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Racial/Ethnic Disparities in Preterm Birth in an Intergenerational Cohort of Mothers and Babies in California: The Role of Neighborhood Disinvestment

by

Bina Patel Shrimali

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Public Health

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Graduate Division

of the

University of California, Berkeley

Committee in change:
Professor Mahasin S. Mujahid (Chair)
Professor Barbara Abrams
Professor Carolina Reid
Michelle Pearl, PhD

Summer 2017

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Bina Patel Shrimali

Abstract

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Doctor of Public Health

University of California, Berkeley

Professor Mahasin S. Mujahid, Chair

Background

Preterm birth in the U.S. is higher than other comparable countries. Babies born preterm are at higher risk of life-threatening complications in their first days as well as a range of health and educational problems over the life course. Despite recent declines in preterm birth, significant racial/ethnic disparities persist. A growing body of literature suggests conditions in the places where people live, especially during critical time periods of development, may be playing a fundamental role in shaping the development of maternal health, and disparities in birth outcomes in the subsequent generation. However, this literature is limited by cross-sectional neighborhood and health data and incomplete definition and measurement of complex historical and economic processes that shape neighborhood environments. The overarching goals of this study are 1) to expand current measurement of neighborhood contexts to capture historical and economic processes of structural marginalization that have shaped them, and to assess the relationship between these expanded measures and preterm birth 2) to develop and apply a framework informed by structural marginalization to catalyze a next-generation practice of Maternal and Child Health.

Method

The Life Course Social Context database, which contains geocoded birth records linked between mothers and babies in California, provides a unique opportunity to assess the relationship between neighborhood-level exposures experienced at two different stages of a mother's life course (early childhood and adulthood) and preterm birth in the next generation. Using these data and other census measures, we construct histories of neighborhood poverty going back to 1970 and examine associations between these neighborhood poverty histories and preterm birth. Next, we assess the relationship between structural neighborhood inequality and preterm birth and preterm birth disparities, using measures of income inequality, racial/ethnic inequality and a combined measure of income and racial/ethnic inequality. Finally, we develop a conceptual model for understanding the broader context in which inequities in birth outcomes arise and

provide case examples and lessons for future development of a next-generation MCH practice that will address the root causes of inequities in birth outcomes.

Significance

Clearer understanding of complex neighborhood processes and how they shape health through generations is vital for the development of targeted and impactful public health programs. The development and assessment of new measures that approximate structural forces underlying neighborhood conditions shaping health over the life course will help direct the scope and scale of policy and practice efforts aimed at improving health and reducing inequities in birth outcomes. This study aims to contribute to more complete definition, measurement, and intervention for historical and structural forces that shape neighborhood conditions.

Dedication

To Sandeep, for inspiring me to be my best self, and to Ishaan and Surya for teaching me life's most valuable lessons.

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Chapter 1

Introduction

1.1 Background information

Birth Outcomes: Significance and Scope in the United States

Almost 10% of infants in the United States are born early[1], and more than 1 in 200 die before they reach their first birthday.[2] In 2010, the U.S. ranked at the bottom of 19 comparable countries in preterm birth (birth before 37 weeks of completed gestation), and ranked 26th among the 29 Organization for Economic Cooperation and Development (OECD) countries in infant mortality (death within the first year of life).[3] These birth outcomes are not only an important measure of general population health, but also represent significant costs to society: the Institute of Medicine (IOM) estimates that $26.2B was spent on preterm birth alone in 2005.[4] In addition, significant racial disparities persist in birth outcomes. In 2014, 13.2% of Nonhispanic Black and 9.0% of Hispanic babies were born preterm compared to 8.9% of Nonhispanic White babies.[1] These trends have been alarmingly consistent over time.[6] As a result of the gravity of these public health issues, reducing preterm birth and infant mortality have been prioritized as leading health indicators by Healthy People 2020, the U.S. Department of Health and Human Services' major initiative to improve health and close health disparities.[5]

Causes of Birth Outcomes are Poorly Understood

Causes of birth outcomes, including preterm birth, are poorly understood. In the case of spontaneous preterm births, which account for approximately 75% of preterm cases, multiple complex endogenous and exogenous risk factors are likely to be interacting to cause premature delivery.[7] A variety of factors have been identified as linked to preterm birth but none of them fully explain it, including cigarette smoking, prior preterm birth, family history of preterm birth, genital tract infection, young or advanced maternal age, low prepregnancy weight, anxiety and depression, stressful life events (e.g. death in the family), catastrophes (e.g. earthquakes), chronic stress exposures (e.g. homelessness), low socioeconomic position, low educational attainment, and racial discrimination.[4]

There is growing consensus that birth outcomes should be viewed through a life course perspective, and that factors over a woman's life course, especially early in life, may influence a her health status when she gets pregnant, and the health of her baby in the next generation.[8,9] This approach suggests the need for current research to broaden from assessing singular risk factors during pregnancy to examining a more holistic view of a woman's lifetime of exposures, both biological and social, especially during critical life periods in her development. In this way,

birth outcomes are one measure of health that both predict and are a product of lifelong health, and may represent one pathway through which social status and health are transferred through generations.

Neighborhood Context and Health

Neighborhood context may be a particularly important driver of racial/ethnic disparities in birth outcomes in the U.S. because clear patterns of racial residential segregation have resulted in unequal exposures to adverse neighborhood conditions and opportunity structures along racial/ethnic lines.[4] For example, concentrated poverty and neighborhood disadvantage are more common in predominantly Black neighborhoods than predominantly White neighborhoods and may play a role in persistent disparities in health.[4]

A large body of literature exists documenting an association between neighborhood context and a variety of health outcomes. The bulk of this literature uses census-defined boundaries to approximate neighborhoods, and has established associations between poverty, socioeconomic position, and indices of deprivation and segregation with various health outcomes, including mortality, self-rated health, mental health problems, chronic diseases, and adverse childhood outcomes. Although it is difficult to synthesize these diverse studies because they use a variety of exposure and outcome definitions, reviews of this literature conclude that living in poor, deprived, or segregated communities is associated with poor health outcomes.[10,11]

In addition, there is a large body of literature indicating a relationship between neighborhood context and poor birth outcomes. Metcalfe, et al. in a systematic review of 28 studies (mostly comprised of studies from the United States), found through both descriptive analysis (of 28 studies) and meta-analysis (of 5 studies) that living in a poor neighborhood has a negative impact on birth outcomes, above individual effects. They found a positive pooled odds ratio of 1.11 (95% CI: 1.02, 1.28) for neighborhood income and low birth weight. Their inclusion criteria required studies to have used multilevel models and have small area units <10,000 people, which induces greater confidence in their pooled estimate.[12]

In another systematic review of 24 studies in developed countries (mostly in Europe), Vos et al. found a consistent relationship between neighborhood deprivation and perinatal outcomes.[13] They reviewed studies that used large spatial unit sizes, which could overlook heterogeneity that exists in geographic regions, although these studies were excluded from their meta-analysis. In their meta-analysis of seven studies, they found a pooled odds ratio of 1.23 (95% CI: 1.18, 1.28) for neighborhood deprivation and preterm birth, and similar estimates for small-for-gestational age (SGA) and stillbirth. Notably, all but one of these studies included were neighborhood-level not multilevel studies, which may not account for neighborhood-level clustering.

In another recent review of 60 studies in the U.S. only, Ncube et al. reported a pooled odds ratio of 1.27 (95% CI: 1.16, 1.39) for neighborhood disadvantage and preterm birth in a meta-analysis of 11 studies.[14] Ncube et al. also reported a race-adjusted composite measure (OR=1.01, 95% CI: 0.94, 1.09) and a race-stratified composite measure [OR=1.15 (95% CI: 1.09, 1.22) for

Nonhispanic Black and OR=1.48 (95% CI: 1.25, 1.75) for Nonhispanic White].[14] The authors surmise that there may be unmeasured factors that influence birth outcomes for Nonhispanic Black women irrespective of their residential environments. They also acknowledge that because race is a strong predictor of where people live in the U.S., racial differences in preterm birth may be a function of other unmeasured factors in the environment, although they do not suggest what those might be.

Overall, despite differences in their inclusion criteria, each of these reviews found that the overwhelming majority of studies found a positive and significant association between neighborhood conditions and poor birth outcomes. Although the effect sizes of the pooled measures reported in each of these meta-analyses are modest, given the high prevalence of neighborhood poverty in the U.S., the impact on the health of the population may be sizeable.

Gaps in the Literature

Despite a growing body of literature on neighborhood factors and health outcomes, there are some important limitations to current research. First, there is little attention to temporal trends in the measurement of neighborhood economic processes. Most health studies assessing neighborhood conditions relationship to birth outcomes have focused on point in time exposure measures. Neighborhood conditions are dynamic and characterizing long-term neighborhood economic conditions may paint a fuller picture of experiences within neighborhoods. More nuanced characterization of neighborhood typologies may help explain persistent health disparities as there is evidence that some racial/ethnic groups (e.g. Black people) have been exposed to more persistent conditions of disadvantage over time.[15,16] Although some non-health studies have focused on creating typologies of neighborhoods to capture dynamic neighborhood conditions,[17,18,19] these have not been applied to birth outcomes research.

Second, there is a lack of attention to conceptualizing and assessing exposures that approximate structural processes that underlie community conditions. The economic, demographic, and policy changes that resulted in the geographic distribution of opportunity that persists today in the U.S. has been well-documented.[20–23] Many large neighborhood and health studies commonly use percent poverty or indices of neighborhood deprivation to define neighborhood exposure, and scholars have tended to simplify neighborhood structural processes into two dichotomous categories as either race/ethnicity or class, ignoring the possible intersection of racial/ethnic segregation and discriminatory economic processes in housing and lending markets that have occurred in both past and recent history.[24] Despite growing attention to processes of group-based structural marginalization[25] tied to past and present housing discrimination and segregation (which I describe further in Chapter 5), most studies do not conceptualize exposure measurement as tied to processes of combined economic and racial/ethnic inequality.

Finally, few health studies assess the impacts of early childhood poverty or employ intergenerational data to assess the enduring impact of social context. As growing research supports the importance of childhood as a critical time period in development,[26–29] there is a need

for more studies that capture the effects of neighborhood-level exposures experienced at this time.

Overall, these gaps point to a body of literature limited by cross-sectional health data and incomplete definition and measurement of complex neighborhood processes, ignoring temporal and structural forces that shape neighborhood environments and the processes that promote or hinder health within them. In addition, despite growing attention to the role of neighborhood contexts over the life course, there are few examples of county-level Maternal and Child Health (MCH) practice that address the structural contexts that underpin disparities in birth outcomes,[30–34] and much remains to be done to shift the paradigm of MCH practice.[35–37] Clearer understanding of structural and temporal dimensions of neighborhoods and how they shape health through generations may be vital for the development of public health programs and policies that will improve health and close health disparities.

1.2 Specific Aims

The overarching goal of this dissertation is to examine the role of structural neighborhood conditions of long-term disinvestment and economic and racial/ethnic inequality on preterm birth, and to advance a new generation of maternal and child health practice that both acknowledges the historical and structural forces at the root of inequities in birth outcomes and develops innovative practice to begin to address them.

Specific aims for this dissertation are as follows (Figure 1):

1) Examine associations between long-term structural neighborhood disadvantage and preterm birth among primiparous mothers.
    a. Hypotheses:
        i. Neighborhood poverty histories, a historical measure of neighborhood socio-economic status that approximates processes of long-term disinvestment in neighborhoods, will be associated with preterm birth.
        ii. The relationship between neighborhood poverty histories and preterm birth will be independent of mother's early childhood neighborhood poverty.
        iii. The relationship between neighborhood poverty histories and preterm birth will be independent of cross-sectional poverty, thereby representing additional risk over and above what is captured in a typical single-point poverty measures.
        iv. The effect of neighborhood poverty histories on preterm birth will be modified by race/ethnicity.

2) Examine associations between neighborhood privilege and disadvantage, measured during early childhood and adulthood, and preterm birth among primiparous mothers, using measures of income, racial/ethnic, and combined income and racial/ethnic neighborhood inequality.
    a. Hypotheses:

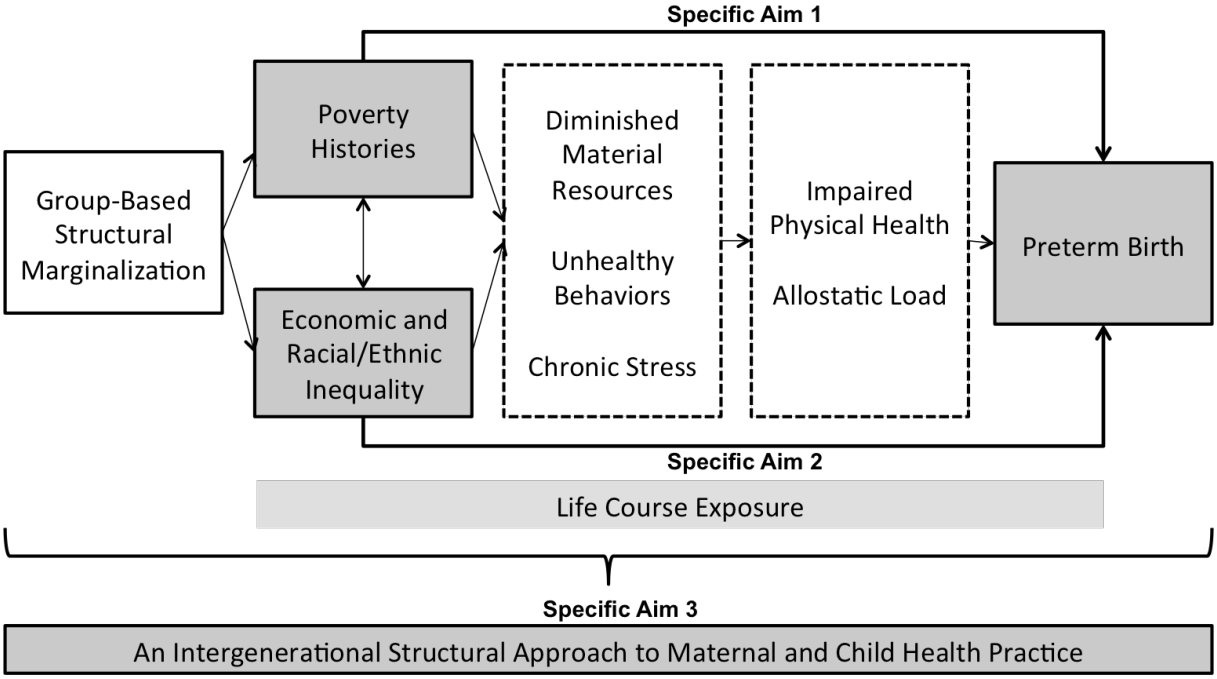
i. Living in a neighborhoods with less privilege will be associated with higher odds of preterm birth.
ii. Neighborhoods where mothers lived during childhood and adulthood will have unique and independent associations with preterm birth in the next generation.
iii. Accounting for structural neighborhood conditions of inequality during early childhood and adulthood will reduce racial/ethnic disparities in preterm birth.

3) Demonstrate an early-stage practice of maternal and child health that recognizes current day disparities as products of long-term structural disadvantage, and put forth a call to action to begin to transform maternal and child practice to attend to the changing the institutions, policies and practices that continue to perpetuate these disparities.
    a. Objectives:
        i. Describe a conceptual framework to contextualize racial/ethnic differences in birth outcomes as a product of inequitable policies and practices under a system of group-based structural marginalization.
        ii. Outline the process of incorporating aspects of this framework into local-level public health practice.
        iii. Offer lessons learned and areas of future development to enable the development of next-generation maternal and child health practice that addresses the structural factors at the root of racial/ethnic disparities in birth outcomes.

Aims 1 and 2 will be achieved through analyses of the Life Course Social Context Dataset, a cohort of intergenerationally linked mothers and infants developed by the California State Department of Public Health. Aim 3 will be achieved by describing a conceptual model and its application at the Alameda County Public Health Department.

1.3 Tables and Figures

Figure 1. Summary Graphic of Specific Aims



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Chapter 2

Does History Matter? Long-term Structural Poverty and Preterm Birth in an Intergenerational Cohort of Primiparous Mothers and Infants in California

2.1 Introduction

As interest grows in place-based efforts to improve birth outcomes and close racial/ethnic disparities,[1] clearer characterizations of neighborhood contexts and greater understanding of how they affect health during critical periods of development will help prioritize efforts. A robust body of literature establishing an association between neighborhood socioeconomic environments and birth outcomes supports the need for place-based efforts.[2–4] A relationship between a mother's early childhood neighborhood and poor birth outcomes in the next generation has also been identified, indicating that intervention early in the life course may be critical for improvements in health for the subsequent generation.[5,6] However, the bulk of this research characterizes neighborhoods using single point-in-time socioeconomic (SES) measures contemporaneous with the birth outcome. This cross-sectional characterization may overlook an additional dimension of neighborhood context: the accumulation of disadvantage as a result of long-term structural conditions of poverty and neighborhood disinvestment. An approach to intervention development that acknowledges the historical forces that have shaped current neighborhood conditions may be critical for developing public health programs and policies that will improve health and close health disparities.[7]

The distribution of conditions of persistent poverty in the United States is the result of well-documented historical patterns of racial residential segregation and neighborhood disinvestment across decades.[8–12] In short, highway funds, homeownership subsidies, and business tax incentives drew people to the suburbs in the 1950s and 60s, but discriminatory institutional practices such as redlining, racially restrictive covenants, and blockbusting excluded minorities and the poor from participating in this new American symbol of prosperity and the wealth-building opportunities it offered. The fair housing laws of the late 1960s exacerbated challenges of concentrated deprivation by making leaving the central city easier for middle-class minorities, increasing conditions of poverty for those left behind. At the same time, manufacturing and industrial jobs began to leave the central city for the suburbs, other regions, and eventually overseas, lured by tax incentives and the promise of lower-wage non-union workers. These circumstances of economic restructuring, industrial relocation, and racial/ethnic discrimination are the historical roots of the current conditions of concentrated poverty in urban areas of the US. Today, these conditions of concentrated neighborhood disadvantage in areas of poverty are posited to play a role in persistent socioeconomic and racial disparities in health.[8,13]

Disadvantaged neighborhood contexts present limited access to health-promoting resources over the life course, including quality childcare and schools, fresh and healthy food, parks,

transportation, and job opportunities; and disproportionate exposure to health-damaging ones, such as violence, crime, poor housing conditions, and environmental toxins.[14,15] Recent literature focused on social and physical neighborhood features has established connections between recreational resources and healthy foods and healthier behaviors, and between safety/violence, social cohesion, disorder and various health outcomes.[16] Chronic stress from prolonged exposure to health damaging features of disadvantaged neighborhoods may also play a role in the development of poor health. The body's response to "toxic" stress that is strong, frequent, and prolonged leads to a disregulation of the stress response, called allostatic load.[17] Allostatic load refers to the "wear and tear" that accumulates in the body's systems that in the long-term leads to biological as well as chromosomal damage[18] and increased likelihood of developing a range of diseases.[19]

Neighborhood disadvantage is associated with many different poor health outcomes over the life course, but preterm birth (birth before 37 weeks of completed gestation) is of particular importance. Nearly 1 in 10 babies in the U.S. are born early.[20] In 2010, the U.S. ranked last among 19 comparable countries in preterm birth.[21] Being born preterm puts infants at high risk of complications in their first days, such as respiratory distress syndrome, chronic lung disease, intestinal injury, compromised immune system, cardiovascular disorders, hearing and vision problems, or neurological issues.[8] Two-thirds (67%) of infants who die within the first year of life are born preterm,[22] and one detailed study of infant mortality cases found that one-third of them were directly by complications of being preterm.[23] Early complications often shift trajectories of subsequent development and may result in a range of health and educational problems over the life course. Children born preterm are at greater risk for neurodevelopmental issues, learning disabilities, behavioral problems, social-emotional difficulties, and lower academic achievement.[8] Preterm birth is an important measure of population health, and is a proxy for life chances and intergenerational health.

Causes of preterm birth and drivers of the racial/ethnic disparities in preterm birth continue to elude researchers. While a variety of factors have been identified as linked to preterm birth, these factors do not explain it,[8] and racial/ethnic disparities continue to persist in the US, with proportions of preterm highest for NH Black women (13.2%) and Hispanic women (9.0%) compared to NH White women (8.9%).[20] There is growing consensus that preterm birth should be viewed through a life course perspective. This framework suggests that factors over a woman's life course, especially early in life, may influence a her health status when she gets pregnant, and the health of her baby in the next generation.[24,25] This approach suggests the need for current research to broaden from assessing singular risk factors during pregnancy to examining a woman's lifetime of exposures, both social and biological, especially during critical life periods in her development.

From a life course perspective, the health-damaging effects of neighborhood disadvantage are particularly deleterious during the earliest phases of life. Early childhood has been identified as a particularly important developmental stage as early experiences and environments have lasting impacts on emerging brain architecture and lifelong health.[5,6,26,27] Because of the limited availability of intergenerational datasets, however, few studies have assessed the contribution of

neighborhood poverty to poor birth outcomes controlling for early childhood environments,[5,6] and to our knowledge none have assessed long-term measures of neighborhood SES.

As historical processes have shaped neighborhood concentrations of poverty starting decades ago,[28,29] long-term measures of neighborhood SES may better classify neighborhood exposures by capturing the accumulated disadvantages of persistent poverty or accumulated advantages of affluence over time. Historical characterization of neighborhood typologies may help identify disadvantaged neighborhoods that have experienced structural disinvestment over time and should be prioritized for intervention. Although some non-health studies have focused on creating typologies of neighborhoods to capture dynamic neighborhood conditions,[30,31,32] less attention has been on neighborhood typologies in birth outcomes research.

One study by Margerison-Zilko et. al. examined the role of historical neighborhood poverty from 1970-2010 and preterm birth in California.[33] They found that mothers living in neighborhoods experiencing long-term high poverty had higher odds of preterm birth compared to long-term low poverty, while the association between current neighborhood poverty and preterm birth was *not* statistically significant. To our knowledge no other studies have assessed the association between neighborhood poverty histories and preterm birth, but associations with self-rated health, sense of control, and depressive symptoms have been found.[34,35]

This study builds on existing research by examining associations between long-term structural neighborhood disadvantage and preterm birth, accounting for the mother's experience of early childhood neighborhood poverty. To understand how long-term structural conditions of neighborhood poverty influence birth outcomes, we assessed associations between neighborhood poverty histories and preterm birth in an intergenerational cohort of primiparous mothers and infants in California, and whether they varied by race/ethnicity. Next, we examined whether the association of neighborhood poverty histories and preterm birth was independent of mother's own early childhood neighborhood poverty. Finally, in order to understand whether the neighborhood poverty histories represented an additional risk over and above what was captured in a typical single-point poverty measures, we assessed whether the relationship between poverty histories and preterm birth was independent of a contemporaneous cross-sectional poverty measure. We hypothesized that historical measurement of neighborhood SES would approximate processes of long-term disinvestment in neighborhoods that underpin inequitable geographic distributions of opportunity, and as such, neighborhood poverty histories would be associated with preterm birth, that this relationship would be independent of early childhood neighborhood poverty and cross-sectional poverty, and that the effect would be modified by race/ethnicity.

2.2 Methods

Data Sources

Life Course Social Context Dataset

The Life Course Social Context Dataset is a recently created intergenerationally-linked cohort of vital records and prenatal screening data developed by the California State Department of Public Health.[6] By linking to an existing administrative database of voluntary prenatal and mandatory newborn screening data, researchers have been able to link and geocode two generations of births, despite the fact that addresses were not listed on birth records prior to 1997. The dataset is comprised of mothers born in California in 1982 or later delivering between 1996-2011 linked to their infant's birth record. This dataset provides information on maternal characteristics from birth records, as well as information about her neighborhood context using geocoded census tract data at mother's birth and at their baby's delivery, to approximate early life and adult neighborhood context. This dataset has successfully linked a very high percentage of moms to babies (93%), and to an address (96%) at time of baby's delivery. A high percentage of mothers (85%) and babies (95%) had geocoded street addresses. This study was approved by the UC Berkeley Committee for the Projection of Human Subjects through a reliance from the California Health and Human Services Agency Committee for the Protection of Human Subjects (Protocol #14-01-1466).

Neighborhood Change Database

Data on neighborhood poverty was obtained using census data from the Neighborhood Change Database (Geolytics, Inc.).[36] The Neighborhood Change Database contains information on socioeconomic status, racial/ethnic composition, family structure, and housing characteristics from 1970, 1980, 1990, 2000, 2010 U.S. decennial censuses and the 5-year American Community Survey for 2006-2010 using original boundaries and normalized to Census 2010 boundaries allowing for comparisons over time.[36]

Study Population

The study population for this analysis was pairs of mothers and infants in the Life Course Social Context Dataset who met inclusion and exclusion criteria for the study. The original dataset consisted of 691,030 linked mother-infant pairs of live births with high quality geocodes (point or street address matches). In order to reduce possible bias from over-representing mothers who had a high number of births, which itself may be associated with neighborhood contexts, we choose to include one infant per mother in our study sample. There is no consensus on the best approach for choosing one birth per mother. We chose to focus on primiparous women because they have been estimated to comprise the majority of preterm births in the overall population,[37] and inference to women's first births is intuitive and broadly applicable as all women are represented. As such, our inclusion criteria required infants to be singleton births to primiparous mothers. A total of 435,249 mother-infant pairs met this inclusion criteria. We then excluded infants born with congenital anomalies (n=2,265) and those with missing outcome, exposure or covariate data (n=48,829), leaving a final analytic sample of 383,806 mother-infant pairs.

Study Variables

Study Outcome

The health outcome of interest was preterm delivery (gestational age <37 weeks=1, gestational age ≥37 weeks=0). Gestational age was obtained using the following hierarchy of sources: high-quality clinical estimates from prenatal screening records, obstetric estimates from the birth record, or last menstrual period from birth records.

Neighborhood Measures

Neighborhood poverty histories experienced during the mother's adulthood was the main exposure of interest, and was obtained using the address on the baby's birth record.

Neighborhoods were defined as census tracts, which are small relatively permanent statistical subdivisions of counties with optimal population sizes of 4000 people (range: 1200 to 8000).[38] Although they do not always correspond to how residents define their neighborhoods, tracts are geographically contiguous and attempt to follow visible, identifiable features. Each census tract of residence at time of baby's birth was treated as a separate neighborhood. The mean number of births per neighborhood was 91.9, with a range from 1-372. The mean number of preterm births per neighborhood was 8.3, with a range of 0-41. The data consisted of 7248 clusters (census tracts) across California.

We created a categorical variable for neighborhood poverty histories by adapting methodology used by Margerison-Zilko et al.[33] We first employed thresholds used by Margerison-Zilko et al. for cross-sectional neighborhood poverty: tracts with less than 5% poverty were low poverty, those with 5-20% poverty were moderate poverty, and those with more than 20% poverty were high poverty. We developed a categorical variable describing five trajectories of poverty over the time periods 1970-2000 (for births between 1997-2005) or 1970-2010 (using 06-10 ACS estimates, for births 2006-2011). *Persistent low, persistent moderate,* and *persistent high* each describe neighborhoods with consistent levels of poverty over time using the thresholds for low, moderate and high described above. Categories that describe changes to the neighborhood conditions were *increasing* (tracts that were low poverty in 1970 increased to moderate or high; or tracts that were moderate in 1970 increased to high), and *decreasing* (tracts that were high poverty in 1970 decreased to moderate or low; or tracts that were moderate in 1970 decreased to low). Neighborhoods with no discernible pattern of low and moderate were classified as persistent low, and neighborhoods with no discernible pattern of moderate and high poverty were classified as persistent moderate. Our measure differed from the one employed by Margerison-Zilko, et. al. in two ways: 1). For ease of interpretation we adapted the seven-category measure to a five-category measure by collapsing the two categories each for increasing and decreasing poverty into one for each category, and 2) To more clearly delineate tracts experiencing long-term structural poverty, we categorized tracts that no discernible pattern of moderate and high as persistent moderate rather than persistent high. Dummy variables were created for each category, and persistent low poverty was the reference category. Tracts with zero population at any of the time points, missing the most recent poverty estimate, and tracts that did not fall into any of the trajectories were excluded from the poverty histories measure (n=809).

Covariates

Confounders identified by previous literature were included as individual level controls.[34] Maternal age (continuous, divided by 5 to represent 5 year increments), race/ethnicity (Non-Hispanic (NH) White, NH Black, NH Asian, Hispanic and Other/Unknown; with White as the reference category), educational attainment (defined as appropriate or low so a consistent classification could be applied to both younger and older mothers;[39] defined as low if older than 13 years with less than middle school completion or older than 18 years with less than high school completion, and appropriate otherwise; with appropriate as the reference category), public insurance status (Medicaid) to approximate whether individuals were low-income, which for the majority of enrollees required incomes below 107-138% of the federal poverty level from 2002-2011 for a family of three, (yes/no, with no as the reference category), were included from the infant's birth record. In addition, mother's own poor birth outcome (either preterm or low birth weight; yes/no with no as the reference category) was included from the mother's birth record.

Two additional covariates were included in subsequent models. Poverty in the mother's early childhood neighborhood was controlled to account for an additional time period in the mother's residential history. Using neighborhood poverty from the mother's birth record approximates early childhood risk, which may pose a risk to later life health. Cross-sectional adulthood poverty was also assessed as a control to determine if poverty histories contributed a unique risk over and above that of poverty measured contemporaneously to the time of the infant's birth. For both these variables, <5% poverty in the tract was considered low poverty, 5-20% was moderate poverty, and more than 20% was high poverty.

Statistical Analysis

Frequencies, means, variances, and ranges were calculated for each variable in the analysis. We conducted bivariate analyses using chi-squared tests to describe and compare patterns of preterm birth by each covariate and by the main exposure of interest.

Next, to assess the relationship between preterm birth and neighborhood poverty histories, we estimated population average models using generalized estimating equations (GEE) to account for nested data of individuals within neighborhoods in a series of sequential models. Logit link functions with binomial distribution, exchangeable working correlation structures and robust variance estimates were specified. We estimated the odds of preterm birth for each category of neighborhood poverty compared to the persistent low poverty category, controlling for covariates described above. The model equation is as follows:

$$\log(P(Y_{ij})/(1-P(Y_{ij})) = \beta_0 + \beta_1 A_{ij} + \beta \mathbf{X_{ij}},$$

where i indicates individual, j indicates neighborhood, Y_{ij} is preterm birth (as defined above), A_{ij} is neighborhood poverty histories and $\mathbf{X_{ij}}$ represents the vector of maternal level covariates controlled for in the model (described above).

We first examined the relationship between neighborhood poverty histories, experienced during adulthood, and preterm birth alone, controlling for maternal age, race, education, insurance status, and poor birth outcome (model 1). Next, we further adjusted for mother's early childhood neighborhood poverty (model 2). Finally, we adjusted for adulthood neighborhood cross-sectional poverty to determine whether the history of poverty contributed additional risk of preterm over and above the risk posed by the cross-sectional measure (model 3). In addition, we tested for statistical interaction between poverty histories and preterm birth by race/ethnicity to assess the presence of effect modification.

All analyses were performed using Stata version 12.1.

2.3 Results

Preterm births comprised 8.8% of the study population (Table 1). All of the women in this study were under the age of 30. The majority of the participants were Hispanic (57.8%), NH White (24.7%) and NH Black (11.0%). One-tenth of participants (10.7%) had low-for-age education based on their age, and the majority of participants (62.2%) received public health insurance.

Bivariate analyses indicated differences in the distributions of all covariates and the outcome (Table 1). The proportion of preterm birth was higher among mothers under 18 years old (11.1%) compared to 18-22 (8.3%) or 23-29 (7.5%); and among NH Asian (11.2%) and NH Black (10.6%) mothers compared to NH White (7.4%), Hispanic (8.8%) or other/unknown (8.9%). Those who themselves had a poor birth outcome (10.9%) compared to those who did not (8.5); or currently lived in tracts with persistent high poverty (10.2%) compared to persistent low poverty (7.8%) also had higher proportion of preterm.

Bivariate analyses also indicated differences in the distributions of all covariates and the exposure (Table 2). A lower proportion of mothers under 18 years old lived in persistent low poverty neighborhoods (6.1%) compared to the oldest mothers in the study aged 23-29 (16.4%). The reverse pattern was observed in persistent high poverty neighborhoods with 16.4% mothers under 18 years old living in these areas compared to 5.3% of mothers aged 23-29. Only 2.3% of NH White women lived in persistent poverty, compared to 20.3% of NH Black women, 13.0% of Hispanic women, and 10.7% of NH Asian women. A smaller proportion of NH Black women and Hispanic women also lived in areas with persistent low poverty (6.4% and 7.2% respectively), compared to NH White (17.9%) or NH Asian women (14.3%). Only 6.4% of those with low-for-age education lived in areas of persistent low poverty compared to 10.4% of those with appropriate-for-age education. Among women who lived in low poverty neighborhoods in early childhood, 24.9% lived in persistent low poverty neighborhoods as adults, and only 2.2% lived in persistent high poverty neighborhoods as adults. Conversely, among women who lived in high poverty neighborhoods in early childhood, 20.9% lived in persistent high poverty neighborhoods as adults, and only 5.0% lived in persistent low poverty neighborhoods as adults.

Table 3 shows adjusted odds ratios for preterm birth after adjusting for maternal age, race, education, insurance status, and mother's own poor birth outcome for each research question.

Compared to the reference group of persistent low poverty, exposure to neighborhoods with persistent moderate poverty (OR=1.05, 95%CI: 1.01-1.10), increasing poverty (OR=1.08, 95%CI: 1.03-1.13), and persistent high poverty (OR=1.16, 95%CI: 1.10-1.22) was associated with preterm birth, while decreasing neighborhood poverty was not (model 1). After additional adjustment for mother's early childhood neighborhood poverty (model 2) the estimates for poverty histories were very slightly attenuated, and the estimate for early childhood high neighborhood poverty was associated with preterm birth (OR=1.05, 95%CI: 1.00-1.11). Finally, after additional adjustment for adulthood cross-sectional poverty (model 3), persistent high neighborhood poverty retained an independent association with preterm birth (OR=1.08, 95%CI: 1.01-1.15). There was no evidence of statistical interaction between poverty histories and preterm birth by race/ethnicity (p=0.25).

2.4 Discussion

Our interest in studying long-term neighborhood structural disadvantage was to account for the historical roots of economic, demographic, and policy changes that resulted in the geographic distribution of neighborhood opportunity in the U.S. today. In this intergenerational study of more than 300,000 primiparous mothers and their infants from the Life Course Social Context dataset in California, we examined the associations of neighborhood poverty histories with preterm birth, measured using census estimates starting in 1970. In our dataset, 8.8% of infants were born preterm, and the proportion of preterm births was highest in neighborhoods in persistent poverty (10.2%). We found that individuals who lived in persistent high poverty neighborhoods had 16% higher adjusted odds of preterm birth than mothers who lived in neighborhoods with persistent low poverty. We also found that mothers living in neighborhoods where poverty was increasing over time had an 8% higher odds of preterm birth, and in neighborhoods with moderate poverty had a 5% higher odds of preterm birth than those in persistent low poverty neighborhoods; these findings were statistically significant. There was no association between decreasing neighborhood poverty and preterm birth, compared to persistent low poverty. Together these findings suggest that long-term structural neighborhood disadvantage may be an important contributor to preterm delivery.

To our knowledge, this is the first study showing that long-term neighborhood economic trends may be a more complete characterization of the relationship of neighborhood poverty to preterm birth that also accounts for mother's early childhood neighborhood poverty. Our results are consistent with the one previous study assessing the relationship of long-term measures of neighborhood economic conditions with preterm birth. Using a 7-category measure that we adapted for the present study in a sample of births in California, Margerison-Zilko et. al., found in adjusted models that compared to persistent low poverty, there was a higher odds of preterm birth for those in areas of persistent high poverty (OR=1.41, 95%CI: 1.18-1.69 for long-term high poverty), persistent moderate poverty (OR=1.22, 95%CI: 1.04-1.44), and increasing poverty that started increasing prior to 1990 (OR=1.37, 95%CI: 1.09-1.72).[18] We are aware of no other studies that have examined neighborhood poverty histories in relation to preterm birth. However, our findings were consistent with two other studies examining long-term measures of

neighborhood economic conditions in relation to adult self-rated health, sense of control, and depressive symptoms.[34,35]

We extend the work of Margerison-Zilko, et. al. by accounting for the experience of neighborhood poverty during another critical time point in the mother's residential history, during her early childhoood. Inclusion of this time point allowed us to consider the role of poverty histories independent of the early childhood contribution of neighborhood disadvantage to preterm birth. In this study, adjustment for early childhood poverty did not affect the results in either significance or magnitude. Although the focus of this study was not on the interpretation of the mother's experience of neighborhood poverty during early childhood in relation to preterm birth, there was a significant association, which is consistent with previous studies of intergenerational birth records. In their study of intergenerational birth records, Collins, et. al. found higher odds (OR=1.3, 95%CI: 1.1, 1.4) of low birthweight associated with mother's early childhood residential environment (which they refer to as grandmother's residential environment during pregnancy) in the lowest quartile of median income compared to highest, controlling for maternal age, education, and prenatal care.[5] In a random subset of births from the Life Course Social Context dataset, Pearl et al. found early childhood neighborhood poverty associated with a marginal risk difference for preterm birth of 0.6, 0.7, and 0.3 per 100 for NH White, NH Black and Hispanic mothers, respectively. The findings of the present study support life course hypotheses and previous results that early childhood exposure to neighborhood conditions have a "durable" effect into adulthood and the next generation.[5,40]

In our final model, we assessed whether findings were independent of cross-sectional measurement of neighborhood poverty. In this model, the relationship between persistent high neighborhood poverty and preterm birth remained when controlling for both mother's early childhood neighborhood poverty, and cross-sectional adulthood poverty. There was a reduction in the magnitude of the estimate, which was to be expected because neighborhoods classified as persistent high poverty had high cross-sectional poverty at every time point measured, by definition, so that would attenuate some of the findings. It is important to note though that the results still remained significant and though the effect sizes are modest, it is notable that both historical and cross-sectional measures of neighborhood poverty were significantly related to preterm birth, and that the historical measure of neighborhood poverty was capturing additional risks over and above what is captured using the cross-sectional measure. In this model, the effect size for high cross-sectional poverty was 1.10, and the odds ratio for persistent high poverty was 1.08. This finding suggests that characterizing neighborhood poverty using both a contemporaneous and historical measure may be important, as there was still a statistically significant unique risk from the historical measure. It may then be the case that many studies that do not capture historical measures of neighborhood context may be missing out on this additional source of information that contributes to neighborhood risk.

Persistent moderate poverty and increasing poverty were no longer significantly associated with preterm birth in our final model. This may be a result of the classification of the variables, such that the effect for these two categories was captured in the moderate and high cross-sectional measures. Future studies on neighborhoods experiencing increasing poverty may be warranted,

however, as increasing poverty was significantly associated with preterm birth in the models unadjusted for cross-sectional neighborhood poverty. The psychosocial burden of relative neighborhood decline may be harmful to health, regardless of baseline values.[41] This may be a particularly salient area of research as there has been an increase in the proportion of neighborhoods in high poverty in California: data from the Neighborhood Change Database indicate that 11% of tracts were in high poverty in 1970, compared to 24% in both the 2000 decennial census and 2006-2010 ACS estimates.[36]

We found no evidence of effect modification in the relationship of neighborhood poverty histories and preterm birth by race/ethnicity. This may be due to a study sample of women who were relatively young, given that the Black-White disparity in poor birth outcomes has been shown to be more pronounced for older mothers.[42–47] In studies assessing neighborhood poverty and preterm birth, effect modification by race may also be capturing some effects of racial residential segregation, which may exacerbate the harms of long-standing concentrated poverty.[2] As such, effect modification by race may not have been present this study because while racial residential segregation exists in California, it is less pronounced and has been declining compared to other regions of the country.[48]

A strength of this analysis is the unique opportunity presented by the Life Course Social Context Dataset to explore intergenerational impacts of place-based preterm birth exposures with a very large and racial/ethnically diverse sample of women. The linked birth records in this study allowed us to control for an early life exposure to neighborhood poverty, and also for the mother's own poor birth outcome, a known confounder[49,50] that is often difficult to account for in studies of preterm birth. This study sample was limited to good quality geocodes, which reduces measurement error. Our analysis accounted for tract level clustering using GEE models, although single-level logistical regression models yielded similar results.

This study also has a number of limitations. Because of records available for intergenerational linkage, this sample only includes mothers who themselves were born in California, and is relatively young. All mothers included in this study delivered before age 30, an age range which in 2010 represented only 56.5% of all births in California.[51] Compared to the population of California on the whole, this study sample likely represented a population with a higher risk profile. For example, 62.2% of the study population were enrolled in public health insurance, compared to 50.7% of all hospital births in California in 2010.[52] This sample also contained a somewhat different distribution of race/ethnicity than the general population of infants born in California, with about twice as many NH Black infants (11.0% in this sample vs. 5.4% in CA in 2010), and less than a third of NH Asian infants (3.1% in this sample vs. 11.9% in CA in 2010).[51] Limiting the sample to women's first births reduced the sample size of the study and removed older mothers from the sample, which may have further increased the risk profile of the sample overall. Inference to all births or higher parity births may be different because of the younger age distribution of this population, and because the proportion of preterm birth tends to be higher in primiparous women.[37]

As in most studies of preterm birth, misclassification of gestational age may have occurred in this study,[53] however, over half of the estimates of gestational age in this dataset were derived from obstetric estimates during prenatal screening,[6] which has been shown to be of higher quality than estimates from birth records.[54,55] In addition, our estimates may contain a residual effect of unmeasured individual SES, although some of this effect may in fact be mediated through neighborhood effects. We may have been limited in power in this study to assess effect modification by race/ethnicity given our study population, and our study did not account for heterogeneity within racial/ethnic groups, but this large administrative dataset did capture the vast majority of intergenerational births in California during the study period. Like previous studies, this analysis was limited by lack of detailed information on maternal residential histories. However, the linked data across mothers and infants allowed us to approximate early childhood exposure to neighborhood poverty using address at the time of the mother's birth. But because this study only used address data at two time periods, we were unable to assess cumulative exposure to neighborhood environment.

Possible mechanisms for this relationship should be explored in future studies. It is likely that services and amenities in neighborhoods of longstanding poverty are different than areas facing more recent circumstances of poverty. Specific mechanisms that may mediate the relationship between persistent poverty and poor health should be assessed, such as quality of schools, housing stock, and availability of food. In addition, more attention to structural forces that have shaped distributions of concentrations of poverty across the population such as transportation systems and banking practices will allow for the design of more impactful policy and practice targets for interventions that aim to improve health in neighborhoods.

Our findings that there is a residual effect of poverty histories in neighborhoods of persistent high poverty even after controlling for cross-sectional poverty suggest that communities subject to long-term conditions of structural poverty may be facing additional risks from those who have entered poverty in more recent times. These findings suggest that more work is needed to characterize neighborhood risk in the study of health and place. Additional research to characterize the unique risk profiles of neighborhood facing persistent long-term poverty is warranted for guidance on the prioritization and design of place-based interventions targeting reductions in poor birth outcomes.

2.5 Tables and Figures

Table 1. Characteristics of the Study Sample and Proportion of Preterm Birth, Life Course Social Context Dataset, CA.

Maternal Characteristic	All Participants n	%	Preterm % (<37 weeks)	p-value
All	383,806	100	8.8	
Age				<0.001
<18 years	86,540	22.6	11.1	
18-22	223,707	58.3	8.3	
23-29	73,559	19.2	7.5	
Race/Ethnicity				<0.001
NH White	87,583	24.7	7.4	
NH Black	44,375	11.0	10.6	
NH Asian	12,142	3.1	11.2	
Hispanic	226,918	57.8	8.8	
Other/Unknown	12,788	3.4	8.9	
Education				<0.001
Low for Age	41,198	10.7	9.4	
Appropriate for Age	342,608	89.3	8.7	
Insurance Status				<0.001
Public	238,551	62.2	9.0	
Private	145,255	37.9	8.3	
Mother's Own Poor Birth Outcome				<0.001
Yes	47,532	12.4	10.9	
No	336,274	87.6	8.5	
Adult Neighborhood Poverty Histories				<0.001
Persistent Low	38,402	10.0	7.8	
Persistent Moderate	138,890	36.2	8.6	
Decreasing	42,283	11.2	7.8	
Increasing	121,577	31.7	9.0	
Persistent High	42,654	11.1	10.2	
Early Childhood Neighborhood Poverty				<0.001
Low	29,509	9.7	7.6	
Moderate	205,145	52.4	8.5	
High	149,152	37.9	9.4	
Adult Neighborhood Cross-Sectional Poverty				<0.001
Low	37,390	9.7	7.5	
Moderate	201,162	52.4	8.4	
High	145,254	37.8	9.6	

Table 2. Distribution of Study Sample by Exposure to Neighborhood Poverty Histories

Maternal Characteristic	All	Maternal Adult Neighborhood Poverty Histories: Persistent Low	%	Persistent Moderate	%	Decreasing	%	Increasing	%	Persistent High	%	p-value
All	n	38,402	10.0	138,890	36.2	42,283	11.1	121,577	32.7	42,654	11.1	
Age												p<0.001
<18 years	86,540	5,274	6.1	30,661	35.4	6,767	7.8	29,687	34.3	14,151	16.4	
18-22	223,707	21,052	9.4	82,301	36.8	23,898	10.7	71,826	32.1	24,630	11.0	
23-29	73,559	12,076	16.4	25,928	35.3	11,618	15.8	20,064	27.3	3,873	5.3	
Race/Ethnicity												p<0.001
NH White	87,583	15,710	17.9	32,780	37.4	14,982	17.1	22,141	25.3	1,970	2.3	
NH Black	44,375	2,830	6.4	12,955	29.2	3,997	9.0	15,576	35.1	9,017	20.3	
NH Asian	12,142	1,737	14.3	3,589	29.6	1,437	11.8	4,079	33.6	1,300	10.7	
Hispanic	226,918	16,373	7.2	85,037	37.5	20,079	8.9	75,937	33.5	29,492	13.0	
Other/Unknown	12,788	1,752	13.7	4,529	35.4	1,788	14.0	3,844	30.1	875	6.8	
Education												
Low for Age	41,198	2,624	6.4	14,517	35.2	3,417	8.3	14,387	34.9	6,253	15.2	p<0.001
Appropriate for Age	342,608	35,778	10.4	124,373	36.3	38,866	11.3	107,190	31.3	36,401	10.6	
Public Insurance												p<0.001
Yes	238,551	16,802	7.0	85,381	35.8	21,457	9.0	80,943	33.9	33,968	14.2	
No	145,255	21,600	14.9	53,509	36.8	20,826	14.3	40,634	28.0	8,686	6.0	
Mother's Own Poor Birth Outcome												p<0.001
Yes	47,532	3,949	8.3	16,685	35.1	4,672	9.8	15,649	32.9	6,577	13.8	
No	336,274	34,453	10.3	122,205	36.3	37,611	11.2	105,928	31.5	36,077	10.7	
Early Childhood Neighborhood Poverty												p<0.001
Low	29,509	7,345	24.9	8,969	30.4	5,285	17.9	7,253	24.6	657	2.2	
Moderate	205,145	23,545	11.5	83,108	40.5	25,391	12.4	62,325	30.4	10,776	5.3	
High	149,152	7,512	5.0	46,813	31.4	11,607	7.8	51,999	34.9	31,221	20.9	
Adulthood Cross-Sectional Neighborhood Poverty												N/A
Low	37,390	12,730	34.1	0	0	24,660	66.0	0	0	0	0	
Moderate	201,162	25,672	12.8	127,754	63.5	17,623	8.8	30,113	15.0	0	0	
High	145,254	0	0	11,136	7.7	0	0	91,464	63.0	42,654	29.4	

Table 3. Neighborhood Poverty Histories and Preterm Birth with and without Consideration of Early Childhood and Adulthood Cross-Sectional Neighborhood Poverty (N=383,806).

	Model 1* Poverty Histories Only		Model 2* Poverty Histories and Early Childhood Poverty		Model 3* Poverty Histories, Early Childhood Poverty, and Cross-Sectional Poverty	
	OR	95% CI	OR	95% CI	OR	95% CI
Adulthood Neighborhood Poverty Histories						
Persistent Low	1.00		1.00		1.00	
Persistent Moderate	1.05	1.01-1.10	1.04	1.00-1.09	1.03	0.98-1.08
Decreasing	0.99	0.94-1.04	0.98	0.93-1.04	1.00	0.94-1.05
Increasing	1.08	1.03-1.13	1.07	1.03-1.12	1.02	0.97-1.08
Persistent High	1.16	1.10-1.22	1.15	1.09-1.21	1.08	1.01-1.15
Early Childhood Cross-Sectional Neighborhood Poverty						
Low			1.00		1.00	
Moderate			1.04	1.00-1.10	1.04	0.99-1.09
High			1.05	1.00-1.11	1.04	0.99-1.10
Adulthood Cross-Sectional Neighborhood Poverty						
Low					1.00	
Moderate					1.05	0.99-1.10
High					1.10	1.03-1.18

*all models adjusted for maternal age, race, education, insurance status, and poor birth outcome

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Chapter 3

Racial/Ethnic Disparities in Preterm Birth in an Intergenerational Cohort of Primiparous Mothers and Infants in California: The Role of Local-Level Income and Racial/Ethnic Inequality

3.1 Introduction

Alarming racial/ethnic disparities in preterm birth exist in the United States and have been consistent over time.[1] Although the Healthy People 2020 goal for preterm birth (11.4%) has been met,[2] racial/ethnic disparities persist, with 13.2% of non-Hispanic (NH) Black and 9.0% of Hispanic infants born preterm in 2014, compared to 8.9% of NH White infants.[2] This disparity has significant consequences for infant mortality among these groups, given that preterm birth is the greatest known predictor of infant mortality.[3,4]

Being born preterm puts babies at high risk of complications in their first days, such as respiratory distress syndrome, chronic lung disease, intestinal injury, compromised immune system, cardiovascular disorders, hearing and vision problems, or neurological issues.[5] These complications often shift trajectories of subsequent development and may result in a higher risk of a range of health and educational problems over the life course. Children born preterm are at greater risk for neurodevelopmental issues, learning disabilities, behavioral problems, social-emotional difficulties, and lower academic achievement.[5] There is also a growing body of research in support of the fetal origins hypothesis – that exposures in utero, such as prenatal undernutrition and maternal stress during pregnancy, can modify developmental biology in offspring in a fashion that elevates risk of developing diseases decades later as adults, like diabetes, hypertension, and cardiovascular disease.[5–7] Supporting this theory, there is evidence that preterm birth is associated with lower educational attainment and chronic disease in adulthood.[5,6,8] Therefore, disparities in preterm birth have immediate and later life consequences.

Individual and behavioral risk factors do not explain the racial/ethnic disparities in preterm birth, and interventions that aim to decrease it have not been successful.[9] For example, efforts during pregnancy to promote healthy behaviors, access to prenatal care, and stress management have reduced but not eliminated the disparity.[9,10] As a result of the intractable racial disparity in birth outcomes, there is growing consensus that factors over the life course, especially early in life, may influence a woman's health status when she gets pregnant, and the health of her baby in the next generation.[9,10] Early childhood has been identified as a particularly critical stage in health development over the life course, as early experiences and environments have been shown to have lasting impacts on neurodevelopment and lifelong health.[11]

Through this life course perspective, neighborhood context may be a particularly important driver of preterm birth. While some neighborhoods are characterized by an abundance of affluent and privileged residents, and are rich with the resources, connections and opportunities that enable health and well-being, many other communities have been systematically disinvested, and often consist of low-income and minority populations that lack the political power to demand healthy conditions or to improve circumstances in the places where they live.[12] It has been found that the inequitable distribution of neighborhood opportunity passes through generations in multiple ways,[13] including in the form of poor birth outcomes,[14,15] and may contribute to racial/ethnic health disparities.[15] Indeed, in the U.S., clear patterns of racial residential segregation have resulted in unequal exposures to adverse social conditions and opportunity structures along racial/ethnic lines.[5] For example, concentrated poverty and disadvantage are more common in predominantly Black neighborhoods than predominantly White neighborhoods.[5]

An established body of research links neighborhood conditions and poor birth outcomes,[16–18] including in intergenerational datasets assessing early childhood associations with preterm in the subsequent generations,[14,15] and studies have also found that neighborhood conditions contribute to racial/ethnic disparities in preterm birth.[15,19,20] An additional body of literature has linked structural racism to poor birth outcomes, through measures of racial residential segregation,[21–25] typically assessing racial/ethnic isolation and concentration on metropolitan or regional scales.[26] While these studies have examined a select set of structural indicators, overall there is limited research on measures that capture structural racism and their contributions to racial/ethnic disparities in birth outcomes.

A novel measure known as the Index of Concentration at the Extremes (ICE), developed by sociologist Douglas Massey,[27] was conceptualized to assess neighborhood distributions of economic privilege and disadvantage. This measure has recently been applied to the study of racial/ethnic privilege as well as a combination of economic and racial/ethnic privilege.[28] To our knowledge only one study by Huynh, et. al. applies these measures to preterm birth,[29] and found significant and increasing associations between increasing quintiles of three ICE measures (for income, race/ethnicity and combined income+race/ethnicity) and preterm birth, compared to the highest quintile, suggesting the strength of using this measure to characterize neighborhood conditions of structural inequality. Given the historical roots of neighborhood disadvantage in the United States, predicated on entangled structural marginalization by race and class, this measure may be of particular importance in explaining the simultaneous contribution of structural racism and economic disadvantage that manifests at the neighborhood level.

To our knowledge no studies have assessed ICE measures during multiple life course critical periods to quantify how structural inequalities may influence infant health and birth disparities in the subsequent generation. The aim of the present study was to assess whether early childhood and adulthood neighborhood privilege and disadvantage was associated with preterm birth among primiparous women and whether it explained racial/ethnic disparities in preterm birth, using three ICE measures and a poverty measure. Building on existing research, and applying a life course perspective, we hypothesized that living in a neighborhood with less privilege would

be associated with higher odds of preterm birth, and that the neighborhoods where mothers lived during childhood and adulthood would have unique and independent associations with preterm birth in the next generation. We hypothesized that accounting for these structural neighborhood conditions during early childhood and adulthood would reduce racial/ethnic disparities in preterm birth.

3.2 Methods

Data Sources

Life Course Social Context Dataset

The Life Course Social Context Dataset is a cohort of intergenerationally linked mothers and infants developed by the California State Department of Public Health.[15] For this dataset, researchers linked and geocoded two generations of births, even though addresses were not listed on birth records prior to 1997 by linking birth records to an existing administrative database of voluntary prenatal and mandatory newborn screening data. The dataset is comprised of mothers born in California in 1982 or later and delivering between 1996-2011. This dataset provides information on maternal and infant characteristics from birth records, as well as geocoded census tracts from the mother's birth and the infant's delivery, to allow for linkage of additional tract-level information to approximate early life and adult neighborhood contexts. This dataset has linked a very high percentage of moms to infants (93%), and to address at time of infant's delivery (96%). The majority of mothers (85%) and infants (95%) had geocoded street addresses. This study was approved by the UC Berkeley Committee for the Projection of Human Subjects through a reliance from the California Health and Human Services Agency Committee for the Protection of Human Subjects (Protocol #14-01-1466).

U.S. Decennial Census and American Community Survey

Data on neighborhood poverty and for the creation of ICE measures were obtained using decennial census data for 1980, 1990, 2000 and American Community Survey (ACS) 5-year annualized estimates from 2007-2011 (to best correspond to the bulk of the births in the study sample), downloaded from Social Explorer.[30] The decennial census includes sampled and full count data from households across the US that contains information on socioeconomic status, racial/ethnic composition, family structure and housing characteristics. The ACS is a yearly national survey of approximately 2.5 million randomly selected households with similar population measures.

Study Population

Linked pairs of mothers and infants in the Life Course Social Context Dataset who met inclusion and exclusion criteria comprised the study population for this analysis. The original dataset consisted of 691,030 linked mother-infant pairs of live births with high quality geocodes (point or street address matches). To avoid bias from over-representation of high parity mothers, which

itself may be associated with neighborhood factors, we choose to include one infant per mother in our study sample. There is no consensus on an approach for choosing one birth per mother. We focused on primiparous women because it has been estimated that they comprise the majority of preterm births in the overall population,[31] and inference to women's first births is intuitive as all women are represented. A total of 401,807 mother-infant pairs met our inclusion criteria which required infants to be singleton births to NH White, NH Black, or Hispanic primiparous mothers. We then further excluded infants born with congenital anomalies (n=2,265) and those with missing data on the outcome, exposure or covariates (n=19,748). The final analytic sample was comprised of 379,794 mother-infant pairs.

Study Variables

Study Outcome

Preterm delivery (gestational age <37 weeks=1, gestational age ≥37 weeks=0) was the main outcome of interest for this study. Gestational age was obtained using a hierarchy of sources: high-quality clinical estimates from prenatal screening records, obstetric estimates from the birth record, or last menstrual period from birth records.

Neighborhood Measures

Three ICE measures capturing privilege and disadvantage by income, race/ethnicity, and combined income and race/ethnicity; and neighborhood poverty were the four exposures of interest, assessed as quintiles, with the most privileged or lowest poverty quintile (the fifth quintile) as the reference category. These exposures were assessed during the mother's early childhood, approximated using the address on the mother's birth record, and during the mother's adulthood, using the address on the baby's birth record.

Census tracts were used to approximate neighborhood boundaries. Census tracts are small and fairly permanent statistical subdivisions of counties with ideal population sizes of about 4000 people (range: 1200 to 8000).[32] Tracts are geographically contiguous and attempt to follow visible, identifiable features. Each census tract in this study was treated as a separate neighborhood. The mean number of births per neighborhood was 85.4, with a range from 1-345. The mean number of preterm births per neighborhood was 7.6, with a range of 0-40. The data consists of 7835 census tracts across California.

ICE measures were assigned to the early childhood and adult neighborhoods for each mother using census and ACS measures closest to the years on the mother's and infant's birth record. As described in detail in Appendix A, ICE measures created for each census tract following the work of Krieger, et. al.,[28,29,33] as originally proposed by Massey,[27] using the formula:

$$ICE_i = (A_i - P_i) / T_i ,$$

where A_i equals the number of persons classified as affluent in neighborhood i (defined as >80th percentile for income, based on national estimates from the census and ACS[34]), P_i is the number of people classified as poor in neighborhood i (defined as <20th percentile for income, based on national estimates from the census and ACS[34]), and T_i is the total population of neighborhood. Krieger, et. al. extended Massey's measure to create two additional ICE measures:[28,29,33] ICE-race/ethnicity, focused on racial/ethnic privilege where neighborhood concentration of NH White and NH Black were considered the extremes of privilege and disadvantage (because they represent "extreme categories of racial privilege and disprivilege in the United States and for whom racial residential segregation has been most extreme,"[33]) and ICE-income+race/ethnicity, focused on the joint contribution of economic and racial/ethnic privilege.

Within each neighborhood, the index has a range of -1 to +1. For ICE-income, -1 indicates that all persons in the neighborhood are poor, and +1 indicates that all are affluent, and 0 indicates that the affluent and the poor are equally balanced. For ICE-race/ethnicity, -1 indicates that all persons in the neighborhood are NH Black, and +1 indicates that all are NH White. For ICE-income + race/ethnicity, -1 indicates that all persons in the neighborhood are poor and NH Black, and +1 indicates that all are affluent and NH White.

Covariates

The following covariates identified a priori as confounders were included as individual level controls[5]: maternal age (continuous divided by 5 to represent 5 year increments), race/ethnicity (NH White, NH Black, Hispanic; with White as the reference category), educational attainment (defined as appropriate or low so a consistent classification could be applied to both younger and older mothers;[35] defined as low if older than 13 years with less than middle school completion or older than 18 years with less than high school completion, and appropriate otherwise; with appropriate as the reference category), public insurance status (Medicaid) to approximate whether individuals were low-income, which for the majority of enrollees required incomes below 107-138% of the federal poverty level from 2002-2011 for a family of three,[36] (yes/no, with no as the reference category), and mother's own poor birth outcome (either preterm or low birth weight with yes/no with no as the reference category).

Statistical Analysis

We calculated frequencies, means, variances, and ranges for each variable in the analysis. We conducted bivariate analyses using chi-squared tests to describe and compare patterns of preterm birth by each covariate, racial/ethnic categories by each covariate, and quintiles of ICE and poverty measures by each covariate. We then examined trends across the proportion of preterm births by quintiles of ICE and poverty, using Stata's nptrend procedure, which conducts a nonparametric test for trend across ordered groups developed by Cuzick (1985), an extension of the Wilcoxon rank-sum test.[37]

Next, to assess the relationship between preterm birth and neighborhood ICE and poverty measures, we estimated population average models using generalized estimating equations

(GEE)[38] to account for nested data of individuals within neighborhoods in a series of models: first examining early childhood ICE and poverty with preterm birth, adjusting only for maternal poor birth outcome; followed by adulthood ICE and poverty with preterm birth, adjusted for all maternal covariates described above; and finally models including both early childhood and adulthood ICE and poverty measures, also adjusted for all the covariates listed above. Logit link functions with binomial distribution, exchangeable working correlation structures and robust variance estimates were specified. We estimated the odds of preterm birth for each quintile of ICE and poverty compared to the most privileged category, controlling for covariates described above. The model equation is as follows:

$$log(P(Y_{ij})/(1-P(Y_{ij})) = \beta_0 + \beta_1 A_{ij} + \beta \mathbf{X_{ij}},$$

where i indicates individual, j indicates neighborhood, Y_{ij} is preterm birth (as defined above), A_{ij} is categorical neighborhood ICE or poverty measures, and $\mathbf{X_{ij}}$ represents the vector of maternal level covariates controlled for in the model.

Finally, to assess the contribution of ICE and poverty to racial/ethnic differences in preterm birth, we compared the odds ratios on race/ethnicity in two separate models adjusted for the covariates described above, adapting methods by Schempf, et. al., employed in previous studies.[19,20,39] We compared odds ratios on race/ethnicity in a logistic model unadjusted for neighborhood measures with those from a GEE model, adjusting for ICE-income+race/ethnicity and poverty measures simultaneously. Each model was adjusted for all maternal covariates described above, in order to assess the contribution of neighborhood environments. We chose this approach over other analytic approaches in the range of options described by Schempf and Kaufman[20] for several reasons. We were limited by convergence issues in a fixed-effects model that would fully account for all aspects of neighborhood environments because of the large number of neighborhoods and the small numbers of study participants within them. A hybrid fixed effects approach accounting for between-neighborhood variation in race/ethnicity that contributes to neighborhood level confounding was inappropriate for this study because our neighborhood-level measures also included information about racial composition. We chose a GEE model over a random effects model because we were interested in population average estimates assessing the relationship between exposures and outcomes across the population and wished to simply account for clustering by neighborhood in our data.

Model 1: Neighborhood Unadjusted

The model equation is as follows:

$$logit(Y_i) = \beta_0 + \beta_1 BLACK + \beta_2 HISPANIC + \sum_{k=3}^{t} \beta_k \boldsymbol{X}_{ki} + \epsilon_i$$

where $logit(Y_i)$ is the log odds of mother i having a preterm birth, β_1 and β_2 are coefficients on binary indicator variables for Black and Hispanic race/ethnicity and β_k are the coefficients for the $\boldsymbol{X}_{ki}$ vector of maternal level covariates (described above). This model lacks adjustment for

neighborhood level factors, and provides initial estimates of Black-White and Hispanic-White difference in preterm birth when neighborhood contexts are not taken into account.

Model 2: GEE

This model is described by the equation:

$$logit(Y_{ij}) = \beta_0 + \beta_1 BLACK + \beta_2 HISPANIC + \sum_{k=3}^{t} \beta_k \boldsymbol{X}_{ki} + \sum_{l=4}^{t} \beta_l \boldsymbol{A}_{ij}$$

where i indicates individual, j indicates neighborhood, Y_{ij} is preterm birth, β_k are the coefficients for the vector of maternal level covariates (described above), and β_l are the coefficients on $\boldsymbol{A}_{ij}$, the categorical neighborhood ICE-income+race/ethnicity and poverty measures experienced during childhood and adulthood. We tested for multicollinearity in this model by looking at variance inflation factors (VIF) for each covariate, which were all found to be below the acceptable threshold of VIF=5.

We estimated the odds of preterm birth for NH Black vs. NH White and Hispanic vs. NH White, controlling for covariates described above, and calculated percent changes for each model estimate compared to the model unadjusted for neighborhood, using the following formula, where β_U is the estimate of the odds ratio from the unadjusted model and β_{GEE} is the estimate of the odds ratio from the GEE model adjusting for neighborhood-level measures:

$$\%change = |\beta_U - \beta_{GEE}| \ / \ |1 - \beta_U| \times 100$$

All analyses were performed using Stata version 12.1.

3.3 Results

The population for this study was 62.1% Hispanic, 26.1% NH White, and 11.9% NH Black. All women were under the age of 30. One-tenth (10.8%) of the overall population had low educational attainment based on age, and nearly one-third (62.8%) received public insurance.

Bivariate analysis showed differences in the distributions of all covariates with the outcome (Table 1). The proportion of preterm birth was highest among those under 18 years of age (10.8%), those with poor birth outcomes themselves (10.7%), and NH Black mothers (10.6%). A larger proportion of NH Black women (21.7%) and Hispanic women (27.4%) were under 18, compared to NH White women (11.4%). The proportion of those with a poor birth outcome themselves was almost double for Black women (22.3%), compared to NH White (9.6%) and Hispanic women (11.4%).

Bivariate analysis also showed that all ICE and poverty measures were associated with the study covariates (Table 2). Compared to the proportions in the overall population, NH White women were overrepresented in the most privileged quintile of every measure and underrepresented in the least privileged quintile, while the opposite pattern held for NH Black women. Hispanic

women were underrepresented in the top quintile. Women under 18 years were overrepresented in the least privileged category and underrepresented in the most privileged category, and the opposite pattern held for women in the oldest category of ages 23-29.

A significant trend of proportions of preterm birth was found across quintiles of all three ICE measures and the poverty measure, during adulthood and early childhood, for the full population ($p<0.001$, not shown) and for all race/ethnicities ($p<0.001$, Figure 2a, Figure 2b). The greatest range of preterm birth from first quintile to fifth quintile was found using the ICE-income+race/ethnicity measure, which spanned from 9.73 to 7.47 for adulthood neighborhood and 9.81 to 7.65 for childhood neighborhood (not shown).

In GEE models (Table 3) of childhood neighborhood ICE and poverty measures adjusted for maternal poor birth outcome, the odds of preterm birth compared to the highest quintile showed a clear gradient, wherein each quintile of declining privilege across the four measures showed statistically significant higher odds of preterm birth. The odds were highest for the first quintile of the ICE-income+race/ethnicity compared to the fifth quintile (OR=1.29, 95% CI: 1.24-1.33).

In GEE models (Table 3) of adulthood neighborhood ICE and poverty measures adjusted for maternal age, race, education, insurance status, and poor birth outcome, the odds of preterm birth compared to the highest quintile also increased for each quintile of declining privilege across the four measures. Compared to the reference category of the highest quintile, odds of preterm birth was highest for the ICE-income measure (OR=1.15, 95% CI: 1.11-1.20), followed by the poverty measure (OR=1.13, 95% CI: 1.09-1.18), and the ICE-income+race/ethnicity measure (OR=1.11, 95% CI=1.07-1.16).

In GEE models (Table 3) including ICE and poverty measures at both time periods of childhood and adulthood, adjusted for maternal age, race, education, insurance status, and poor birth outcome, the odds of preterm birth showed a similar trend of increasing odds of preterm birth for each quintile of declining privilege, with the highest quintile as the reference category. As expected, the measures were slightly attenuated, but they maintained a similar pattern to the models assessing separate childhood and adulthood measures, and maintained the same pattern of statistical significance as the model with adulthood measures only. In the ICE-income/race-ethnicity model, the increased odds of preterm birth were higher for the childhood measures than the adulthood measures of the same quintiles, for example, for childhood Q1 (OR=1.13, 95% CI: 1.09-1.18) compared to adulthood Q1 (OR=1.08, 95% CI: 1.03-1.12).

Finally, in sequential models adjusting for neighborhood context, we found that a combination of ICE-income+race/ethnicity measures and poverty measures together yielded the greatest reduction in the coefficients on race/ethnicity (not shown). Accounting for neighborhood disadvantage in a GEE model resulted in an 27.4% decline in the NH Black-White disparity, and an 40.2% decline in the Hispanic-NH White disparity in preterm birth (Figure 2).

3.4 Discussion

Our interest in whether structural inequities experienced during critical time periods in the life course contribute to preterm birth and racial/ethnic disparities motivated this study. In this intergenerational study of 379,794 primiparous mothers (born in California 1984-1997) and infants (born 1997-2011) from the Life Course Social Context dataset of linked birth records, we examined adjusted associations between neighborhood context and preterm birth, We used quintiles of four measures: ICE measures capturing distributions of privilege and disadvantage along the dimensions of income, race/ethnicity, and combined income and race/ethnicity, and a poverty measure. In this study population, preterm birth proportions were 7.3% for NH White, 10.6% for NH Black, and 8.8% for Hispanic mothers. We found significant trends along all four measures of increasing proportions of preterm birth as neighborhood privilege declined. We further found that adulthood and childhood neighborhood context had unique and independent contributions to preterm birth. When accounting for both adult and childhood neighborhood context simultaneously, women who lived in neighborhoods in the lowest quintile of combined income and racial/ethnic privilege during adulthood had an 8% increased odds of preterm birth, and women who lived in the lowest quintile of combined income and racial/ethnic privilege during childhood had a 13% increased odds of preterm. We also found that models adjusting for both combined income and racial/ethnic privilege and poverty yielded a 27.4% decline in NH Black-White disparities and a 40.2% decline in NH White-Hispanic disparities. These findings together suggest that neighborhood inequality experienced during early childhood and adulthood have distinct contributions to preterm birth, and may play an important role in racial/ethnic disparities.

To our knowledge, this is the first study assessing ICE measures in an intergenerational cohort to assess the contributions of two separate time periods on the health of the subsequent generation. Our results were consistent with those of Huynh, et. al. in their assessment of ICE measures and birth outcomes in a large single-generation sample in New York City.[29] They found similar trends in the distribution of preterm birth across quintiles of ICE and poverty measures, although the population of that study had a much wider distribution of preterm birth proportion by quintile of ICE measures (10.3 to 4.8 for ICE-race/ethnicity and 9.8 to 5.1 for ICE-income+race/ethnicity) than the current study. In adjusted analysis, they found increased odds of preterm birth (OR=1.36, 95% 1.39-1.43) for the first quintile compared to the highest quintile of ICE-income+race/ethnicity, which, though larger in magnitude than estimates from our study, is consistent with our findings. While results of their study were broadly consistent with our results, they found that the estimate of highest magnitude was for the ICE-race/ethnicity measure (OR=1.41, 95% CI: 1.34-1.49). In contrast, this measure yielded the lowest estimates in our study, and did not yield significant associations for early childhood in our models adjusting for both time periods. Discrepancies in findings may reflect differences in the two study populations. Huynh's study focused exclusively on a single east coast city population, while ours included mothers and infants from the entire state of California. In addition, there may be differences in racial residential segregation between the studies, as it is less pronounced and has been declining in urban areas in California compared to other regions of the country.[40] To our knowledge, no other studies have examined ICE measures in relation to preterm birth, but our findings are

consistent with several other studies that assessed relationships between ICE and other outcomes, including hypertension, body mass index, allostatic load, black carbon exposure, fatal and non-fatal assaults, and an ecological study of infant mortality, premature mortality, and diabetes mortality.[28,33,41–45]

We extend the work of Huynh, et. al. by assessing associations of ICE measures at two different life course time periods with preterm birth. Our study is consistent with the work of Collins, et. al., who assessed the contribution of neighborhood median income in mother's early childhood (referred to as grandmother's neighborhood in their study) with low birth weight in the next generation and found a 30% increased odds (OR=1.3, 95%CI: 1.1, 1.4) for women in the lowest quartile of median neighborhood income versus the highest quartile.[14] Our findings are also consistent with the work of Pearl, et. al., which, in a random subset of the Life Course Social Context Dataset, found early childhood neighborhood poverty associated with a marginal risk difference for preterm birth of 0.6, 0.7, and 0.3 per 100 for white, black and Hispanic mothers, respectively.[15] Our findings that early childhood neighborhood inequality measures have unique and significant associations with preterm birth independent of adulthood neighborhood, contributes to a life course understanding of birth outcomes. Estimates were attenuated in the models combining neighborhood measures at both time periods, but still remained significantly associated with preterm birth. The attenuation could be due to unmeasured mediators, including that adult-level indicators that could be a consequence of the early childhood exposures. Nonetheless, our finding that the estimates at both time periods were independent of each other speaks to the importance of early childhood environments in shaping preterm birth.

To our knowledge this is also the first study assessing the contribution of ICE measures to racial/ethnic disparities in preterm birth. Few studies have explicitly examined the contribution of neighborhood environments to preterm birth and those that have typically have employed indicators that capture either socioeconomic disadvantage *or* racial residential segregation. For instance, Schempf, et. al.,[19] used a neighborhood deprivation index, capturing dimensions of income/poverty, education, employment, occupation, and housing; and Schempf and Kaufman,[20] in their example of modeling approaches, which used racial composition. Our results are comparable to the these studies, the first of which reported 15% reductions in the Black-White disparity when accounting for neighborhood context over and above individual-level socio-demographic characteristics.[19] In the second study, which was a simplified example for illustrative purposes and did not account for individual-level covariates that may have influenced selection into neighborhoods, estimates of 40% reductions in Black-White disparities were found.[20,46] Our results are also consistent with those in the intergenerational study referenced above by Pearl, et. al. which found a 25% reduction in the Black-White disparity, and a 5% reduction in the Hispanic-White disparity for low (<20% per tract) vs. high poverty in early childhood and adulthood in their slightly older population subset.[15]

In this population, the combined measure of income and racial/ethnic privilege explained the greatest proportion of racial/ethnic disparities. While the trends for all ICE measures across racial/ethnic categories are significant, the gradient in the proportions of preterm birth for NH Black were less clear than those for NH White and Hispanic, especially for the fourth and fifth

quintiles of ICE-income and ICE-race/ethnicity. This gradient is clearer in the combined ICE-income/race-ethnicity measure, suggesting that this measure may better capture neighborhood disadvantage by combining dimensions of economic and racial inequality simultaneously. Given that this combined measure explains more of the disparity than the other measures, the combination of racial and economic inequality may be capturing an additional effect than either dimension separately.

However, a large part of the racial/ethnic disparities in preterm birth are still not explained by these measures, reflecting that there may be unmeasured factors that influence birth outcomes for NH Black women irrespective of their residential environments. Given this fact, research exploring differential impacts of neighborhood environments by race/ethnicity should be undertaken. For example there is some evidence that Black women living in predominantly White communities may face more interpersonal discrimination putting them at additional risk for preterm birth,[47] despite improved neighborhood circumstances, which could explain the higher proportions of preterm birth in the higher quintiles of ICE-race/ethnicity. In addition, given recent interest in accounting for neighborhood context in the analytic phase of studies,[19,20,39] future research should consider comparisons among other analytic models, and should consider the contribution of other contextual variables that capture additional dimensions of neighborhood environments to racial/ethnic disparities.

This is one of only a few studies that have examined the full spectrum of structural privilege and disadvantage that characterize the distribution of neighborhood opportunity along both economic and racial/ethnic dimensions. The intergenerational linkage of birth records offered by the Life Course Social Context Dataset presented a unique opportunity to explore how social contexts influence life course health and subsequent birth outcomes in a very large and racial/ethnically diverse sample of women. In this study we were able to assess early life exposure to neighborhood measures of inequality and poverty, and also to control for the mother's own poor birth outcome, which has known transgenerational effects[48,49] that are often difficult to account for in studies of birth outcomes. This study sample was limited to records with good quality geocodes, which reduced measurement error.

This study also has a number of limitations. Because this sample consisted of mothers and infants born in California within a time frame where addresses where available, all mothers included in this study were born themselves in California. In addition, all mothers were under age 30, which represented only 56.5% of all births in California in 2010.[50] In addition to over-representation of young mothers, this study sample likely represented a population with a higher risk profile than the general population; while half (50.7%) of all hospital births in California in 2010 were enrolled in public medical insurance, almost two-thirds (62.8%) of this study population were.[51] This sample also contained about twice as many NH Black infants (11.0% in this sample vs. 5.4% in CA in 2010).[50] Removing older mothers from the sample, by limiting the sample to first births, may have also heightened the risk profile of this sample. Given that the Black-White disparity in poor birth outcomes widens as maternal age increases,[25,52–56] future life course studies exploring accumulation of toxic stress due to neighborhood environments not captured during the two time points used in this study may provide critical information.

The majority of the estimates of gestational age in this dataset were prenatally ascertained,[15] which have been shown to be of higher quality than estimates from birth records,[57–59] but misclassification of preterm birth may have occurred in this study. Our estimates may also contain a residual effect of unmeasured individual SES, although some of this effect may in fact be mediated through neighborhood effects. This analysis was limited by lack of detailed information on maternal residential histories, which resulted in an inability to fully assess cumulative exposure to neighborhood environment over the life course.

Despite increasing attention, racial/ethnic disparities in preterm birth remain an alarming and enigmatic public health problem. This study contributes to existing research suggesting that structural inequalities that manifest on the neighborhood level during critical time periods of development are important to understanding racial/ethnic disparities in birth outcomes. While more research is needed to better understand the nature of this relationship, this study supports the need for more attention to the structural conditions that distribute opportunities for health across the life course.

3.5 Tables and Figures

Table 1. Characteristics of the study sample and proportion of preterm birth by race/ethnicity, Life Course Social Context Dataset, CA, 1997-2011, N=379,794.

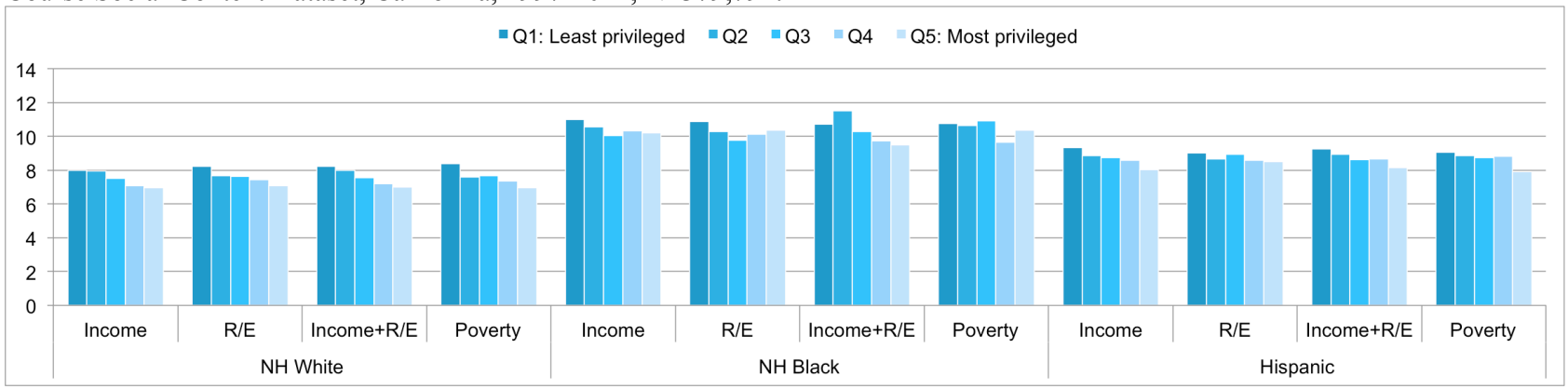
	All Participants				Participants by Race/Ethnicity			
Characteristic	n	%	Preterm %	p-value	% NH White	% NH Black	% Hispanic	p-value
All	379,794		8.6					
Maternal Race/Ethnicity				p<0.001				
NH White	98,971	26.1	7.3					
NH Black	45,012	11.9	10.6					
Hispanic	235,811	62.1	8.8					
Maternal Age				p<0.001				p<0.001
<18 years	86,251	22.7	10.8		11.9	21.7	27.4	
18-22	222,349	58.5	8.2		56.4	63.8	58.4	
23-29	71,194	18.8	7.3		31.7	14.5	14.1	
Maternal Education				p<0.001				p<0.001
Low for Age	41,136	10.8	9.2		8.4	10.6	11.9	
Appropriate for Age	338,658	89.2	8.5		91.6	89.4	88.1	
Insurance Status				p<0.001				p<0.001
Public	238,446	62.8	8.8		48.4	67.3	68.0	
Private	141,348	37.2	8.2		51.6	32.7	32.1	
Mother's own poor birth outcome				p<0.001				p<0.001
Yes	46,317	12.2	10.7		9.6	22.3	11.4	
No	333,477	87.8	8.3		90.4	77.7	88.7	

Table 2. Distribution of the study sample by quintile of adulthood neighborhood ICE and poverty, Life Course Social Context Dataset, CA, 1997-2011, N=379,794.*

	Overall		ICE – Income				ICE – Race/Ethnicity				ICE – Income + Race/Ethnicity				Poverty			
			Quintile 1 (least privileged)		Quintile 5 (most privileged)		Quintile 1 (least privileged)		Quintile 5 (most privileged)		Quintile 1 (least privileged)		Quintile 5 (most privileged)		Quintile 1 (least privileged)		Quintile 5 (most privileged)	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Maternal Race/ Ethnicity																		
NH White	98,971	26.1	13,445	17.9	33,488	45.5	3,355	4.3	46,361	63.1	5,619	7.4	40,987	55.5	8,718	11.4	32,231	43.4
NH Black	45,012	11.9	14,492	19.3	5,957	8.1	23,592	30.3	2,536	3.5	23,915	31.3	3,811	5.2	13,380	17.5	5,568	7.5
Hispanic	235,811	62.1	47,229	62.8	34,217	46.5	50,879	65.4	24,578	33.5	46,932	61.4	29,091	39.4	54,375	71.1	36,524	49.1
Maternal Age																		
<18 years	86,251	22.7	23,104	30.7	10,103	13.7	21,503	27.6	11,349	15.5	21,923	28.7	10,339	14.0	23,488	30.7	11,217	15.1
18-22	222,349	58.5	44,716	59.5	40,005	54.3	46,385	59.6	42,165	57.4	45,633	59.7	40,547	54.9	44,792	58.6	41,816	56.3
23-29	71,194	18.8	7,346	9.8	23,554	32.0	9,938	12.8	19,961	27.2	8,910	11.7	22,003	31.1	8,193	10.7	21,290	28.7
Maternal Education																		
Low for Age	41,136	10.8	10,290	13.7	4,938	6.7	10,691	13.7	5,644	7.7	10,613	13.9	5,046	6.8	10,898	14.3	5,249	7.1
Appropriate	338,658	89.2	64,876	86.3	68,724	93.3	67,135	86.3	67,831	92.3	65,853	86.1	68,843	93.2	65,575	85.8	69,074	92.9
Insurance Status																		
Public	238,446	62.8	57,541	76.6	31,614	42.9	56,504	72.6	37,472	51.0	56,938	74.5	33,385	45.2	59,522	77.8	40,823	54.9
Private	141,348	37.2	17,625	23.5	42,048	57.1	21,322	27.4	36,003	49.0	19,528	25.5	40,504	54.8	16,951	22.2	33,500	45.1
Mother's Own Poor Birth Outcome																		
Yes	46,317	12.2	10,892	14.5	7,357	10.0	11,998	15.4	7,227	9.8	12,137	15.9	7,093	9.6	10,986	14.4	7,429	10.0
No	333,477	87.8	64,274	85.5	66,305	90.0	65,828	84.6	66,248	90.2	64,329	84.1	66,796	90.4	65,487	85.6	66,894	90.0

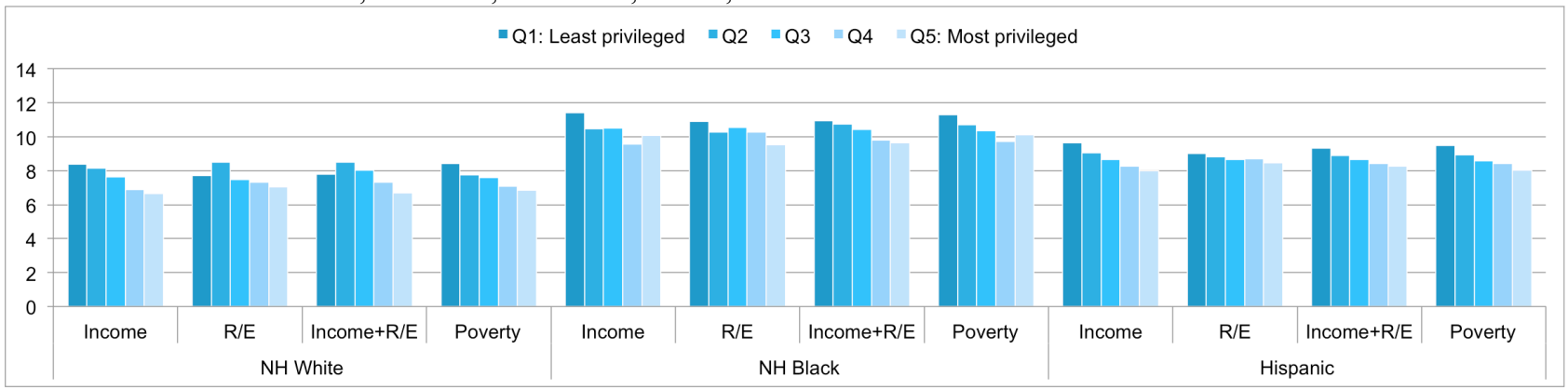
*p<0.001 for all covariates with each exposure

Figure 1a. Proportions of preterm birth for mother's early childhood neighborhood ICE and poverty measures by race/ethnicity, Life Course Social Context Dataset, California, 1997-2011, N=379,794**.***



*R/E=race/ethnicity

Figure 1b. Proportions of preterm birth for mother's adulthood neighborhood ICE and poverty measures by race/ethnicity, Life Course Social Context Dataset, California, 1982-1997, N=379,794.



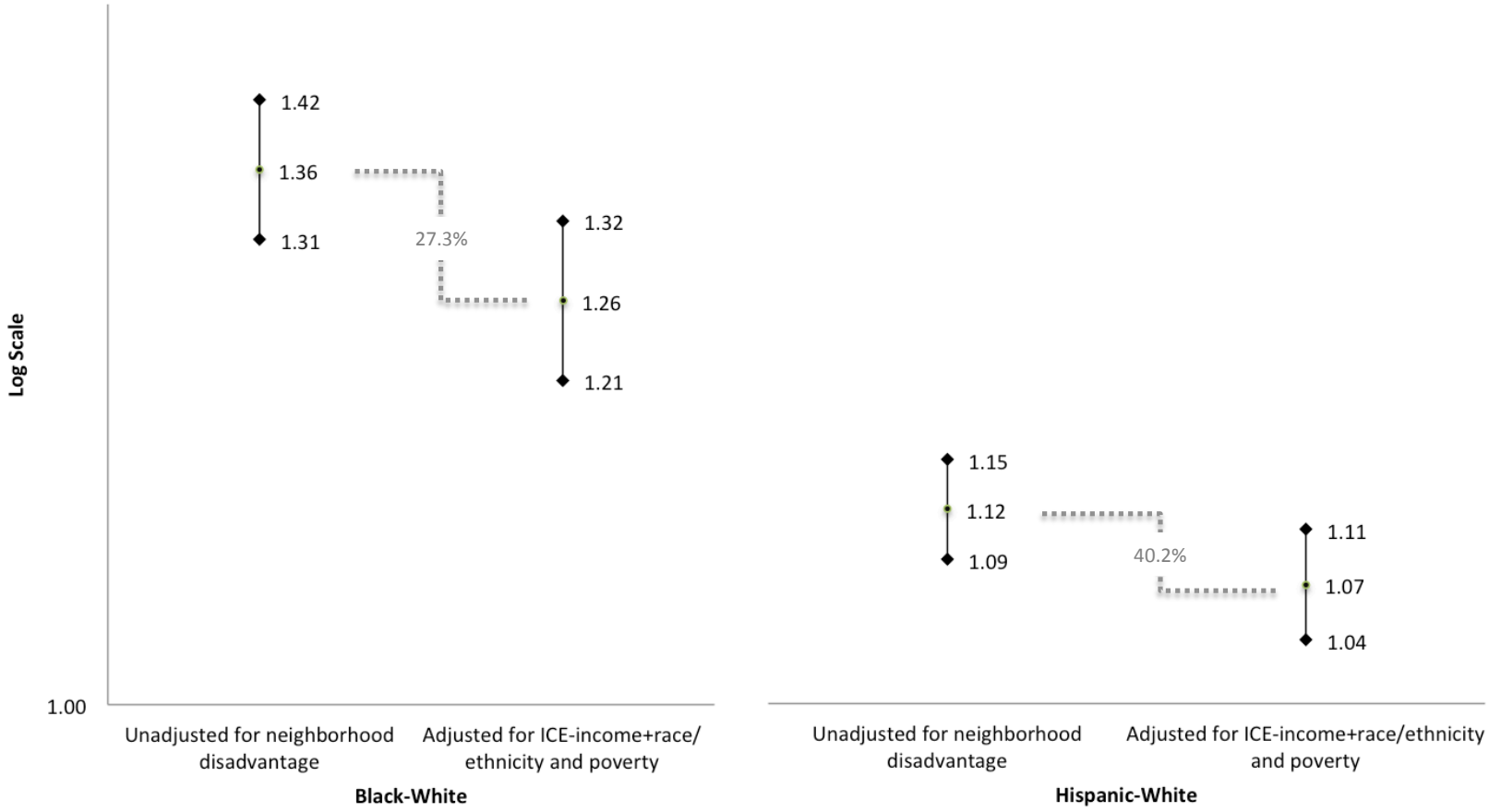
*R/E=race/ethnicity

Table 3. Associations of neighborhood inequality and poverty measures with preterm birth, N=379,778.

	Early Childhood Only Models*		Adulthood Only Models**		Combined Childhood + Adulthood Models**			
					Childhood		Adulthood	
	OR	95% CI	OR	95% CI			OR	95% CI
ICE-income								
Q1	1.25	1.21-1.30	1.15	1.11-1.20	1.10	1.06-1.14	1.12	1.08-1.17
Q2	1.17	1.13-1.22	1.10	1.06-1.14	1.06	1.02-1.10	1.08	1.04-1.13
Q3	1.13	1.09-1.17	1.06	1.02-1.10	1.05	1.01-1.09	1.05	1.01-1.09
Q4	1.09	1.05-1.13	1.01	0.97-1.05	1.03	0.99-1.07	1.00	0.96-1.04
ICE-race/ethnicity								
Q1	1.28	1.23-1.33	1.06	1.02-1.10	1.02	0.97-1.07	1.06	1.01-1.10
Q2	1.14	1.11-1.19	1.05	1.01-1.09	0.97	0.93-1.01	1.05	1.01-1.10
Q3	1.16	1.12-1.20	1.03	0.99-1.07	1.01	0.97-1.05	1.03	0.99-1.08
Q4	1.08	1.04-1.12	1.03	0.99-1.08	0.99	0.95-1.03	1.04	1.00-1.08
ICE-income+ race/ethnicity								
Q1	1.29	1.24-1.33	1.11	1.07-1.16	1.13	1.09-1.18	1.08	1.03-1.12
Q2	1.18	1.14-1.23	1.09	1.05-1.13	1.13	1.09-1.18	1.06	1.02-1.11
Q3	1.11	1.07-1.15	1.07	1.03-1.11	1.09	1.05-1.13	1.05	1.01-1.10
Q4	1.07	1.03-1.12	1.03	0.99-1.07	1.07	1.03-1.11	1.02	0.98-1.06
Poverty								
Q1	1.13	1.09-1.18	1.13	1.09-1.18	1.05	1.01-1.10	1.12	1.08-1.17
Q2	1.07	1.03-1.17	1.07	1.03-1.12	1.05	1.01-1.09	1.07	1.03-1.11
Q3	1.05	1.01-1.09	1.05	1.01-1.09	1.06	1.02-1.11	1.04	1.00-1.08
Q4	1.02	0.98-1.06	1.02	0.98-1.06	1.06	1.02-1.10	1.02	0.98-1.05

*GEE models adjusted for mother's own poor birth outcome
**GEE models adjusted for maternal age, race/ethnicity, education for age, insurance status, and mother's own poor birth outcome

Figure 2. Racial/ethnic differences in preterm birth unadjusted and adjusted for early childhood and adulthood neighborhood ICE-income+race/ethnicity and poverty measures (N=379,794).*



*Odds ratios and 95% CI for Black and Hispanic, with White as reference category, from GEE models adjusted for maternal age, race/ethnicity, education for age, insurance status, and mother's own poor birth outcome

Supplementary Table S1. Documentation for Index of Concentration at the Extremes (ICE) – INCOME
Formula: $ICE_i = (A_i-P_i) / T_i$ = ((N of persons in high income households in tract i) – (N of persons in low income households in tract i))/ total population in tract i

Year tables download names	20th Percentile*	*Closest Category*	80th Percentile *	*Closest Category*	Numerator -80th #households in upper quintile	Numerator -20th #households in lower quintile	Denominator #total population
ACS 07-11** B19001 R11414714_SL140 b03002 R11417524_SL140	20,000	<19,999	100,029	>100,000	acs11_5yr_b19001014 acs11_5yr_b19001015 acs11_5yr_b19001016 acs11_5yr_b19001017	acs11_5yr_b19001002 acs11_5yr_b19001003 acs11_5yr_b19001004	acs11_5yr_b03002001
2000 SF3 Table P52 R11414588_SL140 P7 R11417531_SL140	17,920	<19,999	81,766	>75,000	stf3_p052013 stf3_p052014 stf3_p052015 stf3_p052016 stf3_p052017	stf3_p052002 stf3_p052003 stf3_p052004	sf3_p007001
1990 SF3 P80 R11414643_SL140 P12 R11417535_SL140	12,500	<12,500	55,205	>55,000	stf3_p080_021 stf3_p080_022 stf3_p080_023 stf3_p080_024 stf3_p080_025 stf3_p080_026	stf3_p080_002 stf3_p080_003 stf3_p080_004	stf3_p012_001
1980 SF3 T76 R11414654_SL50 T3 R11420762	7,478	<7,500	31,480	>30,000	stf3_t076_014 stf3_t076_015 stf3_t076_016 stf3_t076_017 stf3_t076_018	stf3_t076_002 stf3_t076_003 stf3_t076_004	stf3_t003_001

Supplementary Table S2. Documentation for Index of Concentration at the Extremes (ICE) – RACE/ETHNICITY
Formula: $ICE_i = (A_i-P_i) / T_i$ = ((N of persons self-identified as "white non-Hispanic" in tract i) – (N of persons self-identified as "black non-Hispanic in tract i)) / total population with race/ethnicity data in tract i

Year table download name	Numerator	Denominator
ACS 07-11** B03002 R11417524_SL140	acs11_5yr_b03002003- acs11_5yr_b03002004	acs11_5yr_b03002001
2000 SF3 P7 R11417531_SL140	sf3_p007003- sf3_p007004	sf3_p007001
1990 SF3 P12 R11417535_SL140	stf3_p012_003- stf3_p012_004	stf3_p012_001
1980 SF1 T7 R11417539_SL50	(stf1_t007_002- stf1_t009_002)- (stf1_t007_003- stf1_t009_003)	stf1_t007_001

Data from Social Explorer
**there were more births in 2011 than 2006 so ACS 07-11 was used

Supplementary Table S2. Documentation for Index of Concentration at the Extremes (ICE) – INCOME + RACE/ETHNICITY
Formula: $ICE_i = (A_i-P_i) / T_i$ = ((N of persons self-identified as "white non-Hispanic" with high income in tract i) – (N of persons self-identified as "black alone" with low income in tract i))/ total population in tract i

Year table download name	20th Percentile*	*Closest Category*	80th Percentile*	*Closest Category*	Numerator – white in the 80th	Numerator –black in the 20th	Denominator #total households
ACS 07-11** B19001 B19001H B19001B R11417527_SL140 b03002 R11417531_SL140	20,000	<19,999	100,029	>100,000	acs11_5yr_b19001h014+ acs11_5yr_b19001h015+ acs11_5yr_b19001h016+ acs11_5yr_b19001h017	acs11_5yr_b19001b002+ acs11_5yr_b19001b003+ acs11_5yr_b19001b004	acs11_5yr_b03002001
2000 SF3 P52 P151B P151I R11417555_SL140 P7 R11417531_SL140	17,920	<19,999	81,766	>75,000	sf3_p151i013+ sf3_p151i014+ sf3_p151i015+ sf3_p151i016+ sf3_p151i017	sf3_p151b002+ sf3_p151b003+ sf3_p151b004	sf3_p007001
1990 SF3 P80 P82 R11417561_SL140 (estimates for black and white not by Hispanic ethnicity) P12 R11417535_SL140	12,500	<10,000	55,205	>50,000	stf3_p082_009+ stf3_p082_010+ stf3_p082_011	stf3_p082_014+ stf3_p082_013	stf3_p012_001
1980 SF3 T081 T083 R11417566_SL50 (estimates for family income; black and white not by Hispanic ethnicity) T3 R11420762	7,478	<7,500	31,480	>35,000	stf3_t083_010+ stf3_t083_011	stf3_t083_013+ stf3_t083_014	stf3_t003_001

Data from Social Explorer
*Percentiles obtained from:
https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-income-households.html
**there were more births in 2011 than 2006 so ACS 07-11 was used.

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Chapter 4

An Intergenerational Structural Approach to Maternal and Child Health Practice: Lessons from Economic Equity Pilot Projects from the Alameda County Public Health Department

4.1 Introduction

For the first time in its history, Healthy People 2020 (HP 2020) set a bold and overarching goal to "achieve health equity, eliminate disparities, and improve the health of all groups."[1] However, alarming and seemingly intractable racial/ethnic disparities in birth outcomes continue to persist in the U.S. today.[2] A Black infant born today is almost twice as likely to be born low birth weight or preterm, and nearly three times as likely to be born very low birth weight compared to a White infant.[2] This has potential implications for lifelong health disparities as birth outcomes predict a range of outcomes over the life course, including infant mortality, childhood health, educational attainment, and adult chronic disease.[3] Birth outcomes, therefore, are measures of population health that capture both past and future experiences, and serve as a proxy for life chances and intergenerational health. Reducing preterm birth and infant mortality thus have both been prioritized by HP 2020 as "leading health indicators."

Also for the first time, HP 2020 highlighted social determinants of health as a key area of intervention, acknowledging the role of the physical, social, and economic environments in shaping the health of populations.[5] HP 2020 proposes a place-based approach to public health practice that attends to "the environments in which people in which people are born, live, learn, work, play, worship, and age," and specifically articulates the need for intervention in five key areas that shape health: economic stability, education, social and community context, health and health care, and neighborhood and built environment.[5] HP 2020 acknowledges that social determinants of health "not only influence the health of populations but also limit the ability of many to achieve health equity."[6] In addition, HP 2020 specifically draws attention to the *structural* factors that shape these environments: "policies, programs, and institutions" including "the government and private sectors," and acknowledge the need for collaboration beyond the health sector to develop approaches for good health.[5]

There has been a call to action to address maternal and child health (MCH) through a life course perspective, with the intention of attending to a woman's lifelong health, such that her health upon pregnancy and the future health of her child will be improved.[2] Given that poor birth outcomes are largely an enigma, and current interventions that aim to decrease racial/ethnic disparities in birth outcomes, for example efforts to promote healthy behaviors, access to prenatal care, and stress management during pregnancy have not been successful,[3,4] interventions designed through a life course perspective may hold promise in helping to achieve the HP 2020 MCH goals.[3] The life course perspective, as conceptualized in MCH by Lu and Halfon in 2003,

acknowledges the complex interconnections of biological, behavioral, psychological, and social factors that result in poor birth outcomes, and combines a focus on critical periods of development, such as early life, with an awareness of how experiences accumulate over time to explain intractable disparities in birth outcomes.[3] A woman's lifetime of experiences, especially those during critical periods of development, influence her health when she gets pregnant, her baby's intrauterine environment, birth outcome, and subsequent health and well-being.

Over a decade after Lu and Halfon's seminal contribution to the field of MCH, a growing number of practitioners in the field are developing interventions that will improve health over the life course by addressing social determinants of health at critical time periods of development,[7–11] but much remains to be done to shift the paradigm of MCH practice.[12–14] More explicit attention to the structural contexts that underlie the distributions of social determinants of health may be necessary in order to fully realize this paradigm shift and achieve health equity, as per Paula Braveman: "We need to be more explicit and clear … that the concepts of health equity and health disparities are not value-neutral, but specifically address social justice in the realm of health. It should, furthermore, be clear that the life-course perspective looks not only over time across life stages, but at how economic and social factors at each life stage shape health at later stages of an individual's life course and in subsequent generations. If we are not clear, valuable, limited resources for research and intervention intended to address health equity may—perhaps unwittingly—be diverted to efforts of little relevance to that goal."[15]A life course perspective to health equity, then, requires us to be attentive to the individual histories of women, which necessitates that we attend to the *histories of the contexts* in which women live and have lived in previous generations, with an awareness of the structural factors that have shaped these contexts, thereby enabling opportunities for good health for some and not for others.

We stand at a critical juncture in MCH history that demands a next-generation MCH practice. This next-generation practice must address the social determinants of health over the life course, and be designed with an awareness and acknowledgement of the structural factors – the institutions, policies, and places – that are at the historical roots of the unequal distributions of opportunity that underlie racial/ethnic health disparities today. The overarching aim of this article is to challenge the field of MCH to define this next-generation MCH practice – a practice that acknowledges and attends to structural roots of current-day disparities in birth outcomes. In order to achieve this aim, we have three objectives, as follows: 1) to describe a conceptual framework to contextualize racial/ethnic differences in birth outcomes as a product of inequitable policies and practices under a system of structural marginalization, 2) to outline the process of incorporating aspects of this framework at the Alameda County Public Health, highlighting early-stage examples of economic equity pilot projects at ACPHD, 3) to offer lessons learned and areas of future development to enable the development of next-generation MCH practice that addresses the structural factors at the root of racial/ethnic disparities in birth outcomes. Our aim is to demonstrate an early-stage practice of MCH that both recognizes current day disparities as products of long-standing history and a call to action to begin to transform MCH practice to attend to the changing the institutions, policies and practices that continue to perpetuate these disparities.

4.2 Objective 1: The Intergenerational Structural Inequities Life Course Model

The field of MCH is uniquely positioned to intervene during key critical time periods of development to improve intergenerational health and reduce health inequities, but in order to develop public health programs and policies that will be effective, we must acknowledge the contexts from which they have arisen. In order to more explicitly articulate the root causes of racial/ethnic disparities in birth outcomes we combine the life course perspective,[15] fundamental cause theory,[16] and concepts of structural marginalization/"othering"[17] to form the Intergenerational Structural Inequities Life Course Model (Figure 1). This model seeks to explain the intractability of racial/ethnic disparities in birth outcomes by situating a woman's health development within the broader structural contexts that have shaped distributions of opportunity over time in the U.S. Using a socio-ecological approach,[18] the model suggests that a baby's health at birth, as a marker of his/her future health and success, is influenced by the lifelong experiences of his or her mother, which has been shaped by her household and neighborhood contexts, which themselves have been subject to a specific policy history, consciously or unconsciously informed by systems of group-based systems of structural marginalization and inequality. In this way, disparities in birth outcomes represent health *inequities* "differences in health that are unnecessary, avoidable, unjust, and unfair,"[19] that are passed down through generations.

We build on the life course perspective framework of Lu and Halfon by seeking to explain the profiles of risks and opportunities across the life course as shaped by systems of group-based structural marginalization and inequality described by powell and Menendian as "othering."[62] powell and Menendian define "othering" as "a set of dynamics, processes, and structures that engender marginality and persistent inequality across any of the full range of human differences based on group identities." Othering provides a framework to acknowledge the existence of multiple and sometimes overlapping dimensions of privilege and disadvantage that have enabled good health for some but not others, on the basis of group identities including but not limited to race/ethnicity, class, religion, sexual orientation and immigration status. In the case of Black-White disparities, group-based structural marginalization has been a driving force in shaping geographic distributions of opportunity in the U.S. Various policies and practices over time, perpetuated by the federal government and other institutions, have resulted in patterns of racial residential segregation and subsequently unequal exposures to adverse neighborhood conditions.[20]

The economic, demographic, and policy changes that resulted in the geographic distribution of opportunity that persists today in the U.S. has been well-documented.[21–24] In short, heavy investments in the war efforts in the 1940s spurred large migrations of Black people and immigrant populations into factories in the North and the West. These migrations resulted in dramatic changes to the urban landscape in metropolitan areas, resulting in overcrowding and competition for jobs and scarce housing. At this time, White people began leaving inner urban areas, spurred on by federal policies that incentivized and subsidized the growth of the suburbs while discriminatory real estate practices such as redlining, racially restrictive covenants, and blockbusting excluded minorities from participating in the wealth-building opportunities offered by the prosperous suburbs. The corollary to investments in the suburbs, such as highway funds,

homeownership subsidies, and business tax incentives, was disinvestment in central cities, where declining tax bases resulted in fewer municipal services and investments in education. These early roots of concentrated disadvantage in urban areas were exacerbated by shifts in the labor market in the late 1970s and 80s that eliminated many manufacturing and industrial jobs.

Importantly, powell and Menendian argue that while past policies and practices were often more explicitly biased, today structural group-based marginalization persist in both visible and less visible or less conscious forms; rather they are insidiously baked into our systems and institutions. It is a "web without a spider."[63] For example, today discriminatory financial practices targeting low-income and minority communities continue to persist,[25] including higher cost car insurance, payday loans, and subprime loans.[26–31] These practices continue to contribute to the ongoing disinvestment and poor health of low-income neighborhoods of color,[25] while the bulk of federal asset-building tax subsidies go to moderate and high income households in the form of homeownership subsidies.[32–34]

Fundamental cause theory, originally proposed by Link and Phelan in 1996, posits that the strong association between socioeconomic status and mortality has been consistent over time, in spite of changing profiles of disease and risk factors, because people of higher SES can avail themselves of social and economic resources, such as "money, knowledge, prestige, power, and beneficial social connections" to protect their health and prolong their lives.[16] Key to this concept is that people use resources to protect their health, and that not having resources puts people at "risk of risk." Racial residential segregation has been recognized as a fundamental cause of health,[35] in that, as described above, policies of exclusion and separation have resulted in an unequal distribution of both individual SES and neighborhood opportunity/risk profiles that reproduces health inequities over generations. Fundamental cause theory elucidates how scarcity of material resources on individual and community levels may contribute to poor health, and there are also possible negative health effects from the psychosocial impacts of both absolute and relative deprivation, including through stress disregulation from unrelenting chronic stress.[36–38]

A key takeaway of this model for MCH practice is the recognition that racial/ethnic disparities in birth outcomes are not unavoidable or out of our power to eliminate – they are a product of manufactured systems of oppression and it is therefore in our power to change the systems that perpetuate this health inequity. The most critical step in this change, according to jon powell, is understanding the function of group-based marginalization in this context, and redefining our ability to address the underlying conditions that perpetuate inequities: "Our collective actions and inactions have created structures that perpetuate group-based inequality-but also *distribute meaning.* Once structures are in place, they appear to have a logic and momentum of their own that reproduces and naturalizes these meanings. This cycle appears as inevitable as it seems vicious." In this vein, the goal of this conceptual framework is not to overwhelm, but rather to highlight the power and responsibility of the field of MCH to acknowledge and act upon the systems that reinforce inequities in birth outcomes.

However, understanding where to intervene in these complex, mutually reinforcing and entrenched health inequities is a challenge to MCH practice.[39] While the model suggests that the

impacts are greatest when intervening from the largest sphere inward, we hypothesize that there will be relationship in the other direction as well, such that better maternal and infant health and improved neighborhood conditions will lead to greater community capacity to shape policies that impact health and begin to challenge structural systems of privilege and oppression. The key thing is that we must not wait for silver bullet solutions. In the wise words of jon powell, though this approach "takes a holistic view of the problem, that should not be taken to mean that the remedy must be similar in scope…A properly aimed intervention can act as a catalyst that transforms the entire system." Our call to action as a field, then, is to collectively acknowledge that current practice of MCH is not enough, and to undertake innovative interventions that will challenge current MCH practice to address the root causes of inequities birth outcomes.

In this vein, ACPHD undertook what we call a deliberately "incrementalist" approach, focused on developing a series of small win projects to grow momentum and support for an ongoing body of work that would, as suggested by Williams and Collins "seriously grapple with reducing racial disparities in socioeconomic circumstances, and with targeting interventions not only at individuals but also at the geographic contexts in which they live."[35]

4.3 Objective 2: Applying the Intergenerational Structural Inequities Life Course Model in MCH Practice: Economic Equity Pilot Projects at the Alameda County Public Health Department

In 2008, ACPHD undertook a strategic plan for health equity, recognizing the role of poverty, racism, and discrimination in shaping distributions of poor health in Alameda County. The goal of the strategic plan was to broaden current public health practice to address the root causes of health inequities through innovative practice and policy development. In 2009, ACPHD launched its Life Course Initiative, in further recognition that MCH programs that worked with Alameda County residents had a key role to play in laying the groundwork for good health during critical time periods of development. The Life Course Initiative witnessed the launch of the Building Blocks Collaborative, several place-based projects addressing social determinants of health, and ultimately Building Blocks for Health Equity, a part of the MCH unit of ACPHD, as previously described.[40]

Through strategic partnership and innovative program development, ACPHD has been advancing an agenda to incorporate attention to social determinants of health as part of MCH practice. Our deliberately incremental approach was rooted in a planning framework[40] that prioritized undertaking efforts at the intersection of existing momentum, partner expertise, and needs of community residents. Because of a confluence of factors, including expertise of Building Blocks Collaborative partners, stated needs of residents in priority neighborhoods burdened by health and social inequities, and ongoing efforts within the health department,[41] economic development became one critical area of focus for BB4HE. Although it is just one predictor in the complex interplay of factors that shape birth outcomes and influence health inequities, there is consensus that addressing socioeconomic conditions may be important to reducing racial/ethnic birth disparities.[42–44] Economic well-being early in life may be a particularly important area in which to intervene because it informs a range of other exposures

over a person's lifetime.

Indeed, it has been suggested that differences in individual wealth may account for a portion of the racial disparity in birth outcomes.[44] The Intergenerational Structural Life Course Model helps to understand context in which racial wealth disparities in the U.S. have arisen. An estimated 67% of Black families were liquid asset poor in 2011, nearly twice the proportion of white families, meaning that the household lacks savings to cover basic expenses at the federal poverty level for three months if they experienced a sudden job loss, a medical emergency or another financial crisis leading to a loss of stable income.[45] In addition, there are stark racial and ethnic differences in household wealth (driven partly by the discriminatory policy history described above), and in wealth losses from the great recession (at least in part driven by differential targeting of predatory capital, as we described above): in 2011, White households had 17.5 times that of black households and 14.4 times the wealth of Hispanic households. Black and Hispanic households lost 50% and 61% of their wealth respectively from 2005 to 2011, compared to 26% for White households.[46] Racial/ethnic differences in wealth are even more pronounced for low-income populations: for example, census data indicate that in the lowest quintile of income, White-headed households had more than 400 times as much wealth than those headed by Blacks.[47]

On an individual level, it has been shown that wealth, a measure of one's accumulated assets, is essential for 1) developing additional personal assets, such as education and job skills that contribute to good health, 2) surviving financial setbacks without seeing standard of living permanently undermined, and 3) giving children a wide range of advantages that position them to build wealth, and thus good health, as adults (moving to good school district, paying for college, giving adult child money for down payment), and 4) limiting day-to-day stress associated with making ends meet.[44] On the neighborhood level, financial resources enable the creation or support of health-promoting resources in the social and built environment, such as good schools, healthy food, neighborhood safety, places to play, and other neighborhood conditions that shape the behaviors and environments within households.

Program Model

Figure 2 describes ACPHD's MCH economic equity program model. The model describes how the current areas of financial education, asset-building supports, and neighborhood grassroots economic development aim to increase sense of control, ability to plan for the future, and material circumstances. These factors will improve both the health of parents and children, by decreasing exposure and vulnerability to stressors. For example, the ability to plan for the future will allow parents to make investments in the next generation, or in their own education – both factors that will increase health over the long run. The dotted line suggests that improved women's health in general will improve the *in utero* environment for any future pregnancies that may occur and, subsequently, birth outcomes. The program model also highlights the critical importance of building an organizational culture that supports the integration of new programming.

For this work, we conceptualize power according to the World Health Organization, as operating on a spectrum, from the "micro-level," between individuals and households, up to the "macro-sphere," mediated through economic, social and political institutions.[48] In this way, we considered that interventions aiming to address social determinants of health, should aim to increase power and control for previously disadvantaged and disempowered groups, and also work to challenge broader power structures that may be reinforcing inequities. In this way, ACPHD departed from some elements of traditional asset-building culture, and took an approach that focuses on strengths of clients, attends to building power and control, and steers away from top-down financial literacy approaches that assume that the root of the problem is lack of education rather than broader structural inequities.

Underpinning this work are ACPHD's ongoing efforts to challenge hierarchical power structures that have been inherent in traditional perinatal service delivery, moving away from the model where a health "expert" provides guidance and advice to a client toward partnership models that allow clients to set and achieve goals. ACPHD has been undergoing larger changes to organizational culture to embody this philosophy, such as a shift away from top-down management to a reflective supervision approach.[49] To further build a culture that will embrace new programming, all-staff trainings have been undertaken on topics of health and social equity; popular education; race, power and privilege; and other related topics.

The main components of the program model are carried out by two separate but interrelated initiatives: Financial Tools & Solutions (FT$) and Best Babies Zone (BBZ). FT$ and BBZ were designed to incorporate community economic development and public health tools and strategies in order to address individual and neighborhood conditions that inhibit families—specifically mothers—from accessing income and wealth-building opportunities.

Financial Education and Asset-Building Supports: Financial Tools & Solutions (FT$)

FT$ was designed, with funding support from the Robert Wood Johnson and the California Wellness Foundations, to provide concrete tools and resources to help low-income families, specifically the clients of early childhood home visiting programs, to achieve financial stability. Home visitors serve over 1000 families per year, and are uniquely poised to help families with financial issues that emerge during a critical time period in their child's life, during the perinatal and early childhood phase. FT$ builds on the work started with ACPHD staff joining the Alameda County Community Asset Network (AC CAN), a local coalition of asset-building organizations in Alameda County in 2009. This partnership resulted exploration of collaboration opportunities, including a full-day Health-Wealth symposium in 2010, and ultimately the launch of the Alameda County Prosperity Project (funded by the Robert Wood Johnson Foundation) in 2011 that sought to influence policy and systems change in order to increase assets, protect wealth, and advance health equity. Through this project, ACPHD staff conducted listening sessions with six early childhood home visiting programs to learn about the financial challenges clients face along with staff challenges in helping clients.

Listening sessions revealed that home visiting staff routinely encounter situations where families are experiencing potentially life-changing tradeoffs when faced with financial crises – like a car breaking down or funeral – that forces the household to choose between paying for medicine or keeping the lights on. Staff also encountered clients who had ideas and initiative for small businesses but were unable to bring their ideas to fruition due to lack of resources, credit or information. FT$ aims to help families weather financial storms, without utility shut-offs, eviction or the use of debt traps like payday lenders, and to assist them in developing income-generating strategies through a strengths-based approach.

Based on these listening sessions, ACPHD developed financial education tools and trainings using a popular education approach and piloted them in two home visiting programs. Results of the pilot informed the following program offerings:

Financial Dialogues with Home Visiting Clients

Results from the pilot indicated that staff were hesitant to take on the role of long-term financial advisors directly, but were well suited to working with clients to start conversations and set goals around financial needs. Two financial coaching trainings were subsequently designed for home visiting staff to assist them in engaging in dialogue about finances. Rather than working to solve clients' problems directly, the goal of this approach is to provide a structure for clients to develop their own solutions, which has been shown to be an effective model in the asset-building field.[50] This work aims to institutionalize an asset-building intervention as a standard offering of early childhood home visiting programs, including establishing protocols and procedures that ensure that all home visitors are having initial client-centered conversations with families about finances and, if desired, referring them for participation in intensive financial workshops, financial coaching and/or to the portfolio of financial options outlined below.

Financial Education Workshops

Following a referral from the home visitors, participants of the pilot commit to attending three two-hour intensive workshops. These workshops are designed to address financial myths and fears, and help individuals understand unconscious financial behaviors that limit their economic well-being. In a supportive setting that encourages peer dialogue, workshop facilitators address various topics including tax planning, money management, emergency savings, credit, and debt management. Clients also receive one-on-one financial coaching as needed. The goal of these workshops is to provide baseline and accurate financial information.

Asset-Building Grants

Recognizing the structural barriers that have limited access to capital in marginalized communities, FT$ goes beyond education and also offers asset-building grants, to allow clients to access resources that enable them to move toward greater financial stability. Once clients have completed all three workshops in the series, they are eligible to receive an asset-building grant in one of two categories: "emergency funds," which offer up to $500 to cope with potentially life-

altering financial crises; or "developmental pathways," which offer $500-3000 to build financial self-sufficiency by supporting investments in small business, education or family development needs, such as childcare. Asset-building grants are one-time only and clients are not eligible for multiple grants or grants in multiple categories. It is notable that income supports to weather emergencies may be especially crucial during pregnancy and early postpartum phases when households income is estimated to drop by over 10% for all families, and over 40% for women who live in households without other adults.[51] The goal of this program offering is to give power to families to decide how small amounts of capital could make an impact in the financial trajectories of their families.

ACPHD is partnering with Self-Help Credit Union to set up a revolving account to hold the asset-building grant funds as a way to build banking relationships between this financial institutions and clients to set them up for greater financial health. Clients of home visiting programs who participate in the asset-building grants program sign up to be members of Self-Help Federal Credit Union and will authorize online deposits to be made into their accounts by ACPHD staff upon successful completion of the FT$ Program workshops. In addition, interested clients are referred to entrepreneurship resources, including the one described below, designed for BBZ.

Lending Circles

Through the development of the above program offerings, ACPHD developed greater receptiveness to working with partners engaged in improving the financial wellbeing of low-income populations. In addition, ACPHD began to recognize that there is no universal financial tool for all clients, making partnership essential to develop multiple offerings. In partnership with Mission Asset Fund, ACPHD is facilitating lending circles with home visiting clients. Lending circles are have been present in many international settings as a way to access capital when banks are not an option.[52] Lending circles offer a way to build community, access zero-interest loans, and increase savings. Mission Asset Fund has developed a unique program model that reports monthly payments to the lending circle to the credit bureaus, so that what used to be an informal "off-the-books" lending model now positively increases credit scores, and builds formal credit for many who are establishing credit histories for the first time.[53]

Brilliant Baby, a two-generation savings account strategy

Based on research that children receiving savings accounts score better on socio-emotional development indicators,[54] Brilliant Baby, a project developed by the City of Oakland, is enrolling interested ACPHD clients from home visiting programs with a child savings account seeded with $500. Parents will have the option of establishing a matched savings account that will also be incrementally seeded with funds up to an additional $500, as the parents complete financial coaching sessions.

Place-Based Neighborhood Grassroots Economic Development: Best Babies Zone (BBZ)

In 2012, the Alameda County Public Health Department was selected as one of three initial pilot sites for the Best Babies Zone (BBZ) initiative, led by UC Berkeley.[7] BBZ, funded by the Kellogg Foundation, the California Wellness Foundation, and an anonymous donor from the San Francisco Foundation, is a multi-sector approach that aims to reduce infant mortality and racial/ethnic disparities in birth outcomes by mobilizing communities to address the social determinants of health. Based on need and existing partnerships, ACPHD selected the Castlemont neighborhood in East Oakland as the site to implement the project.

Castlemont is a neighborhood comprised of 5,192 residents (44% African American and 41% Latino), with approximately 90 births a year in a 7 by 12 block area. The median income in Castlemont ($35,658) is significantly lower than Oakland ($51,444) and Alameda County ($70,821),[55] and three out of four businesses that used to comprise a vibrant economy in the neighborhood's commercial corridor are now closed. Recognizing the dynamics of decades of disinvestment in this neighborhood of primarily people of color, BBZ staff took on economic development as an issue aiming for an inclusive and incremental approach that would build on community strengths and demonstrate small visible wins to engage additional community residents, partners, and funding through action-focused strategies. This approach has yielded three main projects evolved from a focus on neighborhood grassroots economic development: The Castlemont Community Market, Vendor's Association, and the BBZ-Mandela Entrepreneurs.

Castlemont Community Market

In 2013, ACPHD convened 12 economic development leaders from the Bay Area to participate in a 16-week Design Sprint using Human Centered Design to identify first "small win" projects.[56] The group held a series of conversations with residents, business owners, students, and faith-based community members around Castlemont's local economy. The findings from these encounters showed that there is a strong arts culture in East Oakland and that local residents are often enterprising to make ends meet. Furthermore, Castlemont residents said they lacked economic opportunities and would like to spend and keep money in their neighborhood, despite limited options to do so. Residents also expressed the need for more regular events that would create a safe place for people to get to know their neighbors and bring their children.

In collaboration with Castlemont High School and Youth UpRising, ACPHD launched the Castlemont Community Market (CCM), which takes place on the first Saturday of every month. The vision of the CCM is to create a consistent and visible community event that brings together people who are making and selling items, as a way to highlight the local-grown strengths and talents of the community, to enable micro-business opportunities for East Oakland residents, and as a starting place for additional economic development activities. At the close of the first year the CCM had 20 vendors and $2,992 in total gross sales, a marked increase compared to its debut in January 2014 with one vendor and no sales. As of January 2017, three years after the market's launch, 50 vendors have participated and a total of $11,685 has been generated. Importantly, the market has also served as a monthly gathering place for families and children, in a neighborhood where people often stay inside due to fear of violence. Through partners agreeing to host

additional community events on the day of the market, as well as mini-grants offered to residents, the monthly event has grown additional components including swim clinics and play time for young children.

Vendor's Association

The CCM has yielded only modest financial gains, but it has provided a consistent, concrete and visible community event that has resulted in resident-led conversations about the local economy. ACPHD staff views this as an incremental strategy for a neighborhood approach to community economic development, leadership development, and ultimately an opportunity for residents to shape this opportunity to fit their needs. From the launch of the market, the intention for the CCM was to transition decision-making and control of the market to local residents. As of April 2016, ACPHD staff started that process by supporting CCM vendors in hosting themed market events. Themed markets are vendor-led events highlighting a specialized trade or activity. The first themed market, hosted by a local vendor was known as "Natural." Natural was an event that showcased and celebrated natural hair and skin products for African American women, in response to the beauty industry upholding Eurocentric standards of beauty and often excluding women of color. Furthermore, the vendors believed that by celebrating the beauty of African American women they could both empower black women and tap into a thriving economy. The event proved itself successful with approximately 15 vendors, 500 people attending and over $3,000 in gross sales in a four-hour time span. Following this event the CCM vendors launched the Castlemont vendors association— a natural outgrowth of the community market, enabling vendors to share skills, receive resources, and take ownership of the market. The vendors association is currently made up of six women who are exploring opportunities to bring in social, emotional, and health resources to the Castlemont Community.

The BBZ-Mandela Entrepreneurs

Since the market's inception, ACPHD staff continuously heard from vendors that there are challenges to formalizing small local businesses, such as successfully matriculating through business development trainings. Despite a strong ethic of entrepreneurship in disinvested neighborhoods like Castlemont, communities often do not have access to the tools necessary to launch or grow sustainable, income-generating businesses. In order to elevate local community entrepreneurship and support the growth of economically secure communities, BBZ forged a partnership with East Bay Asian Local Development Corporation (EBALDC), Mandela MarketPlace, and Centro Community Partners to launch BBZ-Mandela Entrepreneurs, an entrepreneurship development program that provides a foundational understanding of business planning and licensing in a culturally relevant context. This seven-week program was designed to provide local vendors, who may not identify as entrepreneurs, with a baseline business foundation so that they can successfully matriculate to existing but more advanced social enterprising programs. The program had nine participants whose ages ranged from ages 19-63. Following best practices of business incubator programs, the BBZ-Mandela Entrepreneurs were asked to pay a sliding scale buy-in of $25-$100 prior to beginning the workshop series. Upon completing the workshop series participants were returned their buy-in amount and given a small

matching grant in the same amount as their buy-in. The match/small grant was designed as an incentive to retain attendance, and as startup capital for materials that they might need upon workshop completion. In addition, the entrepreneurs are eligible to apply for mini-grants to further launch their efforts. These grants have allowed budding entrepreneurs to purchase equipment and tools they need for their businesses. Six months after the program, BBZ-Mandela Entrepreneurs have embarked on growing their businesses. One such business is an eco-friendly house cleaning business owned and operated by a single mother whose child is under the age of two. She is the head of household and a client of ACPHD's home visiting programs. Prior to participating in the program she had two clients. Now she has an additional nine clients, a detailed business plan, marketing materials, a website, and set prices that correspond to the various types of cleaning services she provides. Another business is a catering/bookstore cooperative run by survivors of domestic violence. The goal of this business is to provide employment opportunities for domestic violence survivors while operating a successful food enterprise. This business is currently pursuing a short-term loan via Kiva, an online lending platform.

These case examples are a result of uniting community economic development with more traditional public health interventions. This approach has been incremental and has resulted in several small-scale strategies that begin to address the challenges on individual, neighborhood and systems levels that hinder the development of financial health of communities.

4.4 Objective 3: Lessons Learned and Future Development for MCH Practice

We situate Alameda County Public Health Department's ongoing efforts to reduce inequities in birth outcomes within the Intergenerational Structural Inequities Life Course framework to conceptualize disparities in health as the manifestation of underlying historical and current processes of group-based marginalization. We recognize that the efforts we have undertaken to create equitable economic opportunities to ultimately improve maternal and child health are still in their infancy, and we share the following early stage lessons learned for practice:

1. Build on community assets and expertise, and foster community ownership

In order to design programs that are meaningful and inclusive, programs must create opportunities for resident engagement and ownership, and build on community assets and expertise. Because funding priorities and institutional leadership change, it is critical that residents take ownership of projects to ensure the long-term sustainability of projects, and also as an indication that project offerings are resonating and meeting resident needs. In an effort to create opportunities for more grassroots engagement, we launched the CCM with a specific intention of engaging more people in future steps of the program design. While these approaches certainly take longer than traditional planning processes with clear end goals, we believe it will results in a stronger engagement by those who would like to set the vision and course for the effort.

2. Design programs to increase community power and control

The programs described above were all designed to support individuals and communities in setting their own goals, with an aim to increase a sense of agency and control. For example, the grants pool program enables clients to consider for themselves what kind of future-oriented investments they could make with a small amount of flexible capital. In addition, the programs themselves are designed to be flexible to be adapted to fit the needs of clients of different home visiting programs within ACPHD. While not all MCH clients will be interested in or able to use these resources, building flexibility through a coaching model and offering a menu of different resources increases the chances for greatest impact.

3. Seek opportunities to leverage programmatic success for policy change

Increasing individual power is critical but not sufficient. Institutional and legislative strategies are also critical, and the burden of change should not lay solely with those already burdened by the consequences of long-term structural inequity. Per the World Health Organization, "action on the social determinants of health inequities is a political process that [should] engage both the agency of disadvantaged communities and the responsibility of the state."[48]At the writing of this report, we are still early in the development of economic equity activities as part of MCH practice, and although it is our long term goal, we have had little impact in the area of identifying policy targets on institutional and legislative levels in order to push larger scale changes. As such, we have approached this aim with an eye toward changing institutional policies to better support asset building for families. Institutionalizing asset-building activities within the health department rather than relying on ongoing grant funding is one target. In addition, from the beginning of the launch of the Castlemont Community Market, we have sought collaboration and scaling opportunities by maintaining conversations with the City of Oakland to support and sustain grassroots economic development in addition to their typical focus on attracting large scale retail and development projects. We have attempted to influence county leadership to consider how public funds might be used to offer a county-sponsored alternative to payday loans. While these efforts have not borne fruit in the short term, we see the critical importance of continuing to identify policy targets as "north star" goals while continuing to work on the day-to-day in a way that solves concrete and immediate problems and engages community in re-calibrating the "north star." In addition to spearheading policy efforts ourselves, we look for opportunities to lend voice and testimony to ongoing efforts spearheaded by partners and others.

4. Ensure strong leadership and build an organizational culture that embraces social justice and innovation

Even with strong leadership, it has taken several years to design and build the buy-in for implementation of ACPHD's MCH economic development activities. Leadership from the top is critical to this type of work in both prioritizing the time and space for trainings and program design, setting expectations for staff about embracing a new way of working, and fundraising and building partnerships. In addition, leadership is needed to navigate bureaucratic challenges within a government agency. As one example, establishing a revolving fund for FT$ is a

deviation from county finance operations that has required stewardship by top-level leadership at the health department.

Organizational leaders must also be careful to ensure that input is solicited from staff to ensure that the program offerings will be adopted and sustained. Establishing a culture that sustains ongoing awareness and learning about the root causes of health inequities is one critical component. In addition, leaders must ensure that programmatic changes are shepherded consistently with strong communication and ample opportunities for the engagement of staff at various levels. Program staff leading implementation of these innovative efforts must navigate the pressures of various internal stakeholders while maintaining integrity to shifting the power paradigm in the communities being served, requiring an approach that is both patient and culturally humble. If not supported by top-level leadership, innovative program development is very difficult.

5. Maintain long-term partnerships

Partnership and collaboration with community partners and those with expertise in the community development field has also been of critical importance and has not been linear. Some of the partners who were involved in the initial planning of the market have now partnered on the BBZ-Mandela Entrepreneurs program, several years after the market's launch. Also, much of the work highlighted here was borne from BB4HE staff joining an existing collaborative of asset-building organizations. It is not always necessary to spearhead a new large-scale effort to grow partnerships; reaching out and joining existing tables is an important first step. Finding the win-win situations that leverage strengths of both organizations is key to success, and does not always happen on the first attempt. We have found that investing in partnerships and maintaining an open orientation over the long time horizon is wise, and often the fruits of the partnership are borne out later.

6. Embrace an incremental approach

ACPHD's approach, borne from its use of human-centered design,[56] of pursuing small-wins and allowing strategy to be emerge from them has enabled partnership opportunities in a way that would not have occurred had we embarked on a more traditional program planning approach of setting long-term targets and following a linear path. The ambiguity of an incremental approach can be uncomfortable and risky, in the sense that targets are emergent rather than pre-defined, but we found that this approach allows for more authentic engagement and ownership by community residents, because we are not beholden to externally defined targets or timelines. Evaluation of these early efforts has been difficult because of our deliberate efforts to co-designing offerings with staff, clients and residents using an incremental approach. In the early phases, the use of basic metrics and telling stories of successful work has been influential in building momentum.

7. Seek out innovative funders

Finally, innovative funders who understand the connection between health and wealth have been critical to this work. In the early phases of trying strategies in new settings, having the support of outside resources, timelines, and deliverables has benefited these programs immensely. Flexible funding that allows for ambiguity and moving program targets has been instrumental in ensuring innovative program design that meets resident and client needs.

4.5 Conclusion

In order to challenge the field of MCH to define a new generation of public health practice, we set out with three objectives for this paper. We first described a framework for MCH practice, the Intergenerational Structural Inequities Life Course Model, in order to contextualize racial and ethnic disparities in birth outcomes within a broader context of structural marginalization. The framework, while broad and encompassing several overlapping social factors at the root of health and health disparities, necessitates addressing inequities in economic opportunity as one important body of work for MCH practice. We next described the application of this framework to practice with using ACPHD's MCH economic equity pilot projects to represent that there are feasible ways to shift the field of practice and challenge the paradigm in which health inequities are created, and finally shared lessons learned for future practice. While these projects are presently in early phases, the goal is to continue to grow and scale these projects with the input and leadership of community residents and clients, and ultimately to serve as an example of other types of economic development projects that can be undertaken as part of MCH practice. Designing programs guided by the lessons we share above will certainly take more time than applying cookie-cutter top down approaches, but our hope is that they will create opportunities for community engagement and catalyze change in the long run. Ultimately we believe that though shifting the paradigm will not be easy, acknowledging the complexity and scale of the problems underlying health inequities, and investing in incremental approaches to address them is an essential first step to a sustainable next-generation MCH practice that will close disparities in birth outcomes.

4.6 Acknowledgments

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4.7 Figures

Figure 1. The Intergenerational Structural Inequities Life Course Model

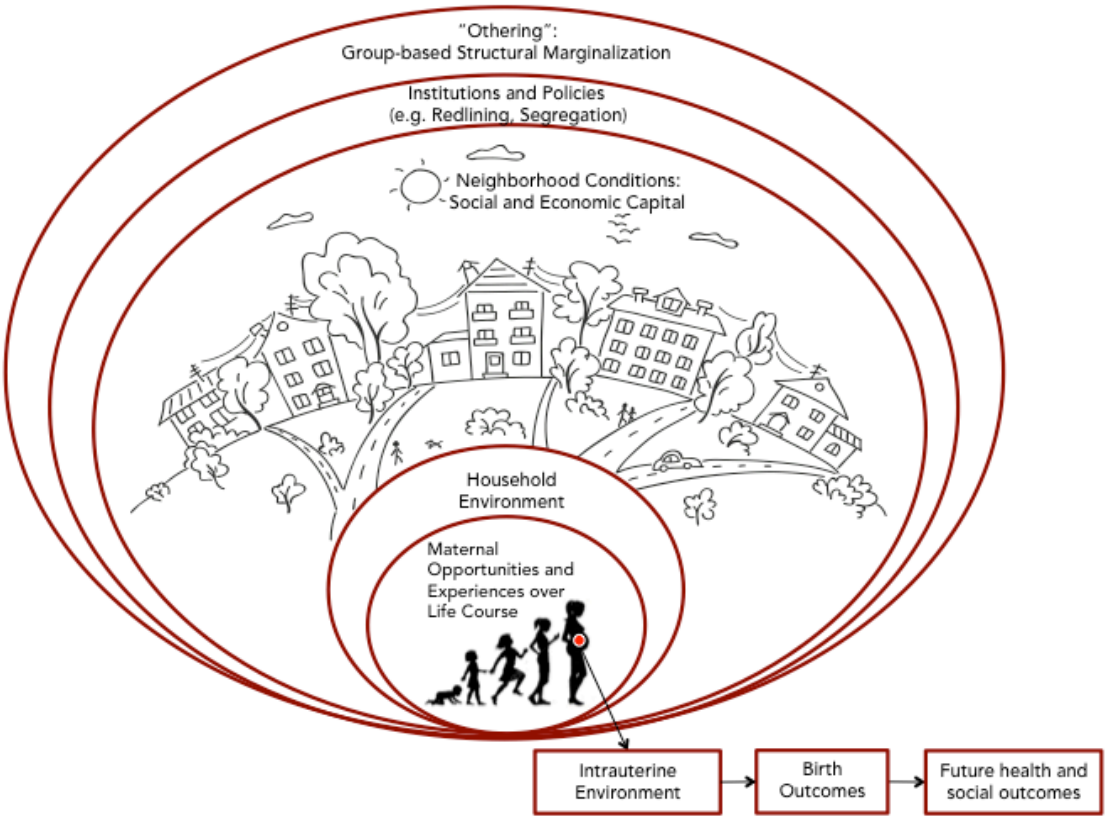
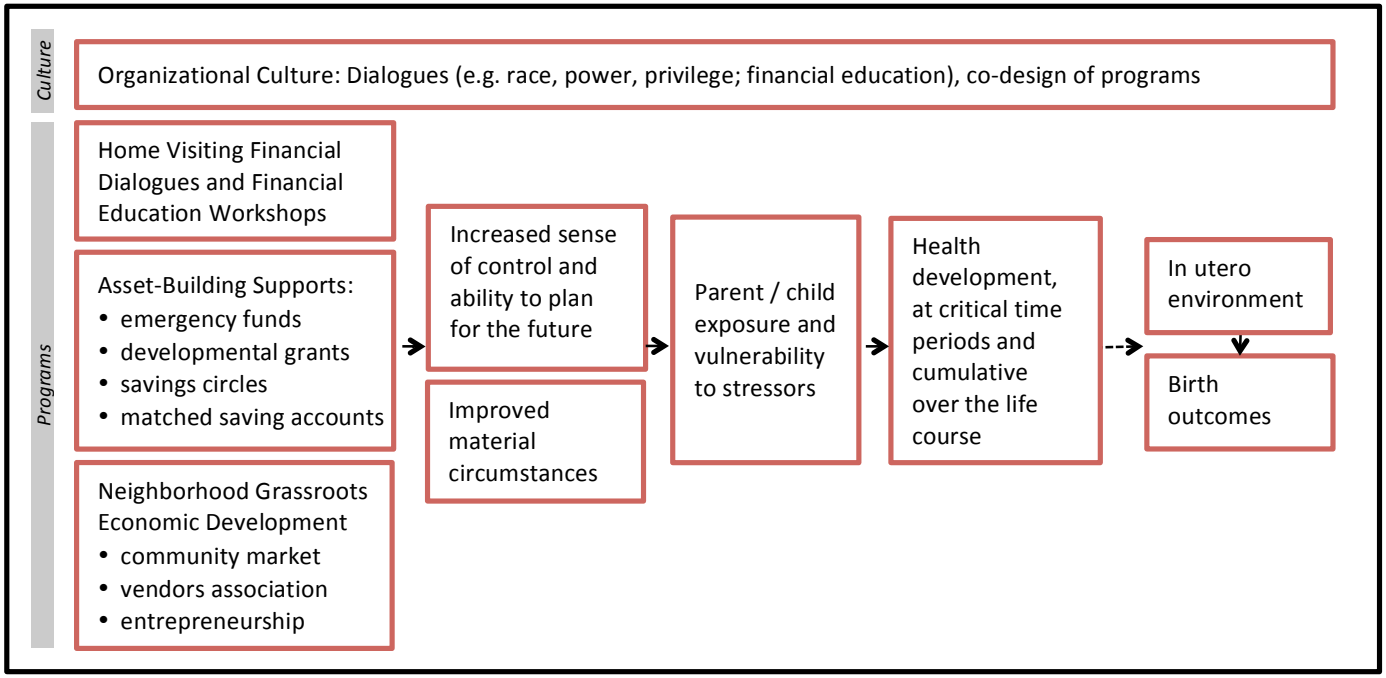


Figure 2. MCH Economic Equity Program Model, Alameda County Public Health Department



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Chapter 5

Conclusion

5.1 Summary of key findings

Preterm birth is a significant public health issue, affecting 9.6% of all births in the U.S. In addition, there are persistent disparities by race/ethnicity. Infants born preterm are at greater risk for serious complications and infant mortality in their earliest days, as well as higher risk for a range of health and educational problems over their life course. This dissertation contributes to growing research suggesting the role structural neighborhood factors play in preterm birth and associated racial/ethnic disparities, and examines the role of MCH practice in addressing these factors.

In Chapter 2, we examined the relationship between long-term structural disadvantage and preterm birth. In our intergenerational cohort of more than 300,000 primiparous mothers and their infants from the Life Course Social Context dataset in California, we assessed the associations of neighborhood poverty histories with preterm birth, defined using census estimates going back to 1970. Preterm infants comprised 8.8% of our study population, and this proportion was highest among mothers residing in neighborhoods with persistent poverty, at 10.2%. In our adjusted analyses we found that compared to mothers who lived in neighborhoods with persistent low poverty, mothers who lived in persistent high poverty neighborhoods had a 16% higher odds, mothers who lived in neighborhoods where poverty was increasing over time had an 8% higher odds, and mothers who lived in neighborhoods with moderate poverty had a 5% higher odds of preterm birth. All these findings were statistically significant. There was no association between decreasing neighborhood poverty and preterm birth. We further found that these relationships, while slightly attenuated, persisted even with adjustment for mother's early childhood neighborhood poverty. Finally we found that persistent high poverty continued to have a higher odds (8%) of preterm birth even when adjusting for cross-sectional neighborhood poverty. Together these findings suggest that long-term structural neighborhood disadvantage may be an important independent contributor to preterm delivery.

In Chapter 3, we examined associations between novel measures of neighborhood-level inequality with preterm birth and their contribution to racial/ethnic disparities, using the Index of Concentration at the Extremes (ICE) along the dimensions of income, racial/ethnicity, and combined income and racial/ethnicity. In our study population of almost 380,000 primiparous mothers and infants, preterm birth proportions were 7.3% for NH White, 10.6% for NH Black, and 8.8% for Hispanic mothers. There were significant trends along all four measures of increasing proportions of preterm birth as neighborhood privilege declined. Adulthood and childhood neighborhood context both had unique and independent contributions to preterm birth. In models that adjusted for both adult and childhood neighborhood context together, mothers

who lived in neighborhoods in the lowest quintile of combined income and racial/ethnic privilege during adulthood had an 8% increased odds of preterm birth, and women who lived in the lowest quintile of combined income and racial/ethnic privilege during childhood had a 13% increased odds of preterm, providing additional evidence to life course hypotheses that childhood environments are critical to the health of the next generation. We also found that models adjusting for both combined income and racial/ethnic privilege and poverty yielded a 27.4% decline in NH Black-White disparities and a 40.2% decline in NH White-Hispanic disparities. Together these findings suggest that childhood and adulthood experiences of neighborhood inequality distinctly contribute to odds of preterm birth, and may play an important role in racial/ethnic disparities.

Chapter 4 advances a conceptual framework for MCH practice, the Intergenerational Structural Inequities Life Course Model, that combines concepts of life course theory, fundamental cause theory, and structural marginalization. We argue that in order to close racial/ethnic disparities in birth outcomes, we must acknowledge the historical and structural forces that have shaped differential distributions of opportunity in the U.S. In addition, we describe how this conceptual framework has been applied to MCH practice at the Alameda County Public Health Department. As one strand of work informed by the Intergenerational Structural Inequities Life Course Model, we describe an incremental approach to design and implementation of economic equity pilot projects, and challenge the field of MCH to develop additional innovative approaches to addressing the root causes of inequities in birth outcomes.

5.2 Conclusion and policy implications

In the U.S., a disproportionate share of health resources go to disease treatment rather than to addressing key underlying factors of disease.[1] Currently 1 in 6 dollars of the U.S. gross domestic product is spent on medical care, but compared to other developed countries we are falling behind in health status and racial/ethnic disparities persist.[2,3] There is a growing movement to direct more health resources toward prevention and advance greater partnerships in health to address the social context that influences health to eliminate disparities in birth outcomes. Efforts have been undertaken by local health departments and public and nonprofit partners to improve opportunities to build assets and transform communities, for example: to prioritize housing for pregnant women[4] to encourage asset-building and financial education in maternal and child health programming[5,6] and provide alternatives to pay-day loans to meet capital needs of communities.[7] The findings from this dissertation research further reinforce the need for cross-sector collaborations[8] in public health and the need for awareness of historical and structural forces that have shaped today's distribution of neighborhood opportunity in the design of interventions. Without awareness of these forces, it is our assertion that interventions will fall short and health disparities will continue to persist.

This work contributes to the growing body of research that health develops over generations and is influenced by the neighborhood contexts. It also provides support to suggestions that we need a "durable" urban policy agenda, one that will reach multiple generations of family members and be sustained over time,[9] because as unhealthy neighborhood conditions developed over a long period of time, we should expect that long-term investments are needed to improve them. It is

our hope that findings from this dissertation showing the additional risk of long-term structural neighborhood disadvantage, the combined risk of economic and racial/ethnic marginalization, and the need for a next-generation MCH practice, will inform future policy and practice to enable all children to be born healthy and have opportunities to reach their full potential.

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