counties.

Nearly all studies noted the use of cross-sectional data as a primary limitation of their study. The use of cross-sectional data, while commonplace in the field, has a key disadvantage when it comes to principles of temporality and, thus, causality. With cross-sectional measures, we attribute a single timepoint measurement to a woman unknowing of their length of residence in that specific area. Even when we have access to longitudinal data on the neighborhood factors, we may not know how long a woman has been resided in any given neighborhood. Imposing the historical context of a neighborhood, unknowing of the amount of time an individual has spent in the neighborhood, may not accurately reflect the impact the neighborhood context has on PTB. While this may appear as a significant issue, we would also expect social mobility to be relatively low.[10] Moving residences during the pregnancy does not appear to be a substantial limitation. One study cited by Cubbin et al. found that 63% of women remained in their neighborhood during pregnancy, and of those who moved, a majority moved to a neighborhood that was socioeconomically similar to their previous neighborhood of residence.[11] However, to address this issue fully, future studies could collect and employ longitudinal data that accurately capture one's lifetime area-level exposures.

Another weakness, not new to social epidemiology, is the imposition of Census tract or block group as one's neighborhood. Nearly all studies, ours included, will experience this issue, as the area-level definitions may not be perceived as one's neighborhood or community amongst those who participate in the study, as described by Wallace et al.[8] The ability to systematically collect a variety of area-level characteristics, however, is a significant benefit of using pre-defined area-level definitions and allows us to analyze their associations with PTB risk. Future studies may employ mixed-methods techniques to better understand what individuals consider their immediate neighborhood environment, allowing us to select the area-level definition that is most congruent with one's definition of neighborhood.

Sealy-Jefferson et al. explored the individual-level characteristics of education, marital status, and spirituality as moderators of neighborhood-level deprivation.[14,17-18] With the exception of those papers based on the LIFE metro Detroit cohort of Black women (2009-2011), none of the other papers reported on effect modification by factors outside of race/ethnicity. Many studies, particularly larger ones that rely on vital statistics data, struggle to consider moderation by factors other than race as individual-level data are often limited in such data. In order to study moderation by individual-level characteristics among Black women, studies must both recruit a sufficient sample size of participants and perform surveys that collect data on individual-level variables of interest. This, however, can be difficult as such budget constraints and recruitment difficulties serve as obstacles in doing so. As a result, little is known about how individual-level characteristics may moderate the effect of neighborhood environment on risk for PTB among Black women.

Conclusion.

Nineteen studies examining the association between area-level characteristics and PTB risk that met the inclusion criteria were selected for this literature review. The selected literature spans a range of individual objective neighborhood characteristics, such as crime rates, built environment, and sociodemographic factors, or utilized neighborhood deprivation indices to examine the role that neighborhood deprivation may play in PTB risk. Sixteen papers recruited Black women solely or stratified on race in their analyses. Only three of the papers looked at effect modification by individual factors outside of mother's race, revealing that there is still much to be learned about effect modification of area-level deprivation and PTB risk by individual characteristics. The literature contributed significantly to the field, as they uncovered characteristics of deprived neighborhoods that may influence PTB risk, as well as identified potential effect modifiers of the relationship. There are gaps, however, in the literature, namely regarding the spatial units of analysis that should be examined, and effect modification by other individual characteristics that our study aims to address in our all-Black cohort.

BIBLIOGRAPHY

1) Matoba, N., Reina, M., Prachand, N., Davis, M. M., & Collins, J. W. (2019). Neighborhood Gun Violence and Birth Outcomes in Chicago. *Maternal and child health journal*, *23*(9), 1251–1259. https://doi.org/10.1007/s10995-019-02765-w

2) Matoba, N., Reina, M., Prachand, N., Davis, M. M., & Collins, J. W. (2019). Neighborhood Gun Violence and Birth Outcomes in Chicago. *Maternal and child health journal*, *23*(9), 1251–1259. https://doi.org/10.1007/s10995-019-02765-w

3) Phillips, G. S., Wise, L. A., Rich-Edwards, J. W., Stampfer, M. J., & Rosenberg, L. (2013). Neighborhood socioeconomic status in relation to preterm birth in a U.S. cohort of black women. Journal of urban health : bulletin of the New York Academy of Medicine, 90(2), 197–211. https://doi.org/10.1007/s11524-012-9739-x

4) Messer LC, Kaufman JS, Dole N, Savitz DA, Laraia BA. Neighborhood crime, deprivation, and preterm birth. Ann Epidemiol. 2006;16(6):455-462.

5) Giurgescu C, Zenk SN, Dancy BL, Park CG, Dieber W, Block R. Relationships among neighborhood environment, racial discrimination, psychological distress, and preterm birth in African American women. J Obstet Gynecol Neonatal Nurs. 2012;41(6):E51-61.

6) Wood, B. M., & Cubbin, C. (2022). Neighborhood Poverty in Combination with Older Housing Is Associated with Adverse Birth Outcomes: A Study on Ubiquitous Lead Risk among 1 Million Births in Texas. International journal of environmental research and public health, 19(3), 1578. https://doi.org/10.3390/ijerph19031578

7) Kash, T. A., Ledyard, R. F., Mullin, A. M., & Burris, H. H. (2023). Neighborhood Walkability as a Risk Factor for Preterm Birth Phenotypes in Two Philadelphia Hospitals from 2013-2016. International journal of environmental research and public health, 20(11), 5932. https://doi.org/10.3390/ijerph20115932

8) Wallace, M., Harville, E., Theall, K., Webber, L., Chen, W., & Berenson, G. (2013). Neighborhood poverty, allostatic load, and birth outcomes in African American and white women: findings from the Bogalusa Heart Study. Health & place, 24, 260–266. https://doi.org/10.1016/j.healthplace.2013.10.002

9) Pickett KE, Ahern JE, Selvin S, Abrams B. Neighborhood socioeconomic status, maternal race and preterm delivery: a case-control study. Ann Epidemiol. 2002;12(6):410-418.

10) Margerison-Zilko, Claire, et al. "Beyond the Cross-Sectional: Neighborhood Poverty Histories and Preterm Birth." American Journal of Public Health, vol. 105, no. 6, 2015, pp. 1174-1180. ProQuest, http://ezproxy.msu.edu/login?url=https://www-proquest-com.proxy2.cl.msu.edu/scholarly-journals/beyond-cross-sectional-neighborhood-poverty/docview/1683336238/se-2?accountid=12598.

11) Cubbin, C., Kim, Y., Vohra-Gupta, S., & Margerison, C. (2020). Longitudinal measures of neighborhood poverty and income inequality are associated with adverse birth outcomes in Texas. Social science & medicine (1982), 245, 112665. https://doi.org/10.1016/j.socscimed.2019.112665

12) Ma X, Fleischer NL, Liu J, Hardin JW, Zhao G, Liese AD. Neighborhood deprivation and preterm birth: an application of propensity score matching. Ann Epidemiol. 2015 Feb;25(2):120-5. doi: 10.1016/j.annepidem.2014.11.021. Epub 2014 Nov 28. PMID: 25523896.

13) Janevic T, Stein CR, Savitz DA, Kaufman JS, Mason SM, Herring AH. Neighborhood deprivation and adverse birth outcomes among diverse ethnic groups. Ann Epidemiol. 2010 Jun;20(6):445-51. doi: 10.1016/j.annepidem.2010.02.010. PMID: 20470971; PMCID: PMC3410674.

14) Sealy-Jefferson S, Slaughter-Acey J, Caldwell CH, Kwarteng J, Misra DP. Neighborhood Disadvantage and Preterm Delivery in Urban African Americans: The Moderating Role of Religious Coping. SSM Popul Health. 2016 Dec;2:656-661. doi: 10.1016/j.ssmph.2016.09.001. PMID: 28367490; PMCID: PMC5371396.

15) Berkowitz, R. L., Mujahid, M., Pearl, M., Poon, V., Reid, C. K., & Allen, A. M. (2022). Protective Places: the Relationship between Neighborhood Quality and Preterm Births to Black Women in Oakland, California (2007-2011). *Journal of urban health : bulletin of the New York Academy of Medicine*, *99*(3), 492–505. https://doi.org/10.1007/s11524-022-00624-8

16) Giurgescu C, Zenk SN, Templin TN, Engeland CG, Kavanaugh K, Misra DP. The Impact of Neighborhood Conditions and Psychological Distress on Preterm Birth in African-American Women. Public Health Nurs. 2017;34(3):256-266.

17) Sealy-Jefferson, S., & Misra, D. P. (2019). Neighborhood Tax Foreclosures, Educational Attainment, and Preterm Birth among Urban African American Women. International journal of environmental research and public health, 16(6), 904. https://doi.org/10.3390/ijerph16060904

18) Sealy-Jefferson, S., Butler, B., Chettri, S., Elmi, H., Stevens, A., Bosah, C., Dailey, R., & Misra, D. P. (2021). Neighborhood Evictions, Marital/Cohabiting Status, and Preterm Birth among African American Women. Ethnicity & disease, 31(2), 197–204. https://doi.org/10.18865/ed.31.2.197

19) Braveman, P. A., Heck, K., Egerter, S., Marchi, K. S., Dominguez, T. P., Cubbin, C., Fingar, K., Pearson, J. A., & Curtis, M. (2015). The role of socioeconomic factors in Black-White disparities in preterm birth. American journal of public health, 105(4), 694–702. https://doi.org/10.2105/AJPH.2014.302008

APPENDIX

Table 1. Table of the Literature Reviewed for this Study

Primary Author	Year	Sample Size	Black Woman Subgroup?	Study Design	Exposure	Exposure Data Source	Spatial Level	Outcome	Outcome Data Source	Study Time Period	Findings: Descriptive Statistics	Findings: Statistical Analysis Results
Matoba, Nana	2019	175065	Yes	Retrospective Cohort Study	public violence crimes rate (thereafter called gun violence in this study), in tertiles	CPD gun violence records	Census Tract	PTB	IDPH vital records of singleton infants	2011-2015	- women in the high violence tertile were of younger age, lower education, inadequate prenatal care, single marital status, higher parity, and increased Medicaid enrollment compared to those in the lower violence tertile - neighborhoods with the highest rates of gun violence also exhibited highest rates of socioeconomic hardship	- compared to white women in the low violence tertile, black and Hispanic women across all three tertiles of gun violence had higher adjusted odds of PTB -race stratified analyses: there was no association between gun violence and PTB risk
O'Campo, Patricia	2007	The authors analyzed each city and race separately, with sample sizes in each group ranging from 4,224 to 54,862	Yes	Retrospective Cohort Study	Neighborhood Deprivation Index Score	2000 Census	Census Tract	PTB	Vital Statistics Birth Certificate Records	1995-2001		- comparing the highest to the lowest quintile of deprivation, neighborhood deprivation was significantly associated with an increased risk of PTB among white women in 7/8 areas in the fully adjusted models - results were more varied for examining neighborhood deprivation and PTB among black women, with only a few cities exhibiting an association between deprivation and PTB
Phillips, Ghasi	2013	6390	Yes	Prospective Cohort Study	Composite variable for neighborhood SES	2000 Census	Census Tract	PTB	Women in the Black Women's Health Study who completed a biennial follow-up questionnaire between 1997-2003 and have given birth in the last 2 years of completing the questionnaire	1997-2003		- no association or trends between individual census variables and PTB - neighborhood SES was not associated with PTB in unadjusted or adjusted models

Table 1 (cont'd)

Messer, Lynne	2006	13960	Yes	Retrospective Cohort Study	Neighborhood Crime, Neighborhood Deprivation	Raleigh Crime Reports (1999-2001), 2000 US Census	Block Group	PTB	Birth records for Wake County, NC	1999-2001	- Black women had twice the rate of PTBs compared to white women - 42.6% of white women lived in the lowest neighborhood deprivation quartile, compared to 42.2% of Black women living in the highest quartile of deprivation - 21% of black women lived in neighborhoods with the highest quartile of property crime rates, as opposed to 4.8% of white women - as deprivation increased, median crime rates increased such that the greatest rates of crime were consistently in block groups with the highest deprivation quartiles	- adverse birth outcomes increased with greater levels of neighborhood deprivation--greater percentages of women delivering preterm lived in the high and very high deprivation quartile block groups - Black women were more likely to be unmarried than white women, and for both groups being unmarried was associated with increased odds of delivering preterm - living in anything but the lowest quartile of deprivation was statistically significantly associated with PTB among Black women - living in the highest violent crime rate quartile block groups was associated with a statistically significant increased risk for PTB among white women (OR = 1.5) and Black women (OR = 1.4) - after adjusting for individual- and neighborhood-level characteristics, the association between vice-crime rate and PTB attenuated from 1.6 to 1.3, suggesting individual-level variables and neighborhood deprivation account for a large amount of the vice-crime/PTB effect

Table 1 (cont'd)

Giurgescu, Carmen	2012	72	Yes	Cross-Sectional	- objective neighborhood physical disorder - objective neighborhood social disorder - objective neighborhood violent crime - subjective neighborhood physical disorder - subjective neighborhood social disorder - subjective neighborhood violent crime	- 2000 census data (vacant housing, abandoned buildings) - 2007 CPD data (prostitution and drug related incidents) - 2007 CPD data (homicide, sexual assault, robbery) - physical environmental stress scale - neighborhood problems scale and perceived neighborhood scale - perceived neighborhood scale	0.5-mile radius	PTB	Birth Records	2007		- objective neighborhood social disorder was positively related to perceived social disorder - perceived physical disorder, perceived social disorder, and perceived crime were positively related to psychological distress - racial discrimination was positively associated to psychological distress - objective social disorder and perceived crime predicted psychological distress - statistically significant association between objective physical disorder (OR = 2.64) and PTB - statistically significant association between psychological distress (OR = 1.06) and PTB risk - psychological distress mediated the effects of objective social disorder and perceived crime on PTB
Wood, Bethany Marie	2022	1040642	Yes	Retrospective Cohort Study	- Residing in pre-1975 housing - high poverty neighborhoods	ACS 2007-2011 (median housing age), ACCS 2006-2010 (census tract-level poverty)	Census Tract	PTB	Birth certificate data from natality files	2009-2011		- in the unadjusted model, women who lived in high risk neighborhoods (median housing age <1975 and >= 20% poverty) were 23% more likely to deliver preterm (95% CI: 1.20, 1.25) - after adjusting for demographic characteristics (child sex, mother's age, race, marital status, parity), women in high risk neighborhoods were still 10% more likely to deliver preterm (95% CI: 1.08-1.12) - after additionally adjusting for urban/rural status, prenatal care, and education of mother and father, women in high risk neighborhoods were still 7% more likely to deliver preterm (95% CI: 1.04, 1.09)

Table 1 (cont'd)

Kash, Theresa	2023	19203	Yes	Retrospective Cohort Study	Walkability (Walk Score ranking)	Walkscore.com	Census Tract	PTB, sPTB, mPTB	Clinical notes	2013-2016		- bivariate associations of walkability with PTB and sPTB were not significant - patients who had an mPTB were more likely to live in census tracts with lower walkability compared to patients who had a term birth - in fully adjusted models, no association between walkability and PTB or sPTB were detected - in fully adjusted models, higher walkability was associated with lower odds of mPTB - when stratifying by race, higher walkability was not significantly associated with PTB, sPTB, or mPTB for any group
Wallace, Maeve	2013	2743	Yes	Retrospective Cohort Study	- Allostatic Load Score - Neighborhood Poverty	BHS Risk Screening Examination, 1990 and 2000 Census	Block Group	PTB	Birth Records	1990-2009		- no association between allostatic load and birth outcomes - AA women living in low poverty neighborhoods were more likely to deliver preterm compared to white women in the same low poverty neighborhoods - no statistical difference in the likelihood of PTB for AA women in high poverty or white women in high R10poverty compared to white women in low poverty - individual-level education was not associated with PTB

Table 1 (cont'd)

Pickett, Kate	2002	1661	Yes	Case Control	Neighborhood SES Factors	1990 Census	Census Tract	PTB	UCSF Perinatal Database	1980-1990		- no significant association between age and PTB - no significant association between marital status and PTB - in unadjusted models, significant association between education and PTB and being on medi-cal and PTB among Black women - in unadjusted models, significant association between family occupation status and PTB and being on medi-cal and PTB among white women - in exploratory GEE models, relationships between neighborhood SES factors and PTB deliveries were found to be linear and non-linear - statistically significant linear relationship between proportion of AA residents and PTB risk among Black women - significant quadratic relationship between proportion unemployed adult men, median HH income, and 1980-1990 change in proportion of AA residents on risk of PTB - in fully adjusted GEE models, quadratic relationships remained significant

Table 1 (cont'd)

Margerison-Zilko, Claire	2015	23291	No	Retrospective Cohort Study	Longitudinal Neighborhood Poverty Category	1970-2000 Neighborhood Change Database, 2005-2009 ACS	Census Tract	PTB	California Maternal and Infant Health Assessment, Birth records	2003-2009		- In cross-sectional model (2005-2009 poverty category), living in a neighborhood with high poverty was significantly associated with PTB (OR = 1.29) in the unadjusted model, however was no longer significant after adjusting for maternal demographics and socioeconomic characteristics - compared to living in a long-term low-poverty neighborhood, living in a long term high poverty neighborhood (OR = 1.41), long term moderate poverty neighborhood (OR = 1.22), and early poverty increase (OR = 1.37) was associated with a statistically significant increased odds of PTB
Cubbin, Catherine	2019	470896	Yes	Retrospective Cohort Study	- Poverty Trajectory - Income Inequality Trajectory	Neighborhood Change Database (Contains Census data from 1990, 2000, and 2006-2010	Census Tract	PTB	Texas Birth Certificates	2009-2011	- Black mothers exhibited higher prevalence of adverse birth outcomes in all categories of neighborhood poverty and inequality trajectories '- Prevalence of adverse birth outcomes were highest for mothers living in neighborhoods which experienced high poverty or inequality	- Living in neighborhoods characterized by long-term moderate poverty, long-term high poverty, poverty increase, or poverty decrease was associated with increased odds of PTB - Living in neighborhoods characterized by long-term high inequality (vs long-term low inequality) was associated with increased odds of PTB - neighborhood-level variables did not reduce the odds of PTB associated with being black vs white – looking at cross-sectional neighborhood economic status, living in neighborhoods with moderate poverty, high poverty, and high inequality was associated with an increased odds of PTB

Table 1 (cont'd)

Ma, Xiaoguang	2015	98.456	Yes	Retrospective Cohort Study	Neighborhood Deprivation Index Score	2000 US Census (PCA used on 8 sociodemographic factors)	Census Tract	PTB	Birth Certificates from the South Carolina Department of Health and Environmental Control	2008-2009	- neighborhood deprivation was higher among Black women than white (12.6% vs 8.5%)	- living in neighborhoods with higher deprivation was associated with increased risk of PTB among Black women compared with living in neighborhoods with lower deprivation - random effects regression models showed that the most deprived white women experienced 1.13x the odds of PTB compared to the least deprived
Janevic, T	2010	517.994	Yes	Retrospective Cohort Study	Neighborhood Deprivation Quartile	1990, 2000 Census	Census Tract	PTB	New York State Department of Health	1998-2002		- in unadjusted analyses, women living in neighborhoods in the highest quartile of deprivation had twice the risk of PTB relative to the lowest quartile, with slight attenuation after adjusting for maternal education. this was even more attenuated after adjusting for all individual-level covariates, primarily ethnicity - association between neighborhood deprivation and PTB was highest among Hispanic Caribbean women
Sealy-Jefferson, Shawnita	2016	1387	Yes	Retrospective Cohort Study	Neighborhood Deprivation Index	2007-2011 ACS	Block Group	PTB	LIFE Study (medical records, Oakland County, Michigan)	2009-2011		- evidence of moderation of the association between neighborhood disadvantage (composite and some individual measures) and PTB by both praying for oneself and asking others for prayer - among women who asked for prayer infrequently, those who lived in neighborhoods with high deprivation index scores had higher rates of PTB rates than women who lived in neighborhoods with low disadvantage scores - complex associations between individual neighborhood characteristics and PTB

Table 1 (cont'd)

Berkowitz, Rachel	2022	5418	Yes	Retrospective Cohort Study	Neighborhood quality	California Healthy Places Index (HPI)	Census Tract	PTB	Life Course Social Context and Disparities in Birth Outcomes Study (California certificates of live birth)	2007-2011	- 86.9% of the 107 Census tracts had at least one PTB (93/107) - women living in the most deprived Census tracts were significantly younger, had significantly higher proportions of women who experienced PTB, had low educational-attainment-for age, were receiving WIC benefits, and were receiving Medi-Cal compared with the study population living in any of the other Census tracts	- in the fully adjusted models, women living in neighborhoods with the highest quality HPI score had a lower risk of PTB compared to those living in the lowest quality (aRR: 0.62; 95% CI: 0.44, 0.87) - living in a moderate-quality neighborhood was also significantly associated with reduced risk (aRR: 0.80; 95% CI: 0.64, 1.00)
Giurgescu, Carmen	2017	101	Yes	Prospective Cohort Study	- objective neighborhood physical disorder - objective neighborhood social disorder - objective neighborhood violent crime - subjective neighborhood physical disorder - subjective neighborhood social disorder - subjective neighborhood violent crime	- 2000 census data (vacant housing, abandoned buildings) - 2007 CPD data (prostitution and drug related incidents) - 2007 CPD data (homicide, sexual assault, robbery) - physical environmental stress scale - neighborhood problems scale and perceived neighborhood scale - perceived neighborhood scale	0.5 mile radius	PTB	Birth Records	2009-2011	- correlations suggested that neighborhood measures consist of 2 latent factors (perceived and observed neighborhood conditions)	- psychological distress was not likely to mediate the effect of objective neighborhood conditions on PTB (reflected on SEM mediation model results)

Table 1 (cont'd)

Sealy-Jefferson, Shawnita	2019	686	Yes	Retrospective Cohort Study	Tax foreclosures	Wayne County Treasurer (ascertained from Data Driven Detroit)	Block Group	PTB	LIFE Study (medical records)	2009-2011	- weak correlations between tax foreclosures and subjective/objective neighborhood measures	- no statistically significant association between tax foreclosures and PTB risk - not statistically significant, but women w/less than 12yr education and resided in neighborhoods with high tax foreclosures had a higher risk of PTB than those who resided in areas with low tax foreclosures - those with >12yr of education who lived in high tax foreclosure areas had lower PTB risk than their counterparts in low tax foreclosure neighborhoods
Sealy-Jefferson, Shawnita	2021	1386	Yes	Retrospective Cohort Study	High eviction rates	Eviction Lab	Block Group	PTB	LIFE Study (medical records)	2009-2011	- eviction judgement and eviction filing rates were weakly correlated with the individual variables that comprised the neighborhood deprivation index	- neither of the eviction rate variables were strongly associated with risk of PTB - evidence of effect modification by marital status between PTB and neighborhood eviction filing and judgement rates, with higher risk of PTB among women who were married/cohabiting with the father of their baby living in neighborhoods with high rates compared to those living in areas with low rates

Table 1 (cont'd)

Braveman, Paula	2015	10400	Yes	Retrospective Cohort Study	- Individual Sociodemographic Characteristics - Census Tract Poverty	- California Maternal and Infant Health Assessment (2003-2010) - 2005-2009 ACS	Census Tract	PTB	California Maternal and Infant Health Assessment, Birth records	2003-2010	- Black women, at each socioeconomic factor, appeared to be at a greater disadvantage than white women - significantly higher PTB rates among Black women compared to white women in most socioeconomic subgroups, except among poor women, women who had not/parents did not complete high school, women for whom paternal employment was recorded as unemployed, and residents of high-poverty census tracts - 61.8% of Black and 23.7% of white women were included in at least 1 of the most disadvantaged subgroups (based on family income, maternal education, paternal occupation status, and census tract poverty rate)	- more favorable socioeconomic characteristics were generally associated with lower PTB rates among white but not Black women - tests of interaction indicated interactions of race with family income, maternal education, paternal occupation, and census tract poverty as predictors of PTB - logistic regression models estimating Black-white disparity within each socioeconomic subgroup showed that there was a significant difference in all the subgroups except the most disadvantaged subgroup, either before or after adjustment for other socioeconomic factors and covariables

CHAPTER 3: METHODOLOGY

Study Population

The Biosocial Impact on Black Births (BIBB) prospective cohort study began recruitment in December 2017 through July 2022. The primary objective of the study is to examine how social stressors alter systemic inflammation during pregnancy, potentially leading to PTB in Black women. Women 18-45 years old who self-identified as Black of African American pregnant with singleton pregnancies were recruited between 8-29 weeks' gestation. A majority of the women were recruited from prenatal care clinics at health institutions in three metropolitan areas: Detroit, MI (n=500); Columbus, OH (n=486); Orlando, FL (n=499). In-person recruitment and advertisement flyers were placed in the prenatal care clinics. The study team was provided appointment schedules weekly to identify potentially eligible women. These women were approached in the waiting areas of the clinical sites to verify eligibility (based on inclusion and exclusion criteria) and to invite them to participate. The inclusion criteria to participate in the parent study were as follows: (a) self-identified as African American or Black; (b) are 18-45 years of age; (c) have a known singleton pregnancy; (d) are of any parity; (e) are English speaking. Women were excluded from the parent study if they had a known multiple pregnancy (e.g., twins). A portion of the sample was recruited postpartum from the same health centers as the prepartum individuals. This includes 187 women from Orlando Health and 4 women from Wexner Medical Center. Because our variables of interest are relatively time-invariant (maternal age, maternal education level, annual household income), they are not sensitive to recall bias. Women who met the inclusion criteria provided written informed consent. Women recruited prenatally completed questionnaire(s) at up to 3 time points during pregnancy, while women recruited postpartum completed a single questionnaire. A total of 1,239 women completed questionnaires. These data included address of residence (used to obtain objective neighborhood measures), and a range of social, behavioral, and psychosocial measures. For the purpose of these analyses, only data from the first collected timepoint for women recruited prenatally were used. Medical records were abstracted for gestational age at birth, presence of chronic diseases, and any pregnancy complications(s). 17 women were excluded for spontaneous abortion, therapeutic abortion, stillborn delivery, or fetal death, as these are not live births and therefore cannot be counted in the outcome of PTB. Additionally, 47 women with missing gestational age data were excluded, as PTB could not be determined. Of the remaining 1,175 women, 62 women had missing residential address data and 1 woman's residential Census tract could not be linked to Census-level data. Our final sample size thus consisted of 1,112 women (Figure 1). A single random imputation method using the conditional distribution of the missing values given the observed values was applied for the treatment of missing data for variables with more than 5% nonresponse rates. There were 20 imputed data sets, from which a single data set was randomly selected for analysis.

Measures

<u>Outcome (Preterm Birth) Measure</u>

Prenatal and hospital birth records of women who participated in the BIBB study were abstracted to obtain multiple measures of gestational age (GA) that were used to arrive at the best gestational age from which to compute PTB (less than 37 completed weeks gestation). GA was computed using a first trimester ultrasound measurement of crown-rump length. This was corroborated with the reported date of the participant's last menstrual period (LMP). If the ultrasound measurement of GA differed by more than 7 days from the LMP-calculated GA, the ultrasound estimate was used. First trimester ultrasounds are routinely performed on women at the prenatal clinics in which BIBB participants were recruited. Additional data on the labor and delivery (to determine spontaneous vs. indicated birth) included: timing of rupture of membranes (premature rupture of membranes, preterm premature rupture of membranes, spontaneous rupture of membranes); type of delivery (vaginal vs. c-section; elective vs. nonelective c-section); timing and type of labor (spontaneous, induced, or augmented; medications prescribed if induction methods were used.

Exposure (Residential Address and Area-Level) Measures

Current residential address was reported on the first prenatal questionnaire (8-29 weeks' gestation) and the postpartum questionnaire. These analyses only focused on measures taken at the first survey timepoint (T1), thus the first address provided during T1 was used for geocoding, including the 31 women who moved during their pregnancy after T1. Previous studies have shown that a majority of women are to experience a static, if not downward, movement in social mobility, thus we would expect the neighborhood environment to be relatively similar if they moved during the pregnancy.[1-4] The residential addresses were geocoded to the street level using ArcGIS Pro Software and ArcGIS World Geocoder (Esri, Redlands, CA). Addresses were overlaid with block groups, and spatially joined to the area-level data obtained from the U.S. Census and American Community Survey (ACS) for the years below. Women who were recruited before 2020 (pre-COVID group) had their addresses overlaid with block groups using 2019 cartographic boundary files, while women who were recruited in 2020 and onwards (post-COVID group) had their addresses overlaid with block groups using 2020 cartographic boundary files. Area-level data came from the ACS in the Integrated Public Use Microdata Series National Historical Geographic Information System (IPUMS NHGIS) (University of Minnesota, 2017-2021). Thereafter, 2015-2019 ACS 5-Year Estimates data were added to the pre-COVID group, and 2017-2021 ACS 5-Year Estimates data were added to the post-COVID group. The dataset included variables to objectively capture dimensions of the neighborhood environment that represent a continuum from investment to deprivation, specifically: proportion of the population that identifies as Black, proportion of the population with a high school education, median household income, unemployment rate, proportion of the population on public assistance, and proportion of housing that is vacant. Area-level characteristics were examined at three spatial levels: county, minor civil division (MCD), and census tract.

Principal components analysis (PCA) was used to create an area-level deprivation index (ADIs) at each spatial level based on the aforementioned area-level characteristics based on the previous literature.[1,8] PCA is a data reduction technique that is often used in neighborhood-level research to develop a sociodemographic index that can capture many correlated characteristics in a few variables to be used in statistical analyses.[1] PCA was performed three separate times, one for each spatial level, using area-level values that were specific to each spatial level. Values of individual area-level variables were centered and scaled prior to PCA. Only the first principal component, which was the unique linear combination that accounted for the largest possible proportion of total variability in the component measures, was retained as the ADI. In accordance with previous studies examining the association between area-level deprivation and PTB risk, ADI scores at each spatial level were categorized into quartiles, and then dichotomized contrasting women residing in the worst quartile of area-level deprivation (coded as 1) with women residing in the upper three quartiles (coded as 0). By categorizing the ADI into quartiles, we allowed for non-linearity of the relationship between area-level deprivation and PTB risk, similar to previous studies.[1,5-8]

Sociodemographic measures

Questionnaires relied on self-report to assessed mother's age, highest level of educational attainment, household income, marital status, smoking behaviors, and alcohol use (details on measures provided below). Maternal age, smoking behaviors, and alcohol use were examined in our statistical models, as being younger or older for reproductive age, smoking, and alcohol use during pregnancy have been implicated as risk factors for PTB.[9] Highest level of educational attainment and household income were hypothesized as potential effect modifiers between neighborhood deprivation and the odds of PTB. Thus, these variables were added in our models to assess heterogeneity in the relationship between neighborhood deprivation and the odds of PTB across educational attainment, household income. Details are provided below with methods for statistical modeling.

Maternal age was assessed by asking women for their date of birth, followed by asking for their age. Age was categorized into three groups: 18-24 years; 25-34 years; and 35 years and older, with the age group of 25-34 years being the reference category. Highest level of educational attainment was assessed by asking women what their highest level of education is (less than high school; graduated high school or GED/technical or vocational training; some college; associate degree; bachelor degree; graduate degree or higher). Education attainment was dichotomized into less than any college education (coded as 1) and at least some college education (coded as 0). Household Income was assessed by asking women their annual household income (less than $10,000; $10,000-$19,999; $20,000-$29,999; $30,000-$39,999; $40,000-$59,999; 60,000-$79,999; more than $80,000). Household income was dichotomized into less than $30,000/year (coded as 1) and $30,000 or greater per year (coded as 0). Smoking behavior was assessed by asking a series of questions that determined cigarette, e-cigarette, and other tobacco (cigar) use before and during the pregnancy. Regarding cigarette use, women were asked if they smoked before the pregnancy (yes; no), and if so, how many individual cigarettes did they smoke on an average day (open-ended response asking for a specific number, not a range). Women were then asked if they smoked during the pregnancy (yes/no), and if so, how many individual cigarettes did they smoke on an average day (open-ended). E-cigarette use was determined by asking if used an e-cigarette ever (yes/no), how often did they use them during their pregnancy (every day/some days/rarely/not at all), and how often did they use them in the last 30 days (0 days/ 1-2 days/ 3-5 days/6-9 days/10-19 days/20-29 days/all 30 days). Cigar (Black and Mild's) use was assessed by asking if women smoked cigars (Black and Mild's) before this pregnancy (yes/no) and during this pregnancy (yes/no). While smoking increases the risk of PTB, we do not believe that smoking confounds the relationship between area-level deprivation and the odds of PTB and thus was not included in our analyses. Alcohol use was assessed by asking the patient if they drank alcohol before the pregnancy (yes/no), followed by asking the number of alcoholic drinks consumed on an average week before the pregnancy (1 to 2/3 to 4/5 to 7/8 to 11/12 to 17/18 to 23/24 to 35/36 drinks+). The same two questions were asked again but with respect to alcohol use during the pregnancy. Similar to smoking, we do not have evidence that alcohol use confounded the relationship between area-level deprivation and the odds of PTB, and thus was not retained in our statistical models.

<u>Clinical covariates measures</u>

Medical record abstractions of women who participated in the BIBB study provided clinical covariate data, including presence of pre-pregnancy chronic disease(s), pregnancy complication(s), and prior preterm delivery. In our analytic models, we do not treat these as potential confounders. While the presence of chronic disease, a history of pregnancy complications, and previous PTB are associated with a higher odds of PTB, these factors are downstream of neighborhood deprivation and are best conceptualized as mediators rather than confounders.[1] Parity and gravidity were abstracted as well.

Statistical Analysis

Maternal-level characteristics in this study are reported overall and by PTB status as counts and a corresponding percent. Logistic regression models were used to assess the association between maternal characteristics (age, income, and education) and the odds of PTB. To assess whether the odds of PTB differed between those living in the worst quartile of ADI (coded as 1) and those living in any of the upper 3 quartiles (coded as 0), we employed generalized estimating equations (GEE) using the *geetoolbox* package in R, adjusting for covariates selected a-priori based on the literature. [10] Since the focus of the analysis is the population average effect instead of the decomposition of the total variance of the outcome, we used GEE to account for the correlated or clustered data. The exchangeable working correlation is used and the robust standard errors are used for all estimates.

Models were developed separately for the census tract, MCD, and county levels to examine the association between area-level deprivation and the odds of PTB. The models were compared using the quasilikelihood information criterion (QIC), a modification to the Akaike information criterion (AIC). The model with the lowest QIC indicated the best relative fit in comparison to other models, and thus was selected as our final model.[11] Final models at all three spatial levels adjusted for maternal age. Odds ratios and corresponding 95% confidence intervals were calculated from the estimates derived from the final GEE model. To assess whether the association between ADI and the odds of PTB was modified by individual maternal characteristics (i.e., educational attainment, annual household income), interaction terms between

ADI and these characteristics were added to the GEE models and statistically significant interactions were retained in the final model. Statistical significance was defined as a p-value < 0.05. Such interactions evaluate effect modification multiplicatively as opposed to additively. Analyses were conducted using R (www.r-project.org/)

BIBLIOGRAPHY

1) Messer, L. C., Laraia, B. A., Kaufman, J. S., Eyster, J., Holzman, C., Culhane, J., Elo, I., Burke, J. G., & O'Campo, P. (2006). The development of a standardized neighborhood deprivation index. *Journal of urban health : bulletin of the New York Academy of Medicine*, *83*(6), 1041–1062. https://doi.org/10.1007/s11524-006-9094-x

2) Bond JC, Mancenido AL, Patil DM, Rowley SS, Goldberg J, Littman AJ. Residence change during the first trimester of pregnancy and adverse birth outcomes. J Epidemiol Community Health. 2019;73(10):913-919. doi:10.1136/jech-2018-211937

3) Meeker JR, Burris H, Boland MR. An algorithm to identify residential mobility from electronic health-record data. International Journal of Epidemiology. Published online April 14, 2021:dyab064. doi:10.1093/ije/dyab064

4) Kramer MR, Waller LA, Dunlop AL, Hogue CR. Housing transitions and low birth weight among low-income women: longitudinal study of the perinatal consequences of changing public housing policy. Am J Public Health. 2012;102(12):2255-2261. doi:10.2105/AJPH.2012.300782

5) O'Campo, P., Burke, J. G., Culhane, J., Elo, I. T., Eyster, J., Holzman, C., Messer, L. C., Kaufman, J. S., & Laraia, B. A. (2008). Neighborhood deprivation and preterm birth among non-Hispanic Black and White women in eight geographic areas in the United States. *American journal of epidemiology*, *167*(2), 155–163. https://doi.org/10.1093/aje/kwm277

6) Mehra, R., Shebl, F. M., Cunningham, S. D., Magriples, U., Barrette, E., Herrera, C., Kozhimannil, K. B., & Ickovics, J. R. (2019). Area-level deprivation and preterm birth: results from a national, commercially-insured population. *BMC public health*, *19*(1), 236. https://doi.org/10.1186/s12889-019-6533-7

7) Janevic, T., Stein, C. R., Savitz, D. A., Kaufman, J. S., Mason, S. M., & Herring, A. H. (2010). Neighborhood deprivation and adverse birth outcomes among diverse ethnic groups. *Annals of epidemiology*, *20*(6), 445–451. https://doi.org/10.1016/j.annepidem.2010.02.010

8) Ma, X., Fleischer, N. L., Liu, J., Hardin, J. W., Zhao, G., & Liese, A. D. (2015). Neighborhood deprivation and preterm birth: an application of propensity score matching. *Annals of epidemiology*, *25*(2), 120–125. https://doi.org/10.1016/j.annepidem.2014.11.021

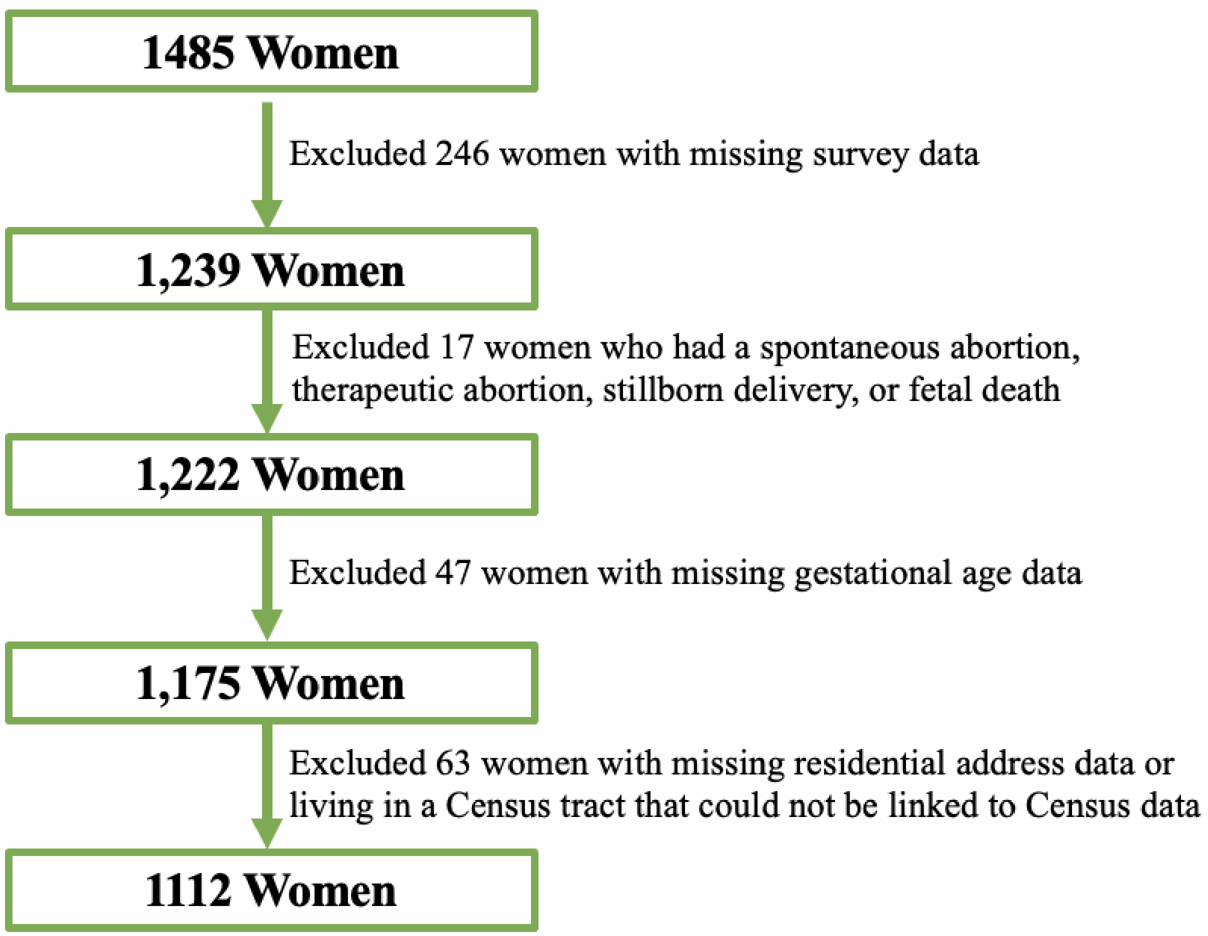
9) U.S. Department of Health and Human Services. (2023, May 9). *What are the risk factors for preterm labor and birth?*. Eunice Kennedy Shriver National Institute of Child Health and Human Development. https://www.nichd.nih.gov/health/topics/preterm/conditioninfo/who_risk

10) James A. Hanley, Abdissa Negassa, Michael D. deB. Edwardes, Janet E. Forrester, Statistical Analysis of Correlated Data Using Generalized Estimating Equations: An Orientation, *American Journal of Epidemiology*, Volume 157, Issue 4, 15 February 2003, Pages 364–375, https://doi.org/10.1093/aje/kwf215

11) Pan W. Akaike's information criterion in generalized estimating equations. Biometrics. 2001;57:120-125.

APPENDIX

Figure 1. Flowchart depicting the Study Population after Exclusion of Ineligible Participants



CHAPTER 4: RESULTS

Table 1 describes the characteristics of the study cohort stratified by preterm birth (PTB; <37 completed weeks gestation) status. Among the 1,112 women with complete area-level information and covariate data, 18% delivered preterm (similar to 18.5% seen in the full BIBB cohort; n=1,485). Individual-level characteristics between women who delivered term compared to women who delivered preterm differed slightly. A greater proportion of women with PTB were older (28.5 years vs 27.1 years), made less than $30,000/year (72% vs 68%), and had a college education (44% vs 36%) compared with women with term births. We categorized maternal age into three categories as age may not have a linear relationship with PTB risk: 18-24 years, 25-34 years (reference group), and 35+ years. Compared to those who delivered term, a greater proportion of women who delivered preterm were above 35 years old, and a smaller proportion of women who delivered preterm were between the ages of 18 and 24. With regards to area-level characteristics, there were 21 counties, 74 minor civil divisions (MCDs), and 504 tracts represented in our dataset.

Table 2 describes the area-level characteristics at the county, MCD, and Census tract levels, stratified into spatial units where there were no PTBs versus spatial units where there was at least one PTB. Logistic regression models were utilized to determine if any of the six individual area-level characteristics (proportion of population that identified as Black, proportion of population with a high school degree, median household income, unemployment rate, proportion of housing that is vacant, and proportion of population on public assistance), were associated with the odds of having PTBs in the unit at each of the spatial levels. At the county and MCD levels, there were no statistically significant associations between area-level characteristics and the odds of PTB. At the Census tract level, there were modest yet statistically significant associations; proportion of population that identified as Black, unemployment rate, and proportion of population on public assistance were each associated with an increased odds of PTB, while median household income was associated with a decreased odds of PTB.

Table 3 describes the results of the Principal Components Analysis (PCA). To develop the area deprivation index (ADI), the following area-level characteristics were inputted into the PCA: population percent Black, percent high school completed, median annual household income, unemployment rate, proportion of housing that is vacant, and percent on public assistance. The PCA was conducted using data at each geographic level: county, minor civil division (MCD, the primary subcounty governmental unit), Census tract). At the county level, principal component accounted for 76.9% of the variance among the six variables included in the analysis. At the MCD and Census tract levels, PC1 accounted for 77.5% and 59.2% of the variance among the six variables, respectively. Factor loadings for PC1 are presented in Table 3. Figures 2A 3A, and 4A, present the correlation plots. The correlation matrices (Figures 2A, 3A, 4A) show how correlated every area-level characteristic is with each of the other characteristics. The greater the correlation the darker the shade, with red squares depicting positive correlations and purple squares demonstrating negative correlations. Figures 2B, 3B, and 4B present the scree plots. The scree plots (Figures 2B, 3B, 4B) visualize the importance of each principal component to determine how many to retain. Figures 2C, 3C and 4C present the PC1 (Principal Component 1) vs PC2 (Principal Component 2) plots for each of the ADI. The first principal component contains the most variation of the data inputted into the PCA and is retained as our ADI. The biplots combined with the square cosine (Cos2) (Figures 2C, 3C, 4C) contain several pieces of information. The biplot shows that variables that are positively correlated to each other are grouped together, variables with a higher distance from the origin have better representation in the first two principal components, and variables that are negatively correlated with one another are displayed on opposite sides of the biplot's origin. Cos2 shows how much each individual characteristic is represented in the first two principal components, with higher values indicating greater representation. As shown in the legend, high Cos2 are colored in green, mid-level Cos2 values are colored in orange, and low values are colored in black. Higher ADI scores reflect neighborhoods with the least advantageous characteristics. As noted in Methods, the ADI was then categorized into a dichotomous variable, contrasting the highest quartile (neighborhood with least advantageous characteristics compared to the lower 3 quartiles (reference group).

Generalized estimating equations (GEEs) models were estimated sequentially. After examining the simple bivariate model of the dichotomous ADI variable, the focus was on considering the two sociodemographic variables as potential confounders or effect modifiers: maternal income (categorized as below $30,000; above $30,000), and maternal education (categorized as no college education; at least some college education). Maternal age (categorized as 18-24 years; 25-34 years; and 35+ years) was identified as a confounder in the simple models and was included in all models.

In models without interactions, we did not find a statistically significant relationship between maternal education and PTB (Table 4). We did find, however, a slightly protective relationship between living in the most deprived area-level compared with living in less derived areas at the MCD-level and the odds of PTB (OR = 0.91, 95% CI: 0.85, 0.97). The models were as follow:

$$\text{Logit}(\Pr(\text{PTB})) = \beta_0 + \beta_1{*}\text{ADI}_{\text{Highest Quartile}} + \beta_2{*}\text{Maternal Age}_{18\text{-}24} + \beta_3{*}\text{Maternal Age}_{35+} + \beta_4{*}\text{Maternal Education}_{\text{No College Education}}$$

When replacing maternal education with maternal income, we found that the model fit improved at all three spatial levels (Table 5). The final model, for all three spatial levels, was:

$$\text{Logit(Pr(PTB))} = \beta_0 + \beta_1\text{*ADI}_{\text{Highest Quartile}} + \beta_2\text{*Maternal Age}_{18\text{-}24} + \beta_3\text{*Maternal Age}_{35+} + \beta_4\text{*Maternal Income}_{\text{Less than \$30,000}}$$

No statistically significant association was found between the ADI and the odds of PTB at the County and Census tract levels (Table 5). At the MCD level, living in the most deprived neighborhood quartile was found to be slightly protective in our study population (OR = 0.89, 95% CI: 0.83, 0.95) of mothers who gave birth to preterm infants.

The same aforementioned process of sequentially building GEEs was continued in order to examine whether the relationship between the ADI and PTB was modified by individual-level maternal characteristics, namely maternal education and/or maternal. No statistically significant ($p<0.05$) effect modification of the relationship by maternal education was found at any of the 3 spatial levels (Table 6). The models at all 3 spatial levels were as follows:

$$\text{Logit(Pr(PTB))} = \beta_0 + \beta_1\text{*ADI}_{\text{Highest Quartile}} + \beta_2\text{*Maternal Age}_{18\text{-}24} + \beta_3\text{*Maternal Age}_{35+} + \beta_4\text{*Maternal Education}_{\text{No College Education}} + \beta_5\text{*ADI}_{\text{Highest Quartile}}\text{*Maternal Education}_{\text{No College Education}}$$

With regards to maternal income, effect modification of the relationship between the ADI and PTB was found at the County and MCD (Table 7). Low-income women who resided in high deprivation areas were less likely to deliver preterm than low income women who lived in low deprivation areas (county-level OR: 0.84, 95% CI: 0.73, 0.95; MCD-level OR: 0.83, 95% CI: 0.74, 0.93). The model with the best fit, at the county and MCD levels, were as follows:

$$\text{Logit(Pr(PTB))} = \beta_0 + \beta_1\text{*ADI}_{\text{Highest Quartile}} + \beta_2\text{*Maternal Age}_{18\text{-}24} + \beta_3\text{*Maternal Age}_{35+} + \beta_4\text{* Maternal Income}_{\text{Less than \$30,000}} + \beta_5\text{*ADI}_{\text{Highest Quartile}}\text{* Maternal Income}_{\text{Less than \$30,000}}$$

Similar patterns were also seen at the Census tract level (Table 7) but this was not the best fit model (see next paragraph, Table 8).

We next created a model that included two 2-way interactions with ADI: maternal education, maternal age. The model fit at the county and MCD levels was not improved compared to considering only the ADI interaction with maternal income (Table 8), leaving that as the best model for those two levels of geographic area. However, effect modification of the relationship between the ADI and PTB was clearly evident at the Census tract level (Table 8). The model with the lowest QIC (QIC = 1019.53) and thus the best fit was as follows:

$$\text{Logit}(\Pr(\text{PTB})) = \beta_0 + \beta_1{*}\text{ADI}_{\text{Highest Quartile}} + \beta_2{*}\text{Maternal Age}_{18\text{-}24} + \beta_3{*}\text{Maternal Age}_{35+} + \beta_4{*}\text{Maternal Education}_{\text{No College Education}} + \beta_5{*}\text{ Maternal `Income}_{\text{Less than \$30,000}} + \beta_6{*}\text{ADI}_{\text{Highest Quartile}}{*}\text{Maternal Education}_{\text{No College Education}} + \beta_7{*}\text{ADI}_{\text{Highest Quartile}}{*}\text{ Maternal Income}_{\text{Less than \$30,000}}$$

Among college-educated women who made less than $30,000 per year, those who resided in high deprivation Census tracts were less likely to deliver preterm compared to their counterparts who lived in low deprivation Census tracts (OR = 0.41, 95% CI: 0.19, 0.90). Conversely, among high-income women who did not have a college education, those who resided in the most deprived Census tracts had an increased odds of PTB compared to women who lived in low deprivation Census tracts (OR = 5.11, 95% CI: 2.36, 11.07).

Finally, because both interaction terms were significant, we tested to see if there was a statistically significant three-way interaction between ADI, maternal education, and maternal income at the Census tract level using the following model:

$$\text{Logit}(\Pr(\text{PTB})) = \beta_0 + \beta_1{*}\text{ADI}_{\text{Highest Quartile}} + \beta_2{*}\text{Maternal Age}_{18\text{-}24} + \beta_3{*}\text{Maternal Age}_{35+} + \beta_4{*}\text{Maternal Education}_{\text{No College Education}} + \beta_5{*}\text{ Maternal Income}_{\text{Less than \$30,000}} + \beta_6{*}\text{ADI}_{\text{Highest Quartile}}{*}\text{Maternal Education}_{\text{No College Education}} + \beta_7{*}\text{ADI}_{\text{Highest Quartile}}{*}\text{ Maternal Income}_{\text{Less than \$30,000}} +$$

β_8*$ADI_{Highest\ Quartile}$*$Maternal\ Education_{No\ College\ Education}$ * $Maternal\ Income_{Less\ than\ \$30,000}$

The three-way interaction term was not statistically significant (z=-0.59, p=0.56), and the QIC for the model indicated a model with a worse fit than the model with two two-way interaction terms ($QIC_{three\text{-}way}$ = 1025.79).

APPENDIX A: TABLES

Table 2. Descriptive Maternal Statistics Stratified by PTB Status

	Total	**Term**	**Preterm**	**Odds Ratio (95% CI)**
N	1,112	912 (82%)	200 (18%)	
	n(%)	n(%)	n(%)	
Self-Reported Race				
Non-Hispanic Black	1,112 (100)	912 (100)	200 (100)	
Study Site				
Metro Columbus	399 (35.9)	321 (35.2%)	78 (39.0%)	
Metro Detroit	393 (35.3)	322 (35.3%)	71 (35.5%)	
Metro Orlando	320 (28.8)	269 (29.5%)	51 (25.5%)	
Maternal Age Category				
18-24 Years	392 (35.3%)	336 (36.8%)	56 (28%)	0.70 (0.56, 0.89)
25-34 Years	581 (52.2%)	470 (51.5%)	111 (55.5%)	(Ref) 1.00
35+ Years	139 (12.5%)	106 (11.6%)	33 (16.5%)	1.32 (0.99, 1.75)
Maternal Household Income				
At least $30,000/yr	356 (32%)	300 (32%)	56 (28%)	OR = 1.00
Less than $30,000/yr	756 (68%)	612 (68%)	144 (72%)	OR = 1.26 (0.81, 1.96)
Maternal Education				
At least some College Education	402 (36.2%)	324 (35.5%)	78 (44%)	OR = 1.00
No College Education	710 (63.8%)	588 (64.5%)	122 (56%)	OR = 0.86 (0.54, 1.37)

Table 3. Descriptive Area-Level Statistics, Stratified by PTB Status

	Term Only Births	At Least 1 PTB
County-Level Data		
Number of Spatial Units	5	16
Population Identifying as Black (%)	15.1 (8.8)	13.9 (9.5)
Population with High School Education (%)	56.6 (9.3)	62.4 (6.3)
Median Annual Household Income ($1,000)	64.0 (13.5)	59.6 (8.4)
Unemployment rate (%)	5.6 (1.6)	5.7 (1.4)
Proportion of Housing that is Vacant (%)	9.5 (2.8)	13.1 (5.7)
Population on Public Assistance (%)	16.0 (7.0)	14.6 (3.6)
MCD-Level Data		
Number of Spatial Units	35	39
Population Identifying as Black (%)	23.0 (24.1)	21.7 (18.4)
Population with High School Education (%)	61.4 (10.5)	61.4 (10.3)
Median Annual Household Income ($1,000)	66.0 (29.3)	61.8 (17.2)
Unemployment rate (%)	6.1 (4.2)	6.2 (2.7)
Proportion of Housing that is Vacant (%)	9.4 (6.4)	10.9 (7.2)
Population on Public Assistance (%)	16.3 (11.2)	15.9 (7.7)
Census Tract-Level Data		
Number of Spatial Units	353	151
Population Identifying as Black (%)	42.3 (33.2)	51.8 (31.8)
Population with High School Education (%)	63.1 (11.9)	65.3 (11.9)
Median Annual Household Income ($1,000)	50.8 (21.2)	43.7 (18.4)
Unemployment rate (%)	8.8 (6.6)	10.3 (6.7)
Proportion of Housing that is Vacant (%)	15.5 (12.8)	15.9 (11.4)
Population on Public Assistance (%)	23.7 (15.2)	29.4 (15.8)

Table 4. Area-Level Deprivation (ADI) Results from Principal Components Analysis (PCA)

	County-Level Area Deprivation Index (ADI)	**MCD-Level ADI**	**Census Tract-Level ADI**
Proportion of Variance	0.77	0.78	0.59
Standard Deviation	2.15	2.16	1.88
Principal Component Analysis (PCA) Loadings			
Population Identifying as Black (%)	0.39	0.43	0.46
Population with High School Education (%)	-0.43	-0.44	-0.43
Median Household Income ($)	0.36	0.26	0.34
Unemployment rate (%)	0.45	0.44	0.40
Proportion of Housing that is Vacant (%)	0.35	0.40	0.34
Population on Public Assistance (%)	0.46	0.45	0.46

Table 5. Association between Area Deprivation Index (ADI) and Preterm Birth (PTB) Adjusting for Maternal Age and Educational Attainment

	N	% Preterm	Odds Ratio (95% Confidence Interval)
County-Level (QIC* = 1046.31)			
ADI Lower 3 Deprivation Quartiles	834	18.35	1.00
ADI Highest Deprivation Quartile	278	16.91	0.95 (0.79, 1.13)
Any Maternal College Education	392	19.90	1.00
No Maternal College Education	710	17.18	0.96 (0.67, 1.38)
MCD-Level (QIC = 1070.75)**			
ADI Lower 3 Deprivation Quartiles	834	18.47	1.00
ADI Highest Deprivation Quartile	278	16.55	0.91 (0.85, 0.97)
Any Maternal College Education	402	19.40	1.00
No Maternal College Education	710	17.18	0.99 (0.71, 1.38)
Census Tract-Level (QIC = 1043.11)			
ADI Lower 3 Deprivation Quartiles	833	17.41	1.00
ADI Highest Deprivation Quartile	278	19.78	1.21 (0.85, 1.73)
Any Maternal College Education	402	19.40	1.00
No Maternal College Education	709	17.21	0.95 (0.67, 1.33)

***Quasilikelihood Information Criterion; lower values indicate better relative model fit**
****Minor Civil Division; the primary subcounty governmental unit**

Table 6. Association between Area Deprivation Index (ADI) and Preterm Birth (PTB) Adjusting for Maternal Age and Maternal Household Income

	N	**% Preterm**	**Odds Ratio (95% Confidence Interval)**
County-Level (QIC* = 1043.44)			
ADI Lower 3 Deprivation Quartiles	834	18.35	1.00
ADI Highest Deprivation Quartile	278	16.91	0.89 (0.77, 1.04)
Maternal Income over $30,000/yr	356	15.73	1.00
Maternal Income below $30,000/yr	756	19.05	1.49 (1.11, 2.01)
MCD-Level (QIC = 1050.57)**			
ADI Lower 3 Deprivation Quartiles	834	18.47	1.00
ADI Highest Deprivation Quartile	278	16.55	0.89 (0.83, 0.95)
Maternal Income over $30,000/yr	356	15.73	1.00
Maternal Income below $30,000/yr	756	19.05	1.50 (1.08, 2.09)
Census Tract-Level (QIC = 1043.07)			
ADI Lower 3 Deprivation Quartiles	833	17.41	1.00
ADI Highest Deprivation Quartile	278	19.78	1.15 (0.80, 1.67)
Maternal Income over $30,000/yr	355	15.77	1.00
Maternal Income below $30,000/yr	756	19.05	1.36 (0.94, 1.96)

***Quasilikelihood Information Criterion; lower values indicate better relative model fit**
****Minor Civil Division; the primary subcounty governmental unit**

Table 7. Effect Modification of Maternal Education on the Association between Area Deprivation Index (ADI) and Preterm Birth (PTB) Adjusting for Maternal Age

Education	Area-Level Deprivation	N	% Preterm	Odds Ratio (95% Confidence Interval)
County-Level (QIC* = 1047.49; $p_{interaction}$ = 0.82)				
College Edu	Low Deprivation	332	19.58	1.00
	High Deprivation	502	17.53	0.99 (0.60, 1.61)
No College Edu	Low Deprivation	70	18.57	1.00
	High Deprivation	208	16.35	0.93 (0.83, 1.05)
MCD-Level (QIC = 1072.18; $p_{interaction}$ = 0.64)**				
College Edu	Low Deprivation	328	20.12	1.00
	High Deprivation	506	17.39	0.82 (0.51, 1.30)
No College Edu	Low Deprivation	74	16.22	1.00
	High Deprivation	204	16.67	0.95 (0.79, 1.16)
Census Tract-Level (QIC = 1039.57; $p_{interaction}$ = 0.10)				
College Edu	Low Deprivation	313	20.13	1.00
	High Deprivation	520	15.77	0.82 (0.46, 1.52)
No College Edu	Low Deprivation	89	16.83	1.00
	High Deprivation	204	19.61	1.47 (0.98, 2.21)

***Quasilikelihood Information Criterion; lower values indicate better relative model fit**
****Minor Civil Division; the primary subcounty governmental unit**

Table 8. Effect Modification of Maternal Household Income on the Association between Area Deprivation Index (ADI) and Preterm Birth (PTB) Adjusting for Maternal Age

Education	Area-Level Deprivation	N	% Preterm	Odds Ratio (95% Confidence Interval)
County-Level (QIC* = 1041.56; $p_{interaction}$ = 0.005)				
High Income	Low Deprivation	316	15.51	1.00
	High Deprivation	40	17.50	1.27 (0.95, 1.70)
Low Income	Low Deprivation	518	20.08	1.00
	High Deprivation	238	16.81	0.84 (0.73, 0.95)
MCD-Level (QIC = 1046.34; $p_{interaction}$ = 0.02)**				
High Income	Low Deprivation	311	15.43	1.00
	High Deprivation	45	17.78	1.35 (0.95, 1.92)
Low Income	Low Deprivation	523	20.27	1.00
	High Deprivation	233	16.31	0.83 (0.74, 0.93)
Census Tract-Level (QIC = 1033.35; $p_{interaction}$ = 0.002)				
High Income	Low Deprivation	303	13.20	1.00
	High Deprivation	52	30.77	2.91 (1.54, 5.49)
Low Income	Low Deprivation	530	19.81	1.00
	High Deprivation	226	17.26	0.86 (0.56, 1.33)

***Quasilikelihood Information Criterion; lower values indicate better relative model fit**
****Minor Civil Division; the primary subcounty governmental unit**

Table 9. Effect Modification of Maternal Education and Maternal Household Income on the Association between Area Deprivation Index (ADI) and Preterm Birth (PTB) Adjusting for Maternal Age

Maternal Income	Maternal Education	Area-Level Deprivation	N	% Preterm	Odds Ratio (95% Confidence Interval)
County-Level (QIC* = 1042.86)					
> $30,000/yr	College Education	Low Deprivation	187	15.51	1.00
		High Deprivation	19	15.79	1.26 (0.83, 1.90)
	No College Education	Low Deprivation	129	15.50	1.00
		High Deprivation	21	19.05	1.33 (0.62, 2.88)
< $30,000/yr	College Education	Low Deprivation	145	24.83	1.00
		High Deprivation	51	19.61	0.81 (0.37, 1.77)
	No College Education	Low Deprivation	373	18.23	1.00
		High Deprivation	187	16.04	0.86 (0.37, 2.00)
MCD-Level (QIC = 1050.59)**					
> $30,000/yr	College Education	Low Deprivation	184	15.22	1.00
		High Deprivation	22	18.18	1.17 (0.76, 1.76)
	No College Education	Low Deprivation	127	15.75	1.00
		High Deprivation	23	17.39	1.64 (0.76, 3.55)
< $30,000/yr	College Education	Low Deprivation	144	26.39	1.00
		High Deprivation	52	15.38	0.65 (0.30, 1.42)
	No College Education	Low Deprivation	379	17.94	1.00
		High Deprivation	181	16.57	0.91 (0.39, 2.12)
Census Tract-Level (QIC = 1019.54)					
> $30,000/yr	College Education	Low Deprivation	178	14.61	1.00
		High Deprivation	28	21.43	1.88 (0.93, 3.90)
	No College Education	Low Deprivation	125	11.20	1.00
		High Deprivation	24	41.67	5.11 (2.36, 11.07)
< $30,000/yr	College Education	Low Deprivation	135	27.41	1.00
		High Deprivation	61	14.75	0.41 (0.19, 0.90)
	No College Education	Low Deprivation	395	17.22	1.00
		High Deprivation	165	18.18	1.12 (0.48, 2.61)

***Quasilikelihood Information Criterion; lower values indicate better relative model fit**
****Minor Civil Division; the primary subcounty governmental unit**

APPENDIX B: FIGURES

Figure 2A. County Area Deprivation Index Correlation Matrix

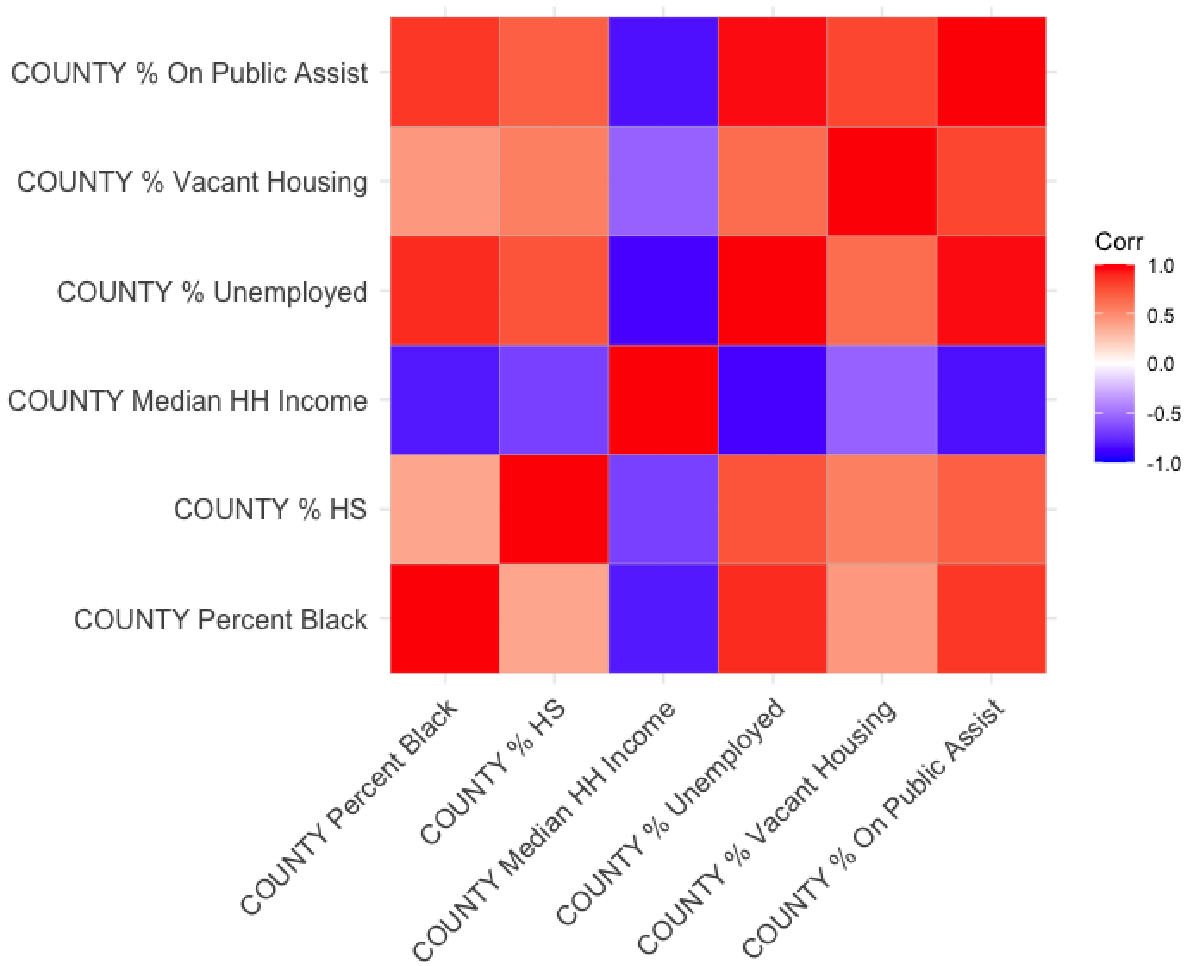


Figure 2B. County-level Area Deprivation Index Scree Plot

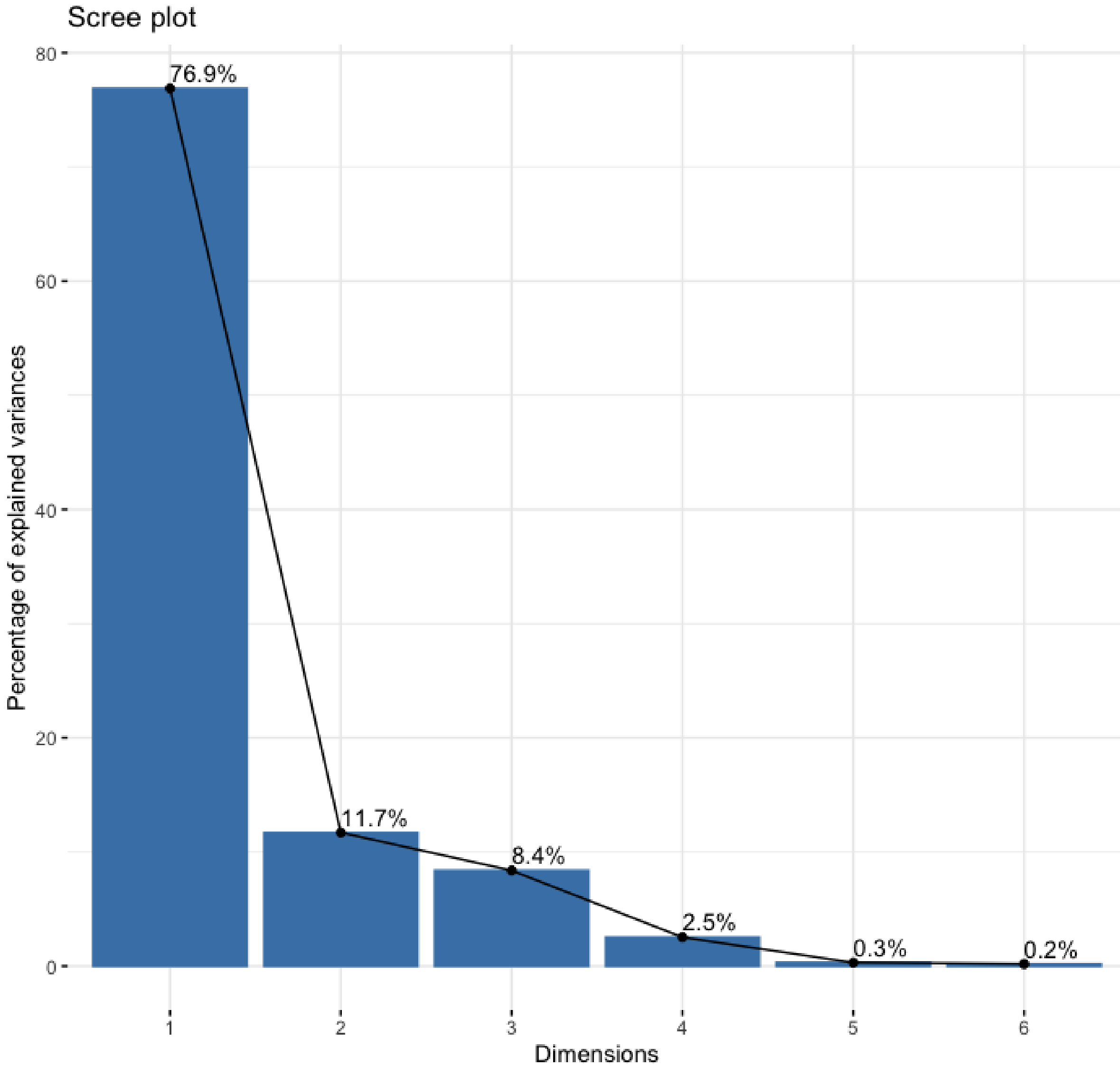


Figure 2C. County-level Area Deprivation Index Principal Component 1 vs Principal Component 2 Biplot

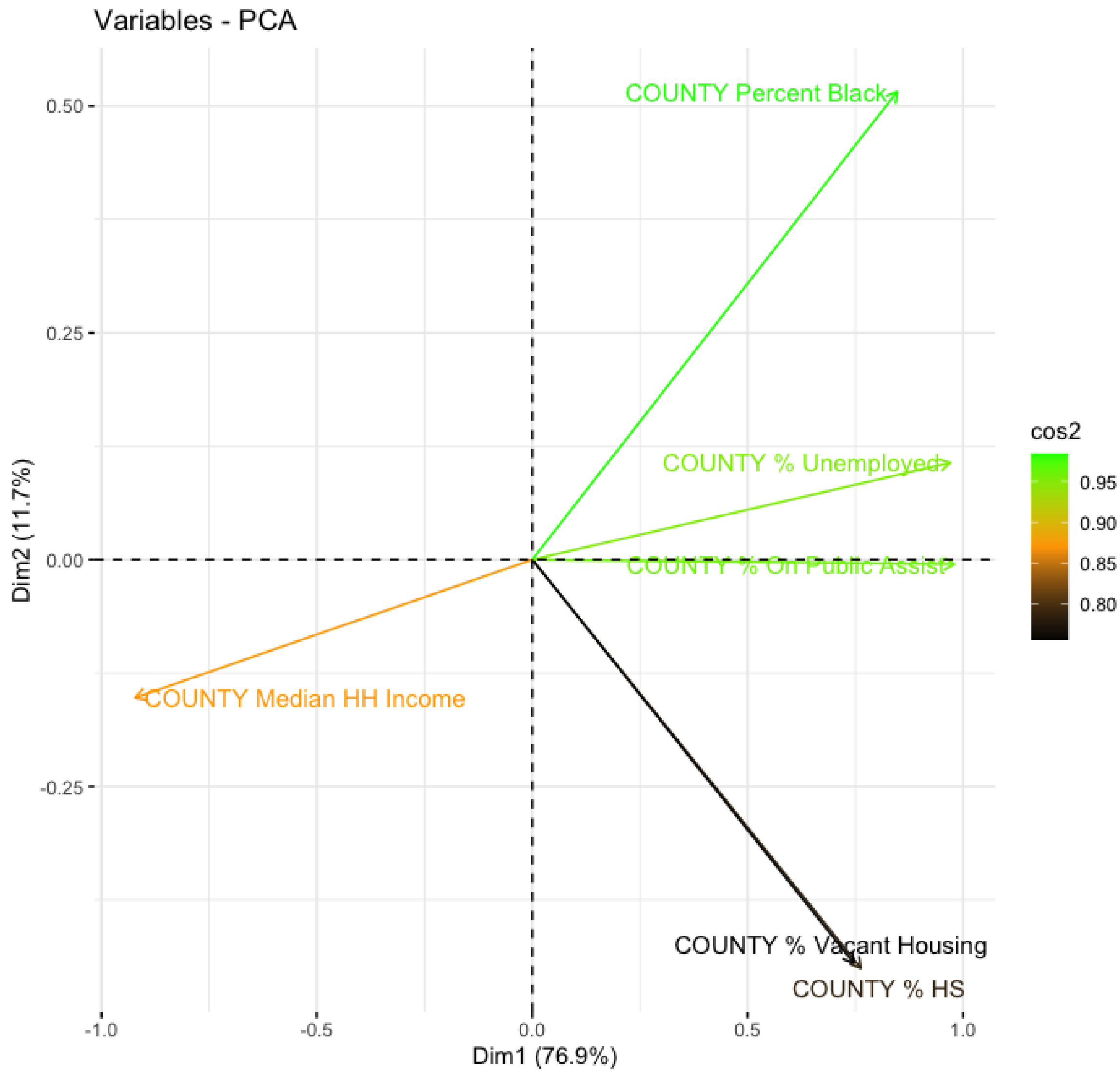


Figure 3A. MCD-level Area Deprivation Index Correlation Matrix

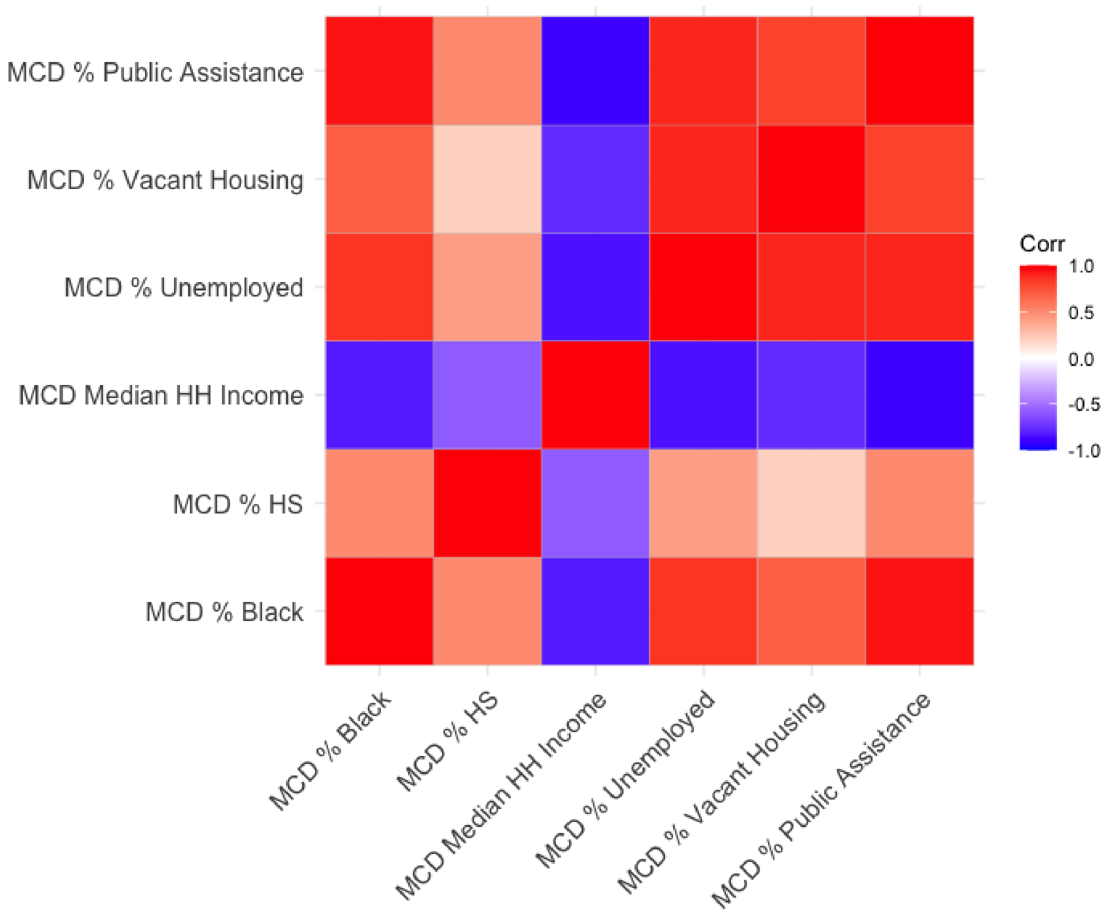


Figure 3B. MCD-level Area Deprivation Index Scree Plot

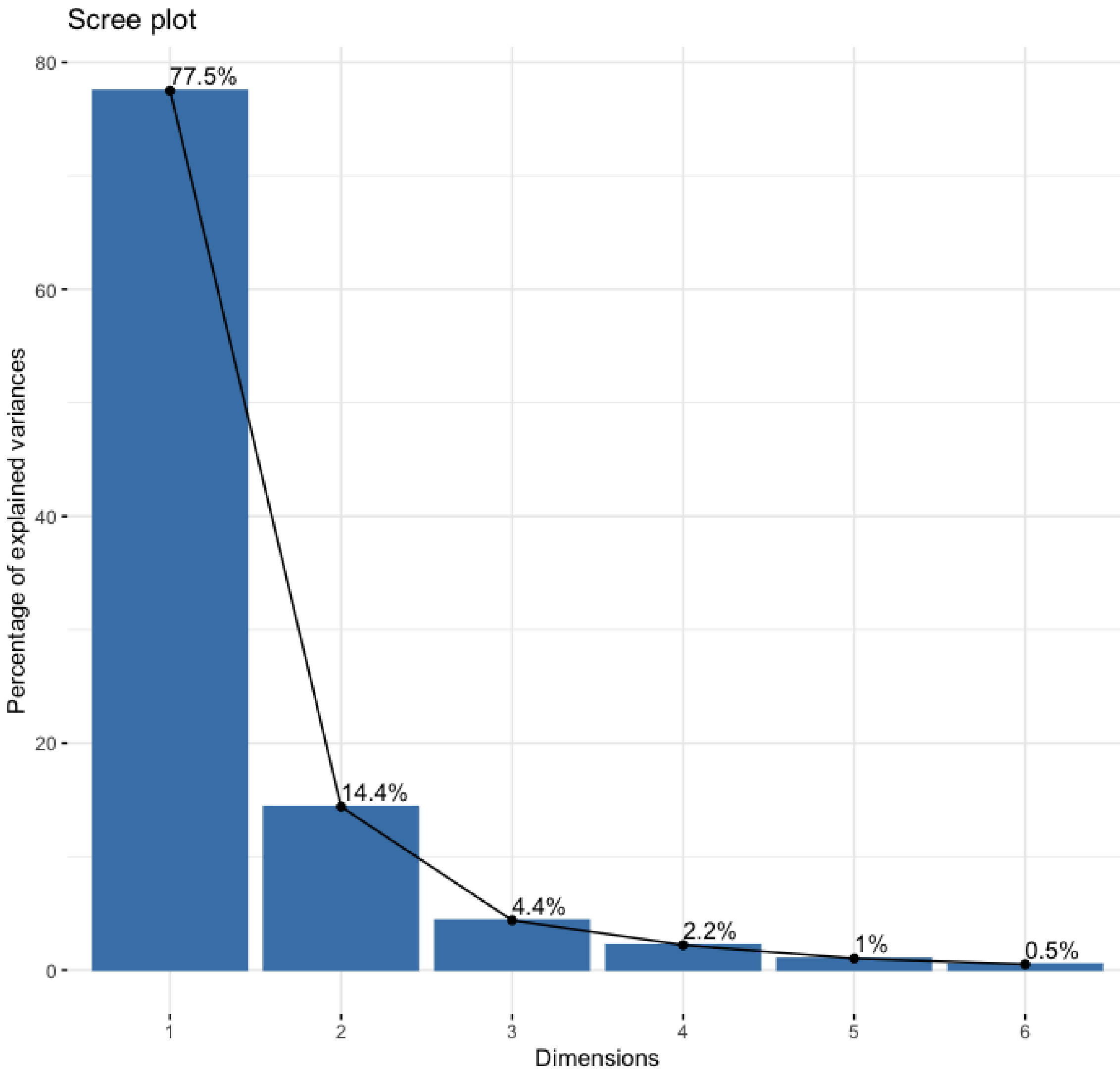


Figure 3C. MCD-level Area Deprivation Index Principal Component 1 vs Principal Component 2 Biplot

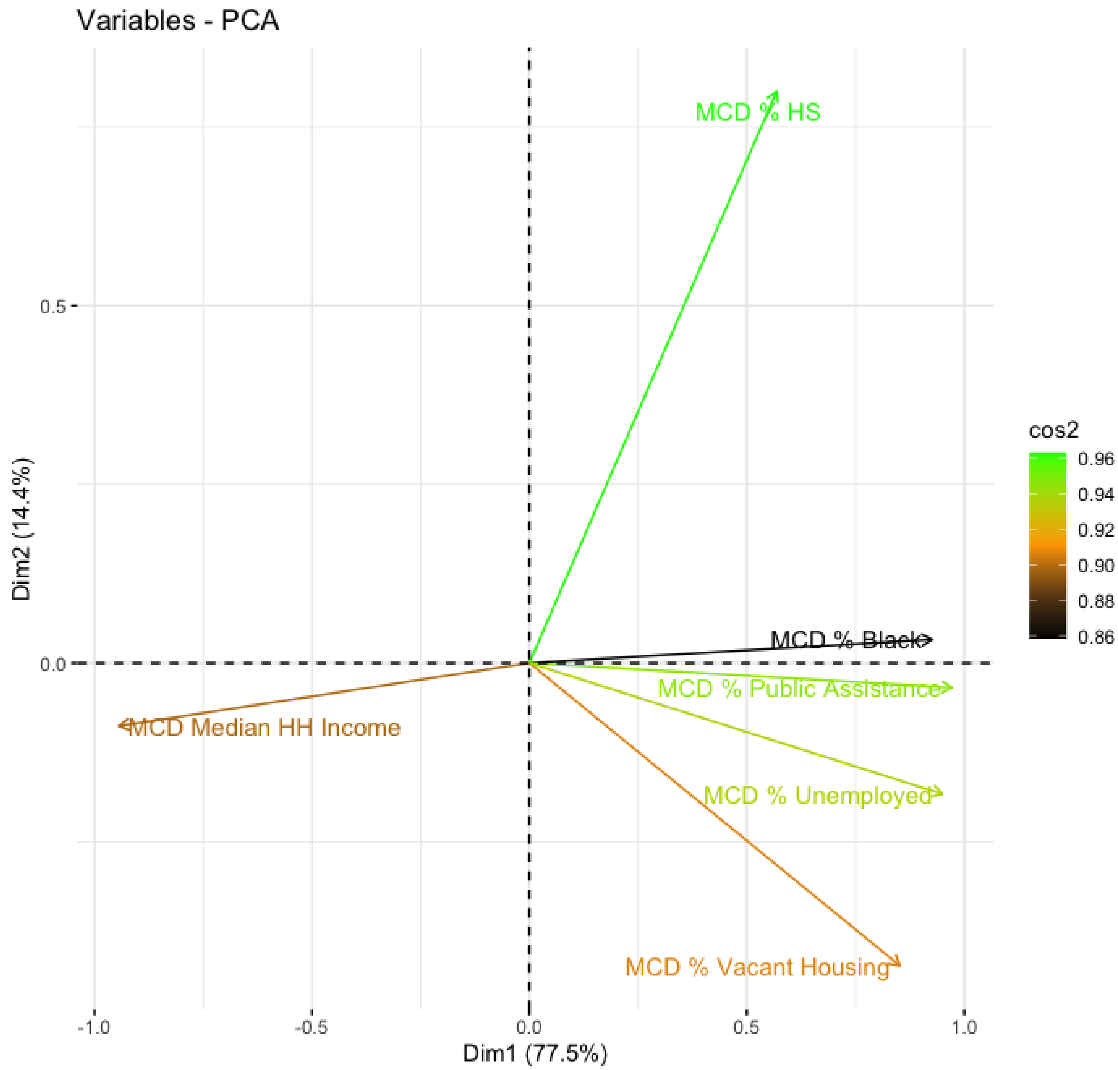


Figure 4A. Census Tract-level Area Deprivation Index Correlation Matrix

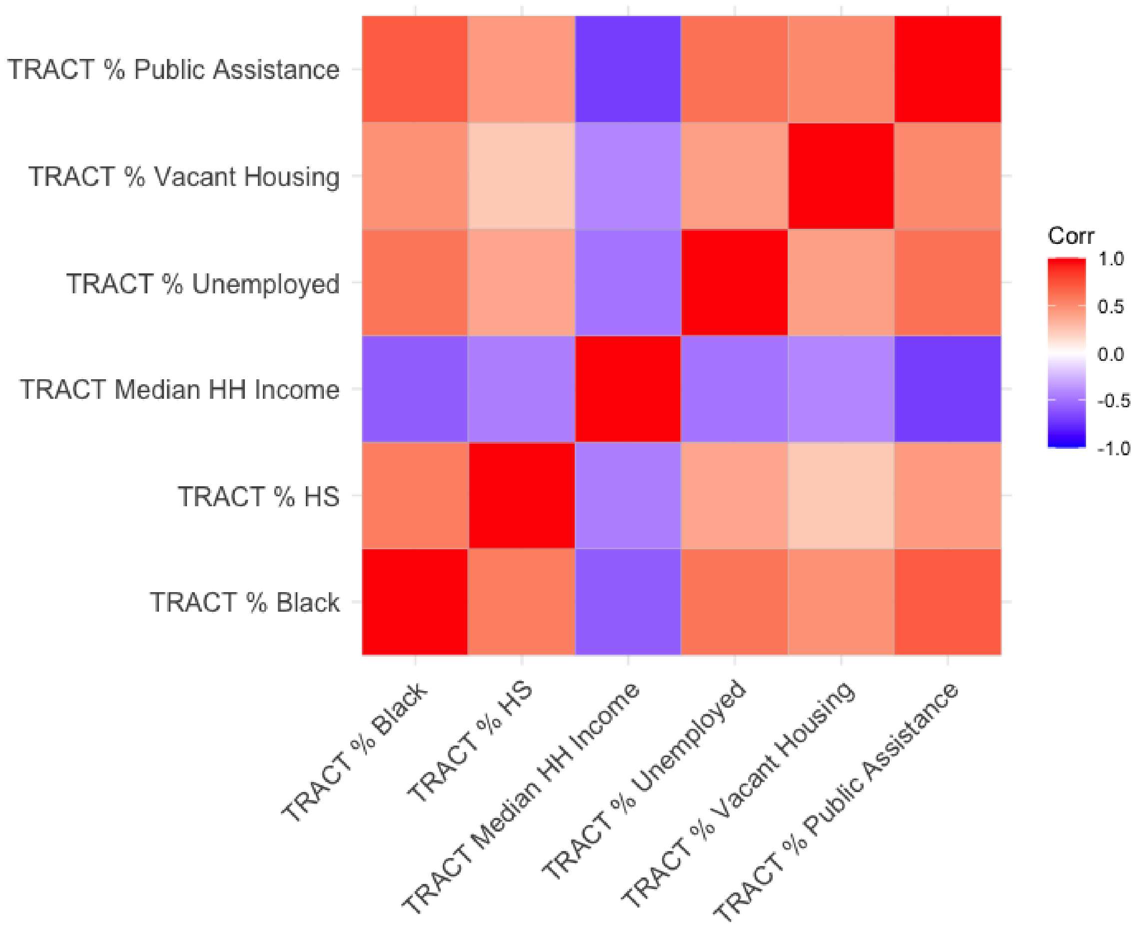


Figure 4B. Census Tract-level Area Deprivation Index Scree Plot

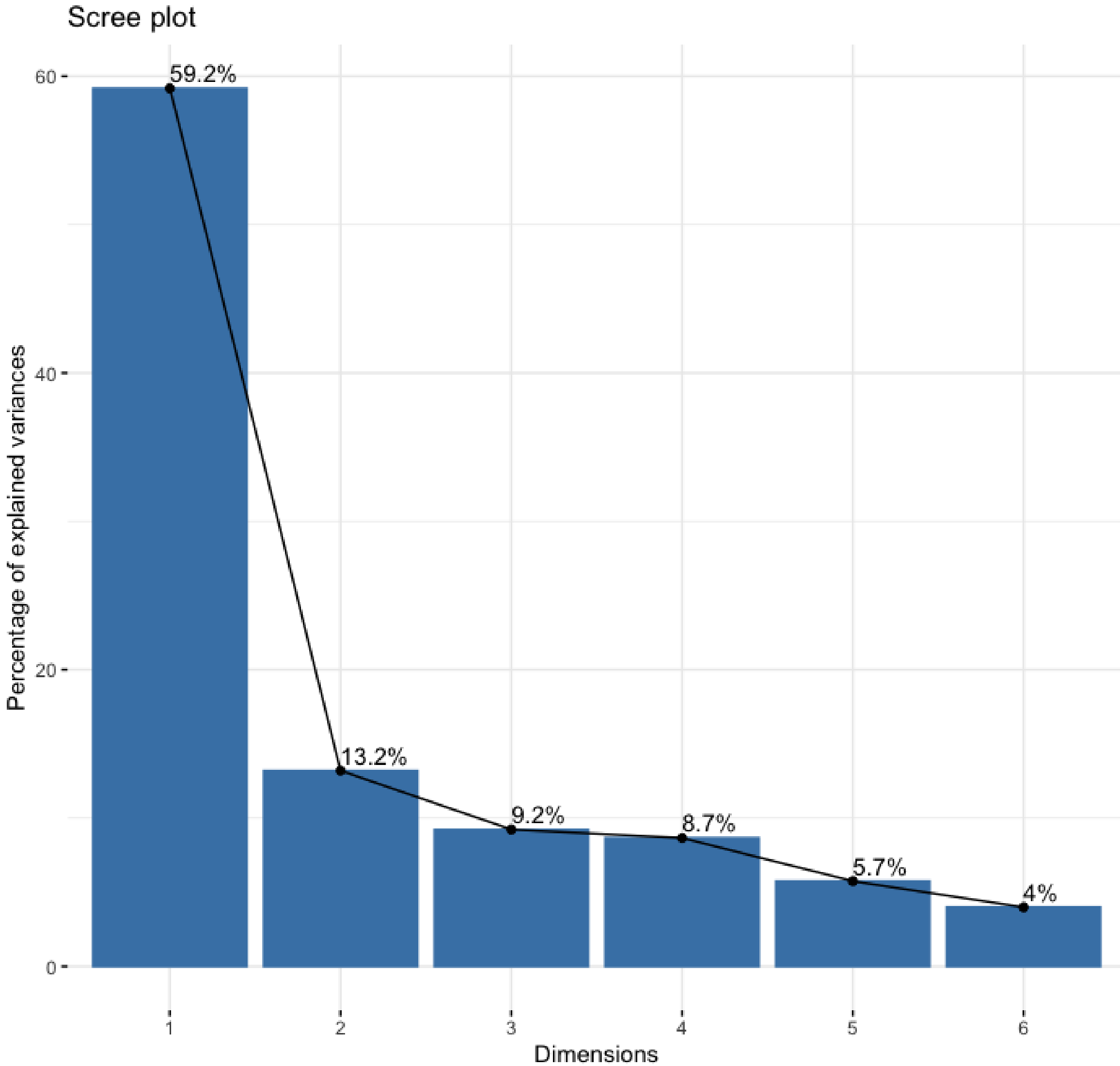
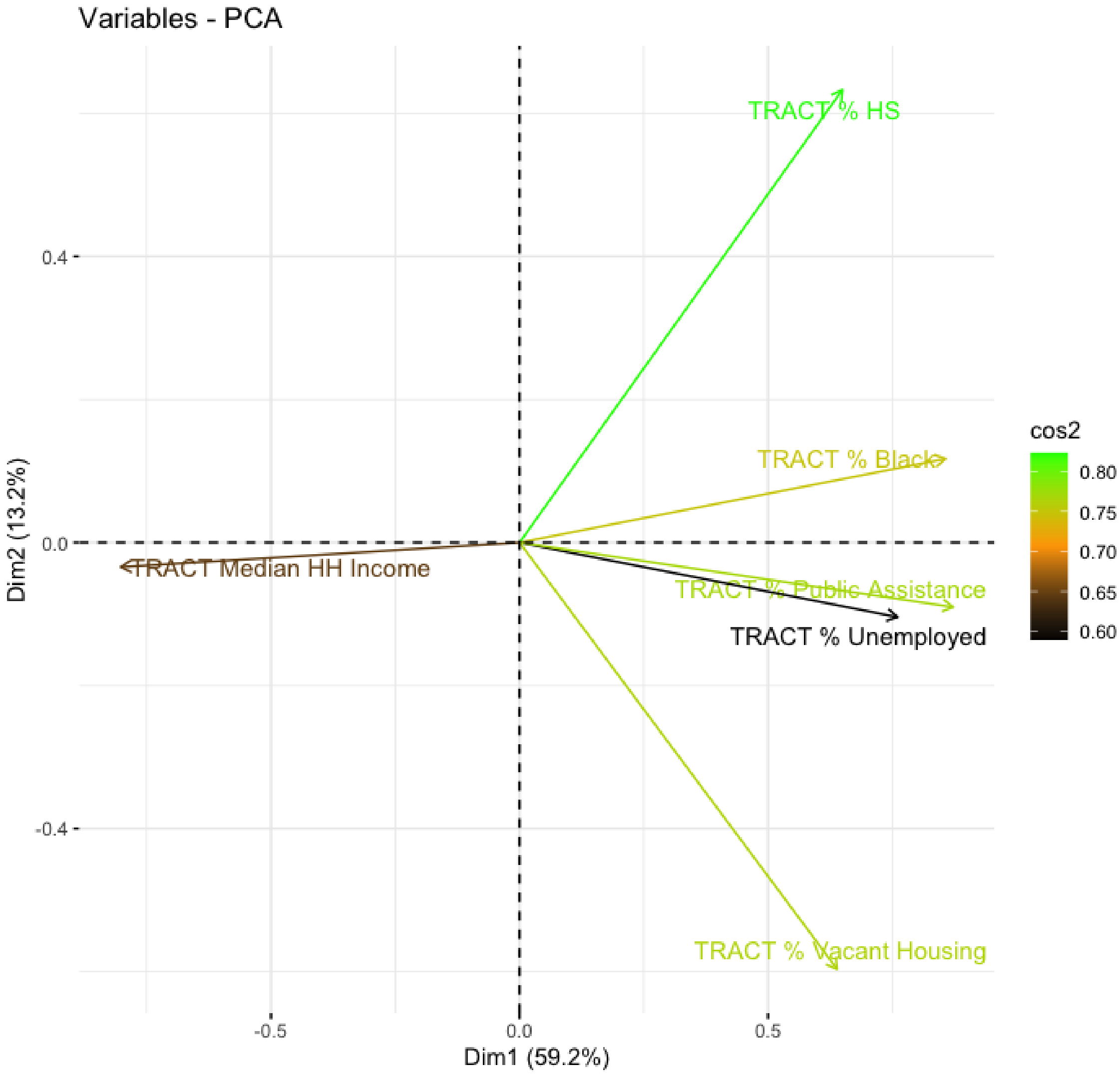


Figure 4C. Census Tract-level Area Deprivation Index Principal Component 1 vs Principal Component 2 Biplot



CHAPTER 5: DISCUSSION

This is the first study to my knowledge to examine the association between area-level deprivation and preterm birth (PTB) at three different spatial scales in a cohort of all Black pregnant women. Our primary finding was that the association between area-level deprivation and PTB varied by the spatial level at which it was measured. Specifically, we found increased area-level deprivation to be associated with a lower odds of PTB at the county and MCD (Metropolitan Community Division) levels, while being harmful at the Census tract level. Among the 6 peer-reviewed publications on area-level deprivation indices and PTB among Black women or stratified on race, all were based on Census tracts or block groups. Similar to what was seen by Messer et al. (2006); Ma et al. (2015); and Janevic et al. (2010), women in our study who lived in Census tracts in the highest deprivation quartile had a 15% increase in the odds of delivering a preterm infant (odds ratio (OR): 1.15, 95% confidence interval (CI): 0.80, 1.67). This finding, however, was not statistically significant. At the county and MCD levels, however, we found statistically significant effects contrary to those which we and others have found at the Census tract level. Living in the highest deprivation quartile of counties and MCDs was associated with an 11% reduction of odds of PTB in our cohort of Black women. One hypothesis that may explain the contradictory effects at the higher-level spatial units compared to the Census tract findings is the nesting of spatial units. Within each county there are several MCDs, and within each MCD are several Census tracts. Some women in our cohort may be living in highly deprived Census tracts that are nested within less deprived counties and MCDs, while others may be living in less deprived tracts nested within highly deprived counties and MCDs. The discordance between Census tract deprivation and county/MCD deprivation represented in our study population could explain why we are seeing protective effects at higher spatial units and harmful effects at more the more granular Census tract level. Appreciation of our findings may provide insights for development of effective policies to improve birth outcomes.

While there are no peer-reviewed publications to my knowledge using county or MCD level data to analyze area-level deprivation as a risk factor for PTB among Black women, there is a body of research on area-level measures related to segregation and PTB that consider data at other spatial levels beyond the Census tract. Focusing on Black women in analyses of 2002 U.S. birth certificate data, Bell et al. (2006) encountered varying results with two measures of segregation (index of isolation, and index of clustering) defined at the Metropolitan Statistical Area (MSA), finding that higher isolation was associated with adverse birth outcomes, while higher clustering was associated with more optimal outcomes.[4] Bell et al. (2006) proposes that these two measures of segregation operate opposite of one another, with isolation reflecting segregation factors that are deleterious to health (poor neighborhood quality and discrimination) whereas clustering may reflect positive factors such as Black political empowerment, social support, and cohesion.[4] Our area deprivation index (ADI) does not directly reflect isolation or clustering but has some common ground as the ADI did include percent Black. The findings shown by Bell et al (2006) are aligned with our findings for ADI at the county and MCD level. Segregation can be viewed as a multidimensional construction that should be studied in tandem with area-level deprivation to understand how these two contextual variables operate in concert to, downstream, impart deleterious and protective influences on PTB risk.

We then turned from analyses of neighborhood factors alone to consider (cross level) interactions. Identifying household income and education as moderators of the area-level deprivation association with PTB is a significant contribution of this work. Many authors have called for consideration of cross-level interactions in research on neighborhood factors and

PTB.[9-10] Outside of papers by Sealy-Jefferson et al. (2016, 2019, 2021) using the LIFE data, only race has been evaluated as a moderator in the peer-reviewed literature to date.[11-13] Not only did we evaluate two sociodemographic characteristics, we did so within a sample of Black women, the group at highest risk for PTB in the U.S. We first modeled each interaction with neighborhood deprivations in separate models of PTB: 1) with annual household income; 2) with maternal education. Among all women who lived in the highest quartile of deprivation at the Census tract level, women with annual household incomes of less than $30,000 had nearly half the odds of PTB compared to those with annual household incomes of at least $30,000. Conversely, among all women who lived in the highest quartile of deprivation at the Census tract level, women who did not have a college education had a 47% greater odds of PTB compared to women who did have a college education. Not only do our findings illustrate the heterogeneity of neighborhood effects on PTB, the moderating impact of income and education were in opposing directions. Adverse neighborhood conditions were associated with a reduction in PTB odds for low-income women while it was associated with higher odds of PTB for women with less education.

There was no evidence of a three-way interaction between income, education, and neighborhood (in this study the fit for a model with a three-way interaction was poor), but the model fit was enhanced when both two-way interactions were included in a single final model: 1) between annual household income and neighborhood deprivation; 2) between maternal education and neighborhood deprivation. The pattern remains complex, as we see effects in two directions. Among women without a college education with annual household income over $30,000 (i.e., lower education, higher income), those who lived in high deprivation neighborhoods had over 5 times the odds of delivering a preterm infant compared to those who lived in low deprivation neighborhoods (OR = 5.11, 95% CI: 2.36, 11.07). Conversely, among women with a college education with annual household income of less than $30,000, those who resided in high deprivation Census tracts had less than half the odds of delivering a preterm infant compared to those who resided in low deprivation Census tracts (OR = 0.41, 95% CI: 0.19, 0.90). The heterogeneity in these patterns may reveal how the influence of area-level deprivation on PTB odds can vary based on individual-level characteristics of the mother, thus warranting further investigation into individual-level effect modifiers in this relationship.

Our work does fail to consider how the current neighborhood may have changed over time. Neighborhoods are constantly changing, and thus the quality of one's neighborhood may not be static even for women who reside in a community all of their lives. To combat the issue of using cross-sectional data to describe the neighborhood environment, three papers utilized the Neighborhood Change Database create their own longitudinal measures of neighborhood deprivation.[5-7] Looking at birth data from Maternal and Infant Health Assessment (MIHA) in California, Margerison et al. (2015) estimated associations between PTB and longitudinal poverty measures, comparing those associations to identical models that employed traditional cross-sectional measures.[5] Cross-sectional poverty categories were assigned to Census tracts using the 2005-2009 American Community Survey data alone. Using the Neighborhood Change database, poverty data points were assigned for prior decades of the Census tracts. Using long-term low poverty as the reference group and adjusting for individual-level characteristics, living in a long-term high-poverty neighborhood was associated with a 41% increased odds in PTB (95% CI: 1.18, 1.69); living in a long-term moderate poverty neighborhood was associated with a 22% increase in the odds of PTB; and neighborhoods that experienced a poverty increase in the earlier decades were associated with a 37% increased odds of PTB.[5] Using birth certificate data in Texas from 2009-2011 and the same trajectories developed by Margerison et al., (2015) and Cubbin et al. (2020) examined the association between neighborhood poverty trajectory and PTB, and neighborhood inequality trajectory and PTB.[6] Similar results were found, where living in long-term moderate poverty, long-term high poverty, poverty increase, and poverty decrease, compared to neighborhoods with long-term low poverty, were associated with an increased odds of delivering a preterm infant. Living in neighborhoods characterized by long-term high inequality compared to neighborhoods with long-term low inequality was also associated with an increased odds of delivering a preterm infant.[6] Lastly, Kim et al., (2020) using the same Texas birth certificate data as Cubbin et al. (2020) using similar trajectory measures of neighborhood racial/ethnic composition.[7] Findings showed that living in neighborhoods with a steady high proportion of non-Hispanic Black was associated with a higher odds of delivering a preterm infant, compared to neighborhoods with a steady low proportion of non-Hispanic Black individuals. Further, Black-white differences in delivering preterm were highest in neighborhoods characterized by a steady high proportion white population.[7] These three studies offer insight on how the historical and trending sociodemographic contexts of neighborhoods may actually have an impact on the PTB risk among women living in these neighborhoods and is worth pursuing in future studies. However, what has yet to be explored is a woman's lifetime exposure to neighborhood deprivation and her risk of PTB. One literature review focused on 19 studies that looked at neighborhood deprivation and adverse health outcomes in children between the ages of 0 -18 years.[8] While over 60% of these studies found significant associations between some area-level characteristic and deleterious health outcomes in children, these studies have not extended beyond the childhood period to examine how childhood exposure(s) to area-level deprivation may impact adult health.

There are several strengths with this study that allow it to meaningfully contribute to the existing body of literature. This is the first study to look at the association between area-level deprivation and PTB risk at three different spatial scales. Previous work on this particular exposure (deprivation) has solely focused on either the block group or the Census tract level. This study adds to that literature by look at larger spatial units. While the aforementioned units better represent what we would consider to be one's immediate neighborhood environment, examining the association at the MCD and county levels allow us to explore the role of policy and programmatic interventions may play. Findings at these higher-level spatial units may have the ability to influence policy more so than findings at more granular spatial units, thus warranting the need to study them. Furthermore, we were able to conduct this study with a large cohort of all Black women, with over 1,100 women providing primary data for these analyses (in contrast to secondary data sources). Black women are not only underrepresented and understudied when it comes to examining risk factors for PTB, but they are also at the greatest risk for delivering a preterm infant. Having a large study population of only Black women allowed us to explore area-level factors that may specifically influence a Black woman's risk for delivering preterm while also having sufficient statistical power to support our analyses. Lastly, our study population is relatively geographically diverse, coming from three different greater-metropolitan cities (Detroit, MI; Columbus, OH; Orlando, FL) representing two different US regions (Midwest; South). This allows our findings to be more generalized and applicable than previous studies whose study populations may have come from a single hospital or a state.

Our study is not without its limitations. Akin to all the other studies in this field, the cross-sectional nature of our work limits the ability to draw conclusions on causality. Future studies must incorporate longitudinal data on the cumulative area-level exposures throughout a woman's life-course in order to truly understand the role deprivation plays on pregnancy health and adverse birth outcomes. Furthermore, recruitment took place at only a handful of prenatal clinics and participation was voluntary. This sampling strategy may lead to some level of selection bias, as higher risk women may be unaware of such a study or choose not to participate due to their high risk. This, however, results in more conservative estimates, as our analyses do not account for these higher risk women who may be more likely to deliver preterm relative to our recruited study population. Had our study recruited more high-risk women, we would anticipate the odds of PTB to further decrease among women who lived in the most deprived counties and MCDs and further increase among women who lived in the most deprived Census tracts based on the findings in this study. Common to many other studies of this topic, our area-level measures are based on the neighborhood of residence during pregnancy, rather than the neighborhoods in which the woman spent her life. Little research has been published to determine whether the neighborhood environments of mothers in early life or any time prior to pregnancy play a substantial role in the risk of delivering preterm. Understanding the life-course exposure to adverse neighborhood conditions should be an avenue of future research endeavors. Also, census boundaries and area-level variables collected by the US Bureau of the Census decennial census and/or American Community Survey (ACS) may not be boundaries or characteristics that accurately reflect what one may consider to be their neighborhood environment. Exploring data beyond what has been studied here, such as accessibility to green spaces and proximity to fresh supermarkets or available pharmacies, could be more indicative of what one considers to be their neighborhood environment. Furthermore, integrating data on perceived neighborhood characteristics alongside objective neighborhood measures may address the issue of accurately measuring what one considers to be their neighborhood environment. Utilizing surveys to collect data on how individuals perceive their own neighborhood allows a more direct insight on how the neighborhood environment impacts the individual, as any two individuals may have different experiences influencing their perceptions on the same neighborhood, and thus may be impacted in different ways. Using a subset of the Biosocial Impact on Black Births (BIBB) cohort studied here, Vaughan et al. found that perceived neighborhood disadvantage may actually capture a different dimension of area-level influence on health than objective neighborhood disadvantage, warranting further studies on the subject.[14] An individual's Census tract may also not be what they consider to be their neighborhood, and imposing pre-defined spatial units onto one's definition of neighborhood may misrepresent the true relationship between neighborhood deprivation and PTB. Incorporating perceived neighborhood data may address this limitation and may provide further insight into what individuals define as their neighborhood. Creating a single deprivation index at each spatial level may also be a potential limitation to this study, as data from the three different states (FL, MI, OH) are aggregated into each index. The three states may be vastly different from one another with regards to the six area-level characteristics included in the deprivation index, thus potentially using a deprivation index score for a spatial unit that doesn't accurately represent it. Future analyses should look towards stratifying by state and creating deprivation indices at each spatial level for each state to examine whether state-specific deprivation indices may better portray the level of deprivation for each spatial unit. Lastly, the generalizability of our results may be limited, as our study takes place in three metropolitan epicenters: two in the Midwest and one in the South. Future studies should include rural populations, as well as other regions across the country in order to fully understand how the area-level environment influences PTB risk among Black women.

In conclusion, we examined the relationship between area-level deprivation (at the county-, MCD-, and Census tract levels) and PTB odds in a cohort of Black women from the metro-Detroit, metro-Columbus, and metro-Orlando areas. Generally, we found area-level deprivation to be protective at the county- and MCD-levels, and harmful at the Census tract level. We also found that annual household income and maternal education may modify the relationship between area-level deprivation and PTB risk. The findings in this study have implications at multiple levels. With regards to examining deprivation at various spatial units, future research should examine area-level deprivation at county- and MCD-levels to inform potential policy measures that may ultimately improve census tract level deprivation. Understanding factors at the more immediate neighborhood level, namely the Census tract and block group levels, would provide guidance for interventions that would, downstream, improve birth outcomes for Black women. Another avenue for future studies to pursue is the incorporation of biological markers in studies as potential mediators that may lie in the pathway between area-level deprivation and PTB risk. Previous studies have found area-level deprivation to be associated with shortened telomeres, potentially acting as a mechanism that drives adverse health outcomes.[15] Telomere shortening, a process that can be accelerated by increased stress, may disproportionately affect Black women as they are more likely to experience psychological stress compared to white women.[9] This may explain why we see increased rates of PTB even among affluent and highly educated Black women.[16] Ultimately, the relationship between area-level deprivation and preterm delivery among Black women is a complex one, with several avenues of future research that may uncover more regarding this relationship.

BIBLIOGRAPHY

1) Wallace, M., Harville, E., Theall, K., Webber, L., Chen, W., & Berenson, G. (2013). Neighborhood poverty, allostatic load, and birth outcomes in African American and white women: findings from the Bogalusa Heart Study. *Health & place*, *24*, 260–266. https://doi.org/10.1016/j.healthplace.2013.10.002

2) Schempf, A. H., Kaufman, J. S., Messer, L. C., & Mendola, P. (2011). The neighborhood contribution to black-white perinatal disparities: an example from two north Carolina counties, 1999-2001. *American journal of epidemiology*, *174*(6), 744–752. https://doi.org/10.1093/aje/kwr128

3) Kramer, M. R., Cooper, H. L., Drews-Botsch, C. D., Waller, L. A., & Hogue, C. R. (2010). Metropolitan isolation segregation and Black-White disparities in very preterm birth: a test of mediating pathways and variance explained. *Social science & medicine (1982)*, *71*(12), 2108–2116. https://doi.org/10.1016/j.socscimed.2010.09.011

4) Bell, J. F., Zimmerman, F. J., Almgren, G. R., Mayer, J. D., & Huebner, C. E. (2006). Birth outcomes among urban African-American women: a multilevel analysis of the role of racial residential segregation. *Social science & medicine (1982)*, *63*(12), 3030–3045. https://doi.org/10.1016/j.socscimed.2006.08.011

5) Cubbin, C., Kim, Y., Vohra-Gupta, S., & Margerison, C. (2020). Longitudinal measures of neighborhood poverty and income inequality are associated with adverse birth outcomes in Texas. Social science & medicine (1982), 245, 112665. https://doi.org/10.1016/j.socscimed.2019.112665

6) Kim, Y., Vohra-Gupta, S., Margerison, C. E., & Cubbin, C. (2020). Neighborhood Racial/Ethnic Composition Trajectories and Black-White Differences in Preterm Birth among Women in Texas. Journal of urban health : bulletin of the New York Academy of Medicine, 97(1), 37–51. https://doi.org/10.1007/s11524-019-00411-y

7) Margerison-Zilko, Claire, et al. "Beyond the Cross-Sectional: Neighborhood Poverty Histories and Preterm Birth." American Journal of Public Health, vol. 105, no. 6, 2015, pp. 1174-1180. ProQuest, http://ezproxy.msu.edu/login?url=https://www-proquest-com.proxy2.cl.msu.edu/scholarly-journals/beyond-cross-sectional-neighborhood-poverty/docview/1683336238/se-2?accountid=12598.

8) van Vuuren, C. L., Reijneveld, S. A., van der Wal, M. F., & Verhoeff, A. P. (2014). Neighborhood socioeconomic deprivation characteristics in child (0-18 years) health studies: a review. *Health & place*, *29*, 34–42. https://doi.org/10.1016/j.healthplace.2014.05.010

9) C, G., D P, M., J C, S. A., S L, G., A L, N., E, D. M., C G, E., S N, Z., T A, L., S, S. J., J, F., S, D., & P, S. (2022). Neighborhoods, Racism, Stress, and Preterm Birth Among African American Women: A Review. *Western journal of nursing research*, *44*(1), 101–110. https://doi.org/10.1177/01939459211041165

10) Burris, H. H., & Hacker, M. R. (2017). Birth outcome racial disparities: A result of intersecting social and environmental factors. *Seminars in perinatology*, *41*(6), 360–366. https://doi.org/10.1053/j.semperi.2017.07.002

11) Sealy-Jefferson, S., Butler, B., Chettri, S., Elmi, H., Stevens, A., Bosah, C., Dailey, R., & Misra, D. P. (2021). Neighborhood Evictions, Marital/Cohabiting Status, and Preterm Birth among African American Women. *Ethnicity & disease*, *31*(2), 197–204. https://doi.org/10.18865/ed.31.2.197

12) Sealy-Jefferson, S., Slaughter-Acey, J., Caldwell, C. H., Kwarteng, J., & Misra, D. P. (2016). Neighborhood Disadvantage and Preterm Delivery in Urban African Americans: The Moderating Role of Religious Coping. *SSM - population health*, *2*, 656–661. https://doi.org/10.1016/j.ssmph.2016.09.001

13) Sealy-Jefferson, S., & Misra, D. P. (2019). Neighborhood Tax Foreclosures, Educational Attainment, and Preterm Birth among Urban African American Women. *International journal of environmental research and public health*, *16*(6), 904. https://doi.org/10.3390/ijerph16060904

14) Vaughan, S. E., Misra, D. P., Gohar, J., Hyer, S., Price, M., & Giurgescu, C. (2023). The associations of objective and perceived neighborhood disadvantage with stress among pregnant black women. *Public health nursing (Boston, Mass.)*, *40*(3), 372–381. https://doi.org/10.1111/phn.13177

15) Powell-Wiley, T. M., Gebreab, S. Y., Claudel, S. E., Ayers, C., Andrews, M. R., Adu-Brimpong, J., Berrigan, D., & Davis, S. K. (2019). The relationship between neighborhood socioeconomic deprivation and telomere length: The 1999-2002 National Health and Nutrition Examination Survey. *SSM - population health*, *10*, 100517. https://doi.org/10.1016/j.ssmph.2019.100517

16) Phillippe M. (2022). Telomeres, oxidative stress, and timing for spontaneous term and preterm labor. *American journal of obstetrics and gynecology*, *227*(2), 148–162. https://doi.org/10.1016/j.ajog.2022.04.024

CHAPTER 6: CONCLUSION

In this study, we examined the relationship between area-level deprivation and preterm birth (PTB) at the county, MCD, and Census tract levels in a cohort of Black women. We found that at the county and MCD levels, area-level deprivation was associated with a decreased odds of delivering preterm, while deprivation at the Census tract level was associated with an increased odds of PTB. While it is difficult to pinpoint the exact reasoning to why we found these discordant results, it is imperative to recognize the opportunities for further exploration of this topic. One hypothesis to why we see this discordance may stem from the relationship between Census tracts and the counties/MCDs within which they are nested. The women in our study who are delivering preterm could be residing in highly deprived Census tracts that are nested within MCDs and counties that, overall, are much less deprived. Conversely, the women in our study who are delivering term could be residing in low deprivation Census tracts nested within counties and MCDs that exhibit greater levels of deprivation. Further, not every Census tract in the counties from which the women reside in are represented in our study, warranting further investigation into the differences in deprivation between the Census tracts that are represented versus those that are not. The findings in this study pave an avenue for future studies, imploring them to examine relationships at both granular and coarse spatial units to better understand how they may change as we zoom in and out of a woman's immediate neighborhood environment.

Unlike Census tracts, due to their small relative size, MCDs and counties are governmental units that have the ability to enact policy changes. These policies, downstream, have an impact on the Census tracts nested within these governmental units. This reinforces the importance of examining the differences that may exist in the relationship between area-level deprivation and PTB across the various spatial units. The end goal, ultimately, is to identify what may be driving the discordance in the relationship between area-level deprivation and PTB across spatial units, and to develop policies at the higher spatial units that, downstream, may improve conditions across the more granular spatial units nested within.

Our findings of multiple cross-level interactions suggest that heterogeneity may be hidden in much of the past research on area-level deprivation and PTB. To date, only publications by Sealy-Jefferson et al and this thesis have reported on interactions with any individual-level variables other than race/ethnicity. There is an urgent need to explore further cross-level interactions by individual-level maternal characteristics.[1-4] A major obstacle, often, to exploring effect modification by individual-level characteristics is acquiring such data. Most studies in the peer reviewed literature have relied on vital statistics (birth certificate) data. While vital statistics data lack information like household income, they do contain information such as maternal education level. This data can and should be utilized by larger studies in order to better understand how individual-level characteristics may modify the relationship between area-level deprivation and PTB.

What also must be considered in future analyses is the integration of both objective and subjective area-level data within the same study. Giurgescu et al. has previously published studies that examine both the relationship between objective neighborhood disorder and birth outcomes, as well as subjective neighborhood disorder and birth outcomes.[5-7] The value of this work cannot be understated, as more insight into how individuals experience their area-level environment, and that relationship with adverse health outcomes needs to be appreciated. There may be a discordance between objective area-level environment and subjective perspectives of one's area-level environment that needs to be further evaluated. A woman may be living in what, objectively, may be defined as a high deprivation neighborhood, however her perception of the neighborhood could be quite the opposite. If an individual's family has lived in a neighborhood for generations, has strong social networks within the neighborhood, or has aspects of their neighborhood that support their lives, the neighborhood, no matter how objectively deprived it may be according to an area-level deprivation index, may confer positive benefits that cannot be captured by objective measures. Additionally, psychosocial factors, such as stress and social support, should be considered as potential mediators that may explain the effect modification by individual-level characteristics on the relationship between area-level deprivation and PTB.

Finally, language plays a powerful role when writing about results of such studies. It is often difficult to accurately represent what we mean when we describe a "deprived neighborhood." Rather than focusing solely on negative qualities in describing the neighborhood, we must broaden our lens to consider the assets that may exist alongside the deficits. This can be achieved through qualitative research, as residents themselves can provide firsthand insight as to strengths of the community and what common needs would improve the quality of their neighborhood. After all, neighborhoods are often products of decades of segregation, and oftentimes individuals, particularly those with limited social mobility, do not always get to choose where they live. By shifting the language, we use to describe area-level deprivation, we aim to shift the "blame," per se, from individuals to the neighborhood environment within which they live and calling to action an exploration of improvements.

The field of neighborhood environment and its association with PTB is a growing field with several avenues for future research. Through studies like this, and those that follow, we hope to drive the development of policies aimed to improve the conditions of neighborhoods, and, downstream, the health of their residents. Ultimately, we hope that this work paves the way for future work aimed to better understand preventable causes of PTB.

BIBLIOGRAPHY

1) Sealy-Jefferson, S., Butler, B., Price-Spratlen, T., Dailey, R. K., & Misra, D. P. (2020). Neighborhood-Level Mass Incarceration and Future Preterm Birth Risk among African American Women. *Journal of urban health : bulletin of the New York Academy of Medicine*, *97*(2), 271–278. https://doi.org/10.1007/s11524-020-00426-w

2) Sealy-Jefferson, S., Butler, B., Chettri, S., Elmi, H., Stevens, A., Bosah, C., Dailey, R., & Misra, D. P. (2021). Neighborhood Evictions, Marital/Cohabiting Status, and Preterm Birth among African American Women. *Ethnicity & disease*, *31*(2), 197–204. https://doi.org/10.18865/ed.31.2.197

3) Sealy-Jefferson, S., & Misra, D. P. (2019). Neighborhood Tax Foreclosures, Educational Attainment, and Preterm Birth among Urban African American Women. *International journal of environmental research and public health*, *16*(6), 904. https://doi.org/10.3390/ijerph16060904

4) Sealy-Jefferson, S., Slaughter-Acey, J., Caldwell, C. H., Kwarteng, J., & Misra, D. P. (2016). Neighborhood Disadvantage and Preterm Delivery in Urban African Americans: The Moderating Role of Religious Coping. *SSM - population health*, *2*, 656–661. https://doi.org/10.1016/j.ssmph.2016.09.001

5) Vaughan, S. E., Misra, D. P., Gohar, J., Hyer, S., Price, M., & Giurgescu, C. (2023). The associations of objective and perceived neighborhood disadvantage with stress among pregnant black women. *Public health nursing (Boston, Mass.)*, *40*(3), 372–381. https://doi.org/10.1111/phn.13177

6) Giurgescu, C., Zenk, S. N., Templin, T. N., Engeland, C. G., Kavanaugh, K., & Misra, D. P. (2017). The Impact of Neighborhood Conditions and Psychological Distress on Preterm Birth in African-American Women. *Public health nursing (Boston, Mass.)*, *34*(3), 256–266. https://doi.org/10.1111/phn.12305

7) Giurgescu, C., Zenk, S. N., Dancy, B. L., Park, C. G., Dieber, W., & Block, R. (2012). Relationships among neighborhood environment, racial discrimination, psychological distress, and preterm birth in African American women. *Journal of obstetric, gynecologic, and neonatal nursing : JOGNN*, *41*(6), E51–E61. https://doi.org/10.1111/j.1552-6909.2012.01409.x