Examining the Complex Legacy of Structural Racism in Shaping Neighborhood Contexts and Racial Disparities in Allostatic Load: Analyses From the Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) Study

by

Marcus R. Andrews

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Doctoral Committee:

Professor Amy J. Schulz, Chair
Professor Linda M. Chatters
Professor Andrew Grogan-Kaylor
Associate Professor Roshanak Mehdipanah

Marcus R. Andrews

marcusan@umich.edu

ORCID iD: 0000-0003-3281-1249

Dedication

This dissertation is dedicated to the memory of my late grandmother, Mrs. Lithia W. Andrews (November 27, 1927 – July 6, 2018), my late stepfather, Mr. Darrin R. Savoy (December 22, 1965 – July 16, 2018), my late aunt, Ms. Dianne Merchant (November 8, 1954 -- January 17, 2022), and those whose shoulders I stand on. May your memories always speak peace to my soul.

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"If God be for us, WHO can be against us?" Romans 8:31. First, giving honor to the good Lord above, who allowed this moment to be possible. Without God, I cannot do anything, and without His hand on my life, where would I be?

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Abstract

In the United States, non-Hispanic Blacks (NHBs) experience shorter life expectancy than non-Hispanic whites (NHWs). This dissertation utilizes multi-level theories and models to examine historic redlining and subsequent neighborhood conditions as contributors to contemporary demographic differences in allostatic load (AL), a measure of chronic stress, using data from the Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study.

Chapter 1 describes the theoretical frameworks and reviews literature pertinent to the central research questions.

Chapter 2 examines associations between Home Owners Loan Corporation (HOLC) score and AL, whether HOLC scores mediate racial disparities in AL, and whether neighborhood socioeconomic status (nSES) mediates associations between HOLC score and AL. Current residents in areas with more redlining had higher AL scores, reflecting higher physiological responses to chronic stress. Associations were stronger for those aged 55-64 compared to those between 35 and 44, and for NHWs compared to NHBs. HOLC scores explained associations between race and AL, and neighborhood deprivation mediated associations between HOLC score and AL. Together, these findings suggest that HOLC scores are associated with contemporary AL and explain contemporary racial inequities in AL. The effects of HOLC on AL are explained by nSES.

Chapter 3 examines: a) associations between four measures of (nSES) and AL over time and variations by age, race, sex, and household poverty; b) whether these associations remain

significant after accounting for physical activity; and c) whether neighborhood perceptions mediate relationships between nSES and AL over time. NDI and neighborhood poverty were associated with AL. Those associations were more positive for individuals aged 65 and older, whites, and women. Associations between nSES and AL were not explained by physical activity (PA) or neighborhood perceptions.

Chapter 4 examines whether: a) the association between neighborhood racial composition (nRC) and AL over time varies by race, sex, and age; b) these associations are mediated by ethnic discrimination, perceived neighborhood environment, or density of neighborhood social institutions; c) nRC mediates associations between HOLC score and AL; and d) nRC mediates associations between HOLC score and nSES. No significant association between nRC and AL was observed, with no variations by race or age. Increases in percent Black was positively associated with AL for females but not males. The non-significant association between nRC and AL was not mediated by perceived ethnic discrimination, perceived neighborhood social environment, or the density of social institutions. Percent Black mediated associations between HOLC score and AL for females but not males and mediated associations between HOLC score and nSES. Together, these findings suggest that nRC is not in and of itself a predictor of AL: Rather, it is on the pathway explaining associations between HOLC score and AL for women, and between HOLC score and some indicators of nSES.

Together, these findings illuminate lasting impacts of historic redlining, a manifestation of structural racism, on contemporary racial inequities in AL, a marker of chronic stress associated with multiple disease outcomes. These associations remain robust after accounting for multiple behavioral and psychosocial indicators, and are significantly explained by the patterning of nSES and nRC. They are consistent with a body of research highlighting the importance of public health interventions that address the lasting impacts of financial divestment from historically redlined and racially segregated neighborhoods in order to address contemporary racial inequities in health.

Chapter 1 : Introduction

Evidence of persistent and longstanding racial/ethnic health disparities has been well documented in the literature (Baciu A, Negussie Y, Geller A, et al., 2017; Kawachi et al., 2005; Orsi et al., 2010). Race-based residential segregation and civic and business disinvestment in predominantly non-Hispanic Black communities have led to substantial and persistent differences in the availability and quality of resources to support health and well-being in predominately non-Hispanic Black as compared to non-Hispanic white neighborhoods[1][2] (Assari, 2018; Brown, 2021; Trounstine, 2018). A clearer understanding of the legacy of historical institutional racism and race-based discrimination is essential for understanding contemporary disparities in resource access and health outcomes and potential interventions to promote racial health equity. Specifically, this study is organized to examine how housing discrimination in the form of redlining practices in the 1940s set in motion processes that continue to influence health inequities today (Chapter 2); specific pathways (positive and negative) through which housing discrimination is linked to health (Chapter 3); and the extent to which neighborhood racial composition, as measured by a racial isolation index and the percentage of a census tract that is Black/African American, is related to

[1] Non-Hispanic Black and non-Hispanic white will be subsequently noted as Black or African American and white, respectively. When referencing specific studies, the racial or ethnic labels that were assigned by article authors will be used.

[2] In conceptualizing our discussion of race for the purposes of this dissertation, it is important that race is not conceptualized as simply a biological category whereby races are defined by their genetic differences as the cause for racial health disparities (Nancy Krieger, 2021a, Chapter From Embodying Injustice to Embodying Equity: Embodied Truths and the Ecosocial Theory of Disease Distribution).

allostatic load, whether those associations are moderated by social relationships, and whether neighborhood racial composition mediates associations between HOLC score and both allostatic load and indicators of neighborhood racial composition (Chapter 4). Together, these findings aim to contribute to our understanding of the long-term health implications of racism imbedded in housing policies, and the pathways through which those health impacts may be operating.

1.1 Theoretical Basis

Briefly, this dissertation is grounded in a large body of theoretical and empirical evidence linking social systems to variations in health outcomes. As noted by Nancy Krieger, these systems allow "some groups [to] have power at another group's expense, in ways that affect options for living a healthy life…[where] differences in health status…are unfair, avoidable, and in principle preventable" (Nancy Krieger, 2021b, p. 2). Further, we must acknowledge the work of Critical Race Theory, specifically the notion that "although structural forces drive inequities, research and interventions disproportionately emphasize individual and interpersonal mechanisms" (Ford & Airhihenbuwa, 2018). Given these complex and multi-level influences on individual and population health, I have grounded my work in several theoretical paradigms that engage multi-level analyses, including the Ecological Model, Fundamental Cause Theory, and the Stress Process Model.

Ecological Model. Ecological Models emphasize that individuals are nested within overlapping social systems which interact to influence individual health outcomes and can also be relevant in understanding the structural patterning of population health outcomes. For this dissertation, social ecological models position individuals as residing in communities whose characteristics are shaped by structural-level influences such as those described below. Applying Bronfenbrenner's (1979) ecological systems model to understand allostatic load (AL), there are three levels of environmental impacts, microsystem (the most minor and most immediate environment), mesosystem (the interaction of different microsystems, i.e., community), and exosystem (the linkages between multiple settings that indirectly influence individual behaviors) (Bronfenbrenner, 1979; Golden & Earp, 2012; Sallis et al., 2008; Stokols, 1992). Using these definitions to apply to this dissertation, the factors in the **Exosystem**[3] include Institutional Racism as codified in policies and legal codes, and in particular, policy decisions and legal codes that have produced and maintained Racial Residential Segregation. Elements in the **Mesosystem** include Neighborhood Resource Distribution, Neighborhood Built Environment, and Neighborhood Social Environment. Finally, factors in the **Microsystem** include Neighborhood Perceptions, Psychosocial Factors, and Social Relationships. Together, these factors in the exo-, meso-, and micro- system have implications for individual health outcomes. In this dissertation, individual health indicators are captured in measures of allostatic load (AL). This dissertation also relies upon the concept of the **Chronosystem** within Bronfenbrenner's models. The chronosystem examines changes over time both within the individual but also within the contexts in which a person may be situated. For the purposes of this dissertation, I will examine changes in the neighborhood or built environmental characteristics with implications for allostatic load as an indicator of health (Bronfenbrenner, 1986). Ultimately, ecological models can be combined with other theoretical frameworks to conceptualize pathways and processes linking various social systems to health outcomes (Sallis et al., 2008). For this dissertation, I integrate social-ecological models with fundamental cause theory and with the stress process model of neighborhoods, as described below.

[3] Bolded terms refer to levels of the Ecological Systems Theory while underlined terms are concepts that will be examined in this dissertation.

Fundamental Cause Theory (FCT)

Socioeconomic Status as a Fundamental Cause. Link and Phelan (1995) assert the need to move beyond merely contextualizing risk factors for disease to identify and consider social conditions that drive differential disease risk-what they term “fundamental causes”. Link and Phelan (1995) argue that fundamental causes are defined by their persistent association with multiple health outcomes and operate by influencing multiple factors that place people or populations in the path of risk and illnesses. In other words, disease risk is shaped by access to specific resources (i.e., money, power, prestige, social connectedness) that can be mobilized to avoid illness or minimize the impact of a disease once obtained (Link & Phelan, 1995). Fundamental causes are factors whose associations with variations in health persist over time, such as socioeconomic status, even as the specific pathways linking them to adverse health outcomes and mortality may shift (Link & Phelan, 1995). The impact of fundamental causes cannot be solely explained by more proximal conditions that link them to a specific illness (Link & Phelan, 1995), and this theoretical framework argues that intervening on proximal health risk factors alone is likely to be ineffective in addressing health disparities if they leave the structural influences on these risk factors unabated (Goldberg, 2014). Specifically, Phelan and colleagues (2010) argue that relationships between fundamental causes and health outcomes are likely to be reproduced with novel mechanisms if interventions focus solely on more proximal factors (Phelan et al., 2010). Furthermore, Link and Phelan (1995) argue and provide evidence to support that the relationship between socioeconomic status and mortality has continued over time because socioeconomic status allows people to have access to a series of health-protective resources irrespective of other oppressive mechanisms that are present at the time (Phelan et al., 2010). If fundamental causes remain unchecked, they will manifest in continued health inequities, even as the specific mediating pathways may change. To be more specific, this argument explains the different pathways through which health disparities are created and remain across population subgroups. Furthermore, these mechanisms shape population health differentials and would continue to be replaced, thus reproducing health inequities.

Segregation as a Fundamental Cause. Building upon the work of Link and Phelan (1995), Williams and Collins (2001) argue that racial residential segregation is a fundamental cause of racial health disparities. Specifically, they argue that racial residential segregation significantly influences Black-white disparities in health outcomes. Segregation is conceptualized as the physical separation by race within the housing sector, supported by government and economic institutions, enforced by the legal system, and legitimized by white supremacy in the United States (Cell, 1982; Massey & Denton, 2019; Smolensky et al., 1991; Williams & Collins, 2001a). Williams and Collins (2001) argued that racial residential segregation is a fundamental cause in that it shapes socioeconomic conditions for Blacks in the U.S. on the individual, household, neighborhood, and community levels.[4] Segregation of Black and white residents of the U.S. has persisted over time, with Blacks disproportionately living in urban or rural communities with predominately Black neighbors, and whites disproportionately living in neighborhoods with predominately white neighbors. While recent data suggests that Black/white segregation has modestly declined, white urban residents continue to live in majority white neighborhoods while Black neighborhoods have become more diverse due to an increase in Hispanic, not white residents

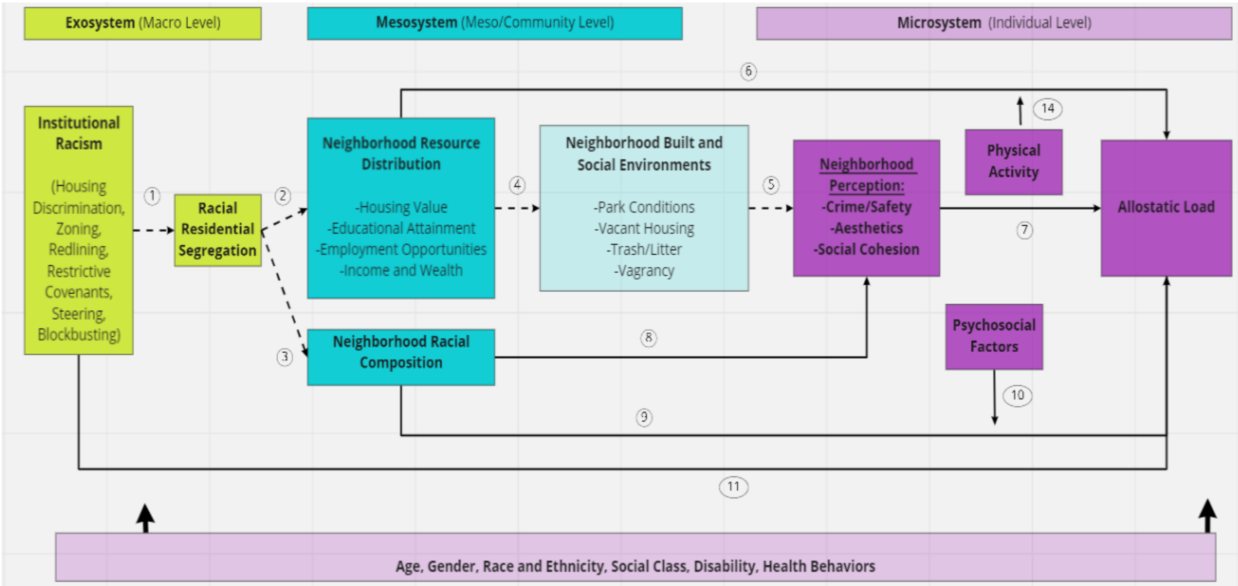
[4] It is important to distinguish between the term's community and neighborhood. Scholars have defined community as "a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in geographical locations or settings" (MacQueen et al., 2001). Conversely, neighborhoods are defined as, "geographical places that can have social and cultural meaning to residents and nonresidents alike and are subdivisions of large places" (Duncan, D; Kawachi, 2018, p. 1).

in these neighborhoods (Frey, 2018). Williams and Collins (2001) spell out in some detail the pathways through which socioeconomic inequalities shaped by racial residential segregation can influence differential social and physical environmental risks, ultimately with adverse impacts on the health of non-Hispanic Black Americans. Those pathways notably include multiple characteristics of neighborhoods that may contribute to stress and poor health among the residents and characteristics that may be protective of health.

The Stress Process Model of Neighborhood. Pearlin (1999) sets forth the Stress Process Model, which incorporates multiple levels of both support and stress at various levels of the ecological model, including the individual and family-levels (microsystems), and community-level (mesosystem). Original formulations of the Stress Process Model focused on mental health as an outcome, asserting that primary stressors (i.e., life events) lead to secondary stressors (i.e., depression) and outcomes that are shaped by the influence of neighborhood context and protective coping (i.e., social support, coping) mechanisms (Pearlin, 1999). Stress processes have subsequently been applied to consider associations between neighborhood context and health outcomes, and substantial research has examined associations between social position and perceptions of neighborhood conditions as aspects of a stress process model. Empirical evidence from a Washington, D.C. metropolitan area study by Schieman and Pearlin (2006) suggested that neighborhood disadvantage was positively associated with subjective reports of neighborhood disorder. However, perceptions of neighborhood disorder were not uniform within neighborhoods, setting in motion efforts to clearly understand what factors may influence those differences even within a particular neighborhood (Schieman and Pearlin, 2006). Specifically, Schieman and Pearlin (2006) found that an individual's subjective financial status, as compared to their neighbors, drives the positive relationship between neighborhood disadvantage and perceived neighborhood disorder. This suggests that those who self-report lower socioeconomic status in comparison to their neighbors may be more likely to have less favorable perceptions of their neighborhoods. Schieman and Pearlin (2006) also found that the associations between observed and subjective indicators of neighborhoods are weakest for those who feel similar to their neighbors economically and most robust both for those who feel advantaged and for those who are unsure of their financial standing. Taken together, these findings suggest some of the characteristics that influence individuals' perceptions of their neighborhoods. Aneshensel (2010) builds upon Schieman and Pearlin's work to examine these hypotheses on the neighborhood level. Specifically, based on her findings, Aneshensel suggests that individual and neighborhood economic statuses impact exposure to various observed neighborhood stressors (Aneshensel, 2010). With this in mind, people residing in the same neighborhood may have vastly different perceptions of their neighborhood environments highlighting limitations of reliance on observed characteristics measured on larger administrative units to estimate neighborhood exposures.

Together these theories inform the conceptual model that underlies the research proposed in this dissertation (Figure 1). The subsequent sections explore the links between concepts that have been hypothesized and supported by empirical evidence (Figure 1). The bolded lines are pathways that will be explicitly tested in this dissertation; The dashed lines are theorized pathways that will not be explicitly tested in this dissertation.

Figure 1-1. Conceptual Model Exploring the Multilevel Influence and Proposed Mechanisms of Institutional Racism on Allostatic Load



<u>Allostatic Load Processes</u>

Allostatic load (AL) is a concept developed by McEwen and Stellar in 1993 (McEwen & Stellar, 1993), to understand the impact of "chronic exposure to fluctuating or heightened neural and neuroendocrine responses resulting from repeated or chronic environmental challenges that an individual reacts to as being particularly stressful" (Guidi et al., 2020, p. 11). Allostatic overload occurs when the environmental stimuli that a person experiences goes beyond an individual's ability to cope. When this occurs, the body's stress responses are consistently activated, and some stress-buffering factors may not be adequate for abating environmental stimuli overload (Guidi et al., 2020; McEwen & Wingfield, 2010).

The body releases a series of primary physiological mediators during a stressful event, including cortisol, epinephrine, dopamine, and serum dehydroepiandrosterone sulfate (Beckie, 2012; Dowd et al., 2009). Each of these mediators causes different primary effects on the cellular level, which can be linked to various measurable outcomes, including blood pressure, HDL cholesterol, total-cholesterol-to-HDL-ratio, and variations in heart rate (Dowd et al., 2009;

McEwen & Seeman, 1999). High AL has been linked to various adverse health outcomes, including cardiovascular diseases (Gillespie et al., 2019), ischemic heart disease (Sabbah et al., 2008), and peripheral arterial disease (Nelson et al., 2007). Research also highlights the importance of examining AL as a health indicator. Specifically, using AL may help understand the different symptom profiles common to clinical practice but often overlooked in the commonly used disease-focused model (Guidi et al., 2020; Henningsen et al., 2018; Kroenke, 2014). This is an important statement because it highlights the importance of using AL to represent multiple bodily systems as a potential precursor to the cumulative impacts of chronic exposure to stressful life conditions and/or environments (i.e., diagnosed disease). One of the potential pathways that explain disease disparities stems from the structural inequalities and other forms of oppression experienced by Blacks in the United States, resulting in chronic stress (Geronimus, 1992).

There are various ways that AL has been operationalized in the literature. For example, roughly 26 different biomarkers used within the literature to measure this concept are primarily related to cardiovascular, metabolic, and immune functions (Duong et al., 2017). The most common markers of cardiovascular function are systolic and diastolic blood pressure, A1C or diagnosis of diabetes are the most common markers of metabolic function, and C-reactive protein (CRP) as the most common marker of immune function (Duong et al., 2017).

Disparities in Allostatic Load Risk

Descriptive statistics from the National Health and Nutrition Examination Survey found racial disparities in the prevalence of AL risk, with Blacks having higher AL scores than whites (Duru et al., 2012). Over the past 20 years, AL has become one of the more common metrics used to examine the body's physiologic response to stress (Duong et al., 2017; Juster et al., 2010; McEwen & Seeman, 1999). Racial and ethnic minority groups are more likely to accumulate more biological risk factors (Crimmins et al., 2007; Geronimus et al., 2006). For example, Crimmins and colleagues (2007) examined biological risk by race, ethnicity, and nativity using data from NHANES. Their analyses found that Hispanics were more likely to have higher biological risk than non-Hispanic whites, but fewer biological risks than non-Hispanic Blacks. However, this relationship for Hispanics disappeared when socioeconomic status was added to the models making the profiles of Hispanics more similar to NHW (Crimmins et al., 2007). Further, their findings posit differences in nativity—for example, the differences in biological risk between foreign-born Hispanics and whites disappeared with the addition of socioeconomic status (Crimmins et al., 2007). Geronimus and colleagues (2006) examined the probability of a higher biological score for Blacks compared to whites using NHANES data. Their results found that Blacks had a higher probability of having a higher allostatic load than whites, and this gap increased with age (Geronimus et al., 2006). When looking at these results by gender, Black women had the highest probability of a high allostatic load score compared to any other racial or gender group (Geronimus et al., 2006). When stratified by race, gender, and socioeconomic status, poorer people had a higher allostatic load than the nonpoor; however, poor whites were less likely to have high scores than nonpoor Blacks (Geronimus et al., 2006). This study presents a series of complex but important findings highlighting racial disparities in allostatic load within the U.S. and suggests that while higher socioeconomic status is protective against earlier mortality among Blacks, it is not protective against early morbidity. Together, these findings suggest that Black/white health disparities are shaped by factors beyond economic resources (Geronimus et al., 2006; Geronimus, 2001; Geronimus et al., 2001; Williams & Collins, 1995).

Additionally, analyses from the National Health and Nutrition Examination Survey (NHANES) found that, on average and after accounting for multiple demographic indicators, Black participants had a higher AL burden than white participants. This higher AL burden was associated with an increased mortality risk independent of socioeconomic factors and health behaviors (Duru et al., 2012). Furthermore, Seeman and colleagues (2001) have proposed that allostatic load is a new measure of the cumulative biological burden placed on the body due to stressful events. While interrelated, allostatic load encompasses more biological indicators than cumulative biological risk. Merkin and colleagues (2009) used data from NHANES to explore the relationship between neighborhood SES and cumulative biological risk. After stratifying their models by race/ethnicity, they found a statistical relationship between lower neighborhood SES and increased AL, with a stronger relationship for Blacks and only Mexican Americans living in urban areas, as compared to whites (Merkin et al., 2009). Merkin and colleagues (2009) explain these findings by highlighting that neighborhood socioeconomic status can determine community resources, including physical activity and recreational facilities, food environments, healthcare resources, and exposure to crime and violence (Merkin et al., 2009). These hypothesized neighborhood factors are important to consider disentangling the associations between neighborhood contexts and health.

Additionally, using data from NHANES, researchers tested four hypotheses related to the role of allostatic load in predicting poor or fair self-rated health. Santos-Lozada and Daw (2018) tested four related hypotheses; a) whether there are racial/ethnic disparities in allostatic load scores; b) whether racial/ethnic differences in self-rated health would be mediated when each of the allostatic load scores were disaggregated; c) whether racial/ethnic disparities in poor/fair health would be mediated by the presence of different allostatic load domains; and d) whether these relationships would vary by gender. Their findings suggest that disaggregating allostatic load into system-specific domains led to the mediation of racial/ethnic disparities and that testing these relationships by sex improved model fit (Santos-Lozada & Daw, 2018). Despite the several studies examining racial differences based on the NHANES dataset, more research is needed to determine whether findings in national studies are replicated in localized contexts.

The Role of Neighborhoods

Neighborhoods have been cited as a significant determinant of health that may be related to individual psychological states and health behaviors (Arcaya et al., 2016; McEwen, 2009). Much of this interest has focused on neighborhood characteristics that may influence health-related behaviors such as physical activity (Ding et al., 2011; Howell et al., 2019; Kepper et al., 2019; Kwarteng et al., 2018; Mitáš et al., 2018; Reid et al., 2017; Sallis et al., 2009) and diet (An & Sturm, 2012; Gilham et al., 2020; McInerney et al., 2016), to name a few. Other work in this area has focused on social and physical characteristics of neighborhoods that may create conditions conducive to stress (Cutrona et al., 2006; Hackman et al., 2019; Sampson S.W & Sampson, and Raudenbush, 2001; Shannon et al., 2020; Stockdale et al., 2007) (e.g., perceptions of safety). Alternatively, building upon stress process frameworks (Aneshensel, 2010; Avison et al., 2010; Schieman & Pearlin, 2006), neighborhoods may offer protection against the adverse health effects of stressors (Andrews et al., 2020; Mair et al., 2010; Salinas et al., 2018) (e.g., social cohesion, social support). Looking beyond individual behaviors to examine macro-level influences may be necessary to understand how more macro contexts matter above and beyond individual behavior. Below, I examine several theoretical frameworks used in the literature examining neighborhood effects on health.

Historical and contemporary aspects of U.S. history have implications for AL through shaping the mesosystems and microsystems within the country. Racism, as a manifestation of white supremacy, is a fundamental cause of disease in that it impacts the lives and health outcomes of marginalized populations (Beech et al., 2021; Devakumar et al., 2020; B. G. Link & Phelan, 1995; Mendez et al., 2021; D. Williams & Collins, 2001b). The superiority attached to whiteness and the inferiority attached to non-white groups results in the inequitable distribution of various resources favoring whites and prejudice towards non-white groups and is demonstrated in various ways (Beech et al., 2021; Bulatao & Anderson, 2004; Marshall, 2015; Steinberg & Jones, 1974). For example, Institutional Racism can be conceptualized as the differences in access to goods, services, and opportunities based on race that become normative through its codification in institutional practices and procedures (e.g., mortgage company lending practices, college admission processes) (C. P. Jones, 2000). Additionally, researchers have defined structural racism as cultural and ideological dimensions that posit non-white groups as different and/or threatening, which rationalizes the inequitable distribution of resources and adverse exposures (Essed, 2014; Nazroo et al., 2020). Also, interpersonal racism includes "day-to-day" experiences and expressions of racism that can be either intentional or unintentional and involves acts of commission or omission in an attempt to maintain structural barriers based on one's membership of a particular racial/ethnic group (Essed, 2014; C. P. Jones, 2000; Nazroo et al., 2020). Finally, internalized racism is conceptualized as accepting stigmatized messages about one's abilities and values based on their membership of a particular race/ethnicity (C. P. Jones, 2000). This dissertation will focus specifically on the role of institutional racism on the social patterning of health outcomes. Each of these levels of racism are interrelated in that there are associations between interpersonal racism and the structural/institutional racism that at play within the United States.

Before continuing, it is essential to note that other racial and ethnic groups, beyond non-Hispanic Blacks, are impacted by racial residential segregation and structural racism within the United States. Although the majority of research focuses on the impact of racial residential segregation on Black health, research also considers the role of racial residential segregation on the health of Hispanic and Asian populations within the United States (Charles, 2003; Iceland, 2009). It stands to reason that racial residential segregation may not uniformly impact health and exposure across all racialized minority groups within the United States. For example, those groups who live in ethnic enclaves have been shown to have protective benefits, including factors such as employment opportunities, decreases in smoking (Kandula et al., 2009), better diets (Osypuk et al., 2009), potential protection from discrimination (Kelly & Schauffler, 1996; Portes & Rumbaut, 2006), that may buffer the ill effects of poverty (Patel et al., 2003; Zhou & III, 1994), and increases in access to capital (Cutler et al., 2008; Edin et al., 2003; Logan et al., 2002; Portes & Sensenbrenner, 2018). This dissertation will focus on associations between neighborhood contextual indicators and allostatic load among Blacks and whites in the United States as research suggests that Blacks have higher allostatic load burden when compared to other racial/ethnic groups (Crimmins et al., 2007).

Historical and Social Developments Associated with the Establishment of Racial Segregation

Institutional Racism[5] can potentially influence AL through housing discrimination and other formal and informal mechanisms that have led to racial residential segregation, limiting housing opportunities for Blacks and other racial/ethnic groups within the United States. This section highlights some of the mechanisms that created and reinforced racial residential segregation. This section also highlights that both personal and institutional racism was historically

[5] Institutional Racism can be conceptualized as the differences in access to goods, services, and opportunities based on race that become normative through its codification in institutional practices and procedures (e.g., mortgage company lending practices, college admission processes) (C. P. Jones, 2000).

and continues to be part of the lived experiences of racial/ethnic groups who have been deemed biologically and culturally inferior and subject to violence and discrimination (Keith, 2014). Whether explicit or implicit, each of these mechanisms supports the physical separation of people based on race (Bell, 2020). Historically, Black neighborhoods in the north and Midwest regions were created as Blacks migrated from the South into northern urban areas as part of the Great Black Migration (Lieberson, 1981; Massey, 2015). During the late 19th and early 20th century, both local and state governments in the South enacted what is known as "Jim Crow Laws," which mandated the physical separation of Black and white neighborhoods (Massey, 2015).[6] Zoning was initially intended to be a mechanism that would protect residential areas from industrial nuisances (Thomas et al., 1997). However, zoning laws became primarily driven by white property owners seeking to protect their property values by limiting Black residential movement under the notion that Blacks would cause neighborhood and property value deterioration (Corburn, 2007; Thomas et al., 1997).[7] The first recorded zoning ordinance was enacted in 1910 in Baltimore, Maryland (Rothstein, 2018). Other southern and border cities that adopted zoning laws in subsequent years included Atlanta, Birmingham, Dade County (Miami), Charleston, Dallas, Louisville, New Orleans, Oklahoma City, Richmond (Virginia), and St. Louis, to name a few (Rothstein, 2018). During the Great Depression, the Home Owners Loan Corporation (HOLC) created maps to guide mortgage companies in refinancing defaulted home mortgages and prevent foreclosures (A. Nardone, Casey, et al., 2020). HOLC categorized neighborhoods into one of four risk groups largely driven by those who lived within them. Predominantly Black or immigrant areas in the city

[6] There are a series of laws that were enacted that vary by cities and other local jurisdictions. However, legislation that was enacted on a national level includes the National Housing Act of 1934, the G.I. Bill, and the Fair Housing Act.

[7] While the enactment of zoning laws varies by city and local jurisdiction, the first case regarding the legality of zoning (Euclid vs Ambler) was argued to the United States Supreme Court in 1926.

were more likely to be outlined in red (Cooney & Jackson, 1987; McClure et al., 2019). In contrast, communities with fewer persons of color were deemed lower risk for mortgages and lending.

In addition to redlining, other mechanisms contributed to the separation of races in residential areas. On the ground, real estate agents played a vital role in maintaining institutional racism. They assigned other colors in what is referred to as "redlining" (Cooney & Jackson, 1987; McClure et al., 2019; W. J. Wilson, 2008). Redlining determined neighborhood eligibility for housing loans and contributed to economic disinvestment and the deterioration of housing in those neighborhoods. Also, the Federal Housing Authority subsidized new developments in suburban areas, stipulating that these new homes were not sold to Blacks (Rothstein, 2018). Restrictive covenants prohibited the sale or rental of property within subdivisions or neighborhoods to non-Whites that began in the late 19th century and became more popular during the early 20th century (Jones-Correa, 2000; C. Rose, 2016). Restrictive covenants were once a standard practice within U.S. real estate institutions.[8] The 1926 U.S. Supreme Court decision on *Corrigan v. Buckley* asserted that since housing contracts were private, the state alone could not interfere if a private seller refused to sell to someone based on their demographic (Jones-Correa, 2000). Even though the Supreme Court outlawed the state-level enforcement of restrictive covenants with the *Shelly v. Kraemer* case in 1948, these practices continued (Rothstein, 2018). For example, parties in favor of restrictive covenants brought court cases against those who violated restrictive covenants under the grounds of damaging community property values since it was believed that Black neighbors diminished property values (Rothstein, 2018). However, the Federal Fair Housing Act of 1968

[8] Restrictive covenants were declared unconstitutional in 1948—before this time, the Federal Housing Authority (FHA) encouraged the enforcement of these covenants as they believed that a sound neighborhood was one where racial residential segregation is enforced (L Brown, 2021; National Commision on Urban Problems, 1969, p. 101).

explicitly outlawed discrimination based on various factors (Rothstein, 2018). Property recording processes make this form of institutional racism present in contemporary times as they still appear in title searches and deeds (Freund, 2014). Despite the unconstitutional nature of these tactics, there are new mechanisms through which racial residential segregation occurs. For example, steering occurs when real estate agents direct or “steer” clients to or away from properties based on the race of the buyers, the race of persons in the neighborhood, or failing to disclose desirable features of either the community or dwelling (Galster & Godfrey, 2005).

Blockbusting was another tactic that utilized white neighbors' fear of having Black neighbors to induce white homeowners to sell their property below market values (Edward Orser, 2019). These properties were then sold to Black buyers at exploitative prices, causing white flight and systematic re-segregation (Edward Orser, 2019). In sum, redlining was a form of institutionalized racism enacted by banks and lending companies, subsidized new development, which barred Blacks from obtaining homeownership in these communities. Neighborhood covenants were a form of institutionalized racism enforced through personally mediated racism, and whites fear of decreased property values caused by having Black neighbors. These examples highlight just a few of the many ways interpersonal and institutional racism has operated in the United States.

Each of these mechanisms highlights how U.S. housing policies provided broader homeownership opportunities for whites. In contrast, Blacks were relegated to either public housing, substandard housing, or predatory tenancy options on segregated terms and had limited housing opportunities (Taylor, 2019). The Federal Housing Authority largely shaped the housing options for residents in metropolitan areas through redlining and Greenlining specific areas (L

Brown, 2021).[9] These actions perpetuate segregation while discouraging integration and taking away opportunities for non-whites (Galster & Godfrey, 2005; Rose, 2016). In the modern context, the enactment of fair housing laws has been credited as the end of racial residential segregation (Bell, 2020). Specifically, the Fair Housing Act (FHA) was enacted as a potential solution to housing discrimination based on a series of demographic characteristics (Fair Housing Act, 1968; Massey, 2015). Despite this federal mandate, housing discrimination within the U.S. has continued to increase, where Blacks and whites live in separate, more homogenous neighborhoods (Bell, 2020; Logan, 2013). Essentially, "forced separation persists through seemingly neutral practices and difficult-to-detect strategies that reinforce racialized power dynamics" (Bell, 2020; Roscigno, 2011). Some of these "seemingly neutral practices" and "strategies that reinforce racialized power dynamics" include mass criminalization through over-policing certain neighborhoods, patrolling borders through monitoring and deciding which demographics belong in white spaces, and designing jurisdictions that allow variations in how the police behave and the policies that they can enforce, to name a few (Bell, 2020).

Racial segregation has been linked to neighborhood inequities, including restricting socioeconomic mobility (Chetty et al., 2020; Hardaway & McLoyd, 2009), limiting access to high-quality education and completion (Axinn et al., 1997; Bhargava, 2017; Conley, 2001; Goldsmith, 2009; Orr, 2003), restricting employment opportunities (Ihlanfeldt, 1994; H. Li et al., 2013; Ruef & Grigoryeva, 2020; Stoll, 2005), and lowering housing/property values (Akbar et al., 2019; P. Christensen et al., 2020; Perry et al., 2018). In the early stages of city development, economically

[9] "FHA almost never insured mortgaged on homes in slum districts, and did so very seldom in the gray areas which surrounded them. Even middle class residential districts in the central cities were suspect, since there was always the prospect that thy, too, might turn as Negroes and poor whites continued to pour into the cities, and as middle and upper-middle income whites continued to move out" (National Commision on Urban Problems, 1969, p. 100)

disadvantaged and minority neighborhoods received fewer and lower-quality services (Trounstine, 2018). These areas were less likely to have sewer connections and paved streets, which placed these communities at higher risk for disease and illness (Trounstine, 2018). Cities in which segregation is increasing are characterized by limited spending on different neighborhood investments, including public goods, leading to inequalities in these neighborhoods' services and goods (Trounstine, 2018).

Furthermore, urban housing structures' dilapidated and worsening status had become inextricably linked with Blackness (Taylor, 2019). Due to mechanisms including redlining and restrictive covenants, limited housing options for Blacks reduced the likelihood that landlords would improve housing conditions within Black neighborhoods. Instead, landlords subdivided already small housing units further to extort Black residents (Taylor, 2019). Furthermore, if the more affluent or non-Black residents view neighborhood racial composition as an indicator of social disorder, they may relocate or disinvest from the neighborhood, reinforcing racial residential segregation (Taylor, 2019). With this in mind, the real estate industry cited the physical conditions of Black neighborhoods as justification for racial residential segregation obscuring the role of broader racist practices and inadequate investments in Black communities (Taylor, 2019).

Research has also suggested a “tipping point” in which the share of non-whites can lead to white flight. In Schelling’s model of racial segregation, he notes how whites’ preferences to living next to one another can lead to complete racial segregation (Schelling, 1971). His model also suggests that even a modest increase in the proportion of non-whites in an area can cause an exodus of white residents. Fernandez and colleagues (1993) have also reported the belief by whites that increasing numbers of Black families would cause them to relocate to other areas (Fernandez et al., 1993). Writing in the early 1990s, sociologist Reynolds Farley (1994) theorized three main drivers of racial residential segregation: economic differences between races, preferences of Blacks and whites, and discriminatory practices within the real estate market (Farley et al., 1994). In later writing, income disparities were dropped from the discussion due to empirical research finding that affluent Blacks do not live near affluent whites, nor do Black poor live near the white poor (Denton & Massey, 1988; Farley, 1977; Farley et al., 1994; Taeuber, 1968). The exclusion of income disparities as a primary driver of racial residential segregation in favor of a more racial/ethnic approach highlights the potential influence of race and ethnicity in constraining and influencing residential choices within the United States context. Ultimately, these frameworks involve individuals' preferences to live near co-ethnics as well as institutional racism embedded in discriminatory practices in the real estate, shaping housing options for certain racial/ethnic groups. Research from the late 20^{th} century analyzed residential preferences and found that Blacks and whites wanted to live in racially concordant neighborhoods. Using this logic, racial residential segregation would only decrease if there were changes in racial preferences by buyers without any penalty for discrimination on the part of mortgage lenders and other real estate actors (Clark, 1991; Clark, 1986, 1988; Farley et al., 1994). Massey and Denton (2019) continue this discussion by hypothesizing that housing preferences by whites are primarily grounded in held racial stereotypes. Specifically, real estate actors may hold racial stereotypes which guide discriminatory practices within the housing market (DeMarco & Galster, 1993; Korver-Glenn, 2018). Korver-Glenn notes that housing market professionals and other real estate actors draw upon widely shared racial stereotypes which are applied to both those who are seeking housing as well as different neighborhoods (Korver-Glenn, 2018). This statement is relevant for this discussion in that it highlights that even race-neutral policies can impact the housing opportunities for minoritized communities within the United States (Korver-Glenn, 2018). Massey and Denton hypothesize that

Blacks often experience housing discrimination and, since they are likely to feel unwelcomed in white neighborhoods, will prefer neighborhoods where Blacks are in the majority (Massey & Denton, 2019). Reynolds Farley and colleagues (1994) examined racial stereotypes on housing preferences in Detroit in the early 1990s. Their results showed that whites were interested in living in integrated neighborhoods and that racial stereotypes about non-whites was not the primary reason why some whites moved with the arrival of Black neighbors (Farley et al., 1994). However, their results found that increases in the number of Blacks in a neighborhood were linked with an increase in white flight and that less than half of the whites in the study indicated that they would move into a neighborhood with more than just a few Black families (Farley et al., 1994). On the other hand, between 1976 and 1992, Black preferences for integrated neighborhoods decreased, suggesting that Blacks, in the early 1990s, preferred to live in more racially concordant neighborhoods (Farley et al., 1994). However, this finding did not hold for upper class Blacks, who did not experience a change in attitudes: they favored residing in more integrated neighborhoods (Farley et al., 1994). Lower-income Blacks in the study noted that they avoided white neighborhoods in favor of Black neighborhoods because they believed that hostile whites did not want them as neighbors (Farley et al., 1994).

While these findings are over 30 years old, similar attitudes have been reported in more recent studies. Specifically, findings from a study that included data from Detroit, Atlanta, Boston, and Los Angeles (Charles, 2006) suggest that roughly 45% of whites indicated that they would be willing to move into a neighborhood where 30% of residents were Black (Charles, 2006). Fewer whites noted that they would move into a neighborhood that was more than 50% Black (Charles, 2006).

Taken together, these findings shed light on several racial differences in housing preferences. These findings are relevant for this exploration because they suggest that whites and Blacks may assess their neighborhoods differently, not solely due to the observed phenomenon but to subjective perceptions of their environments. Additionally, neighborhood preferences may differ based on income, even within the same race.

Contemporary housing processes are slightly different from the practices that have been outlined above. For example, the advent of the internet and the ability for a potential homeowner to visit model homes and engage with housing development staff reduce the need for face-to-face interaction with a realtor or mortgage broker (Lacy, 2007). Existing literature on racial residential segregation is primarily guided by the notion that predominantly white neighborhoods are the primary choice of residence for middle-class Blacks seeking homeownership; however, growing evidence suggests that this may not be true (Lacy, 2015). Karyn Lacy hypothesizes that Black residents were not "steered" to these communities in the sense that was outlined above but were drawn to the concept of living in a distinctly Black suburban enclave (Lacy, 2015). It has also been hypothesized that the rise in Black enclaves was largely guided by whites' avoidance of predominantly Black neighborhoods (Dent, 1992; Lacy, 2015). Lacy hypothesizes that the rise in Black enclaves can be attributed to the fact that housing developers notice that Black upscale subdivisions are profitable (Lacy, 2015). In marketing these communities to upper-income Blacks, they can live in racially concordant neighborhoods that isolate them from whites and the Black poor (Lacy, 2015). Lacy's work is focused on the Washington, D.C. metropolitan area, so it is not necessarily known if this hypothesis would be relevant for other areas across the United States.

To my knowledge, there has only been one study that quantifies the number of non-whites in a neighborhood that would cause a neighborhood to "tip" (Card et al., 2008). Using regression discontinuity methods and census tract data between 1970 and 2000, Card, Mas, and Rothstein (2008) studied this question across the United States. Their analyses suggest that between 1970 and 2000, whites tended to exit cities when the non-white proportion reached between 5% to 20%, with higher tipping points being found in cities with more tolerant racial views (Card et al., 2008). This tipping point has implications for contextualizing the devaluation of assets in Black areas and perceptions of crime and safety with the presence of Blacks (Perry et al., 2018; Quillian & Pager, 2001). Additional studies have used these methods to explore similar relationships across different time points and international contexts (Aldén et al., 2015; Kollmann et al., 2018; Shertzer & Walsh, 2019). This research is relevant to the work of this dissertation in that it could suggest that Black and white residents within the same neighborhood may have very different assessments and experiences of their neighborhood which are grounded in their individual racial/ethnic identity as well as socioeconomic status.

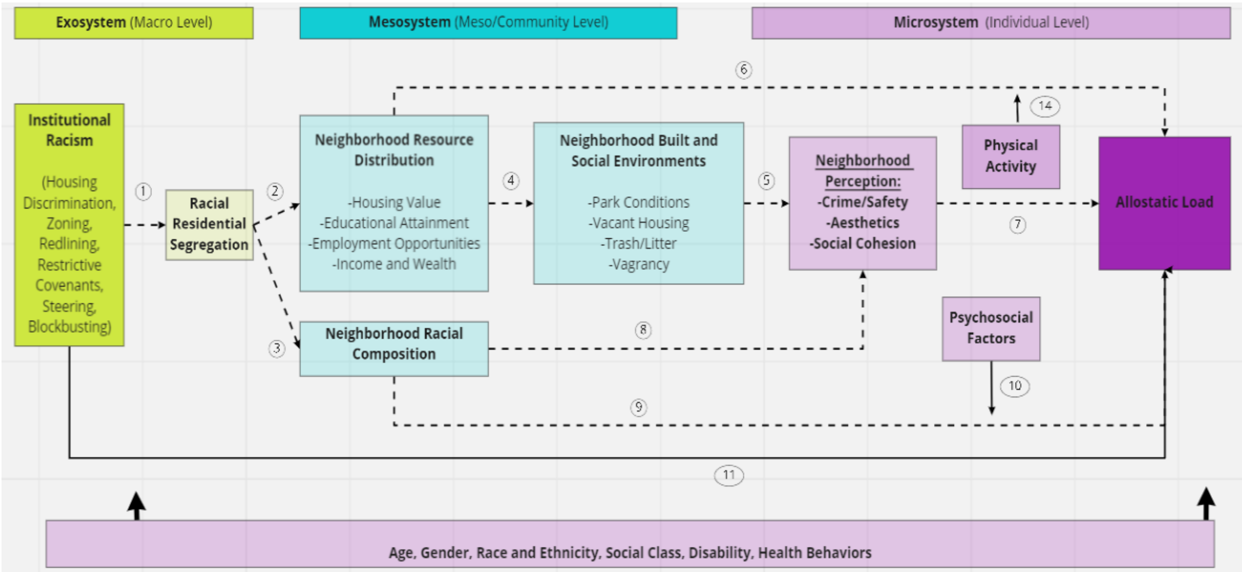
Neighborhood Segregation and AL

As previously mentioned, racial residential segregation has important implications for both AL and overall health and wellbeing. Existing literature has examined the impact of racial residential segregation on AL. Using data from Wave III of NHANES, Bellatorre and colleagues (2011) examined the relationships between two measures of neighborhood segregation and AL. Their analyses found a statistically significant positive relationship between a dissimilarity index and AL that remained significant after adjusting for age, gender, health insurance status, education, health status, income-to-poverty ratio, and marital status (Bellatorre et al., 2011). However, the dissimilarity index and AL models became insignificant with the addition of race/ethnicity, race interactions, and the proportion of residents who were Spanish-speakers (Bellatorre et al., 2011). Segregation, as measured through a normalized exposure index, was statistically related to increases in AL which remained significant after adjusting for age, gender, race/ethnicity, income-to-poverty ratio, health status, race interactions, marital status, education, insurance status, and Spanish-speaking proportion (Bellatorre et al., 2011). These findings suggest that neighborhood characteristics matter for allostatic load. However, there appear to be other factors that also contribute to the excess risk for higher allostatic load among minoritized groups. The normalized exposure measure of segregation remained significant after accounting for various things, while the dissimilarity index did not. This could possibly mean that the measure of segregation that is used may matter in examining these complex relationships. Normalized exposure index measures the likelihood that people of different races will interact with each other while the dissimilarity index simply assesses the distribution of racial groups. The normalized exposure is important in that it shows the likelihood that people will interact, this is important because we cannot assume that just because people live in a neighborhood there will be interactions between these groups. Increases in these interactions could either be protective or detrimental to people's health through either increased exposure to discrimination or increased social support, among others.

Similarly, using biomarker data from NHANES, Li, and colleagues (2019) examined the associations between neighborhood racial/ethnic diversity and metabolic syndrome. Their analyses found that neighborhood racial diversity (measured by the index of racial/ethnic heterogeneity) was related to decreased odds of metabolic syndrome even after adjusting for individual race/ethnicity, age, age squared (age squared was added to account for a possible curvilinear relationship between age and metabolic syndrome biomarkers), gender, marital status, nativity, education, income-poverty ratio, medication, or by neighborhood-level indicators of neighborhood poverty concentration, and urbanicity (Li et al., 2019). When stratified by gender, racial diversity was associated with decreased odds of metabolic syndrome for women when adjusting for urbanicity; this relationship became insignificant when neighborhood poverty concentration was added to the models (Li et al., 2019) and was not found among men. When the models were stratified by age, those between 45-65 had decreased odds of having metabolic syndrome when neighborhood racial diversity increased even after adjusting for urbanicity and poverty concentration (Li et al., 2019). However, these relationships were insignificant among people aged 18-44 (Li et al., 2019). When the models were stratified by urbanicity, increases in racial diversity were related to decreased odds of metabolic syndrome even after adjusting for poverty concentration. However, these relationships were not found among those living in non-rural areas (Li et al., 2019). The stratified models were adjusted for age, age squared, race/ethnicity, marital status, nativity status, education, income-poverty ratio, and blood pressure and cholesterol medication use. It is important to note a significant limitation of this particular study. Racial diversity is conceptualized using the index of racial and ethnic diversity in social sciences. While this measure can assess heterogeneity, it does not account for the relative size of specific racial groups (Rushton, 2008); therefore, neighborhood diversity in relation to these outcomes must be interpreted with caution as estimates of neighborhood composition may underestimate the proportion of each racial group within a jurisdiction. In regard to Li and colleagues' study (2019), their associations between neighborhood diversity and allostatic load are not capturing the true composition of racial groups within their unit of analysis, which are limitations of the racial measure. Taken together, existing literature examining the impact of neighborhood racial composition on AL and similar components of allostatic load and bodily functions suggest that living in a segregated neighborhood may have deleterious impacts on overall health. These findings also suggest that even within Blacks, there are variations in outcomes based on other demographic factors including gender. Furthermore, these studies have primarily utilized national datasets which emphasizes the need to determine whether these relationships can be found within more localized cohorts. This would provide the opportunity to examine potential regional or context specific differences in the patterning of these relationships.

Several recent studies have begun to explore the relationship between historic Home Owners' Loan Corporation (HOLC) redlining maps and contemporary health outcomes, including maternal and child health outcomes (Huang & Sehgai, 2022; Nancy Krieger, van Wye, et al., 2020), self-reported health (McClure et al., 2019; A. Nardone, Casey, et al., 2020), increased mortality (Huang & Sehgai, 2022), gun violence (Benns et al., 2020; Jacoby et al., 2018), COVID-19 (Li & Yuan, 2022), and both physical and mental health (Lynch et al., 2021). Across differing outcomes, these studies found that historic redlining was associated with adverse contemporary health outcomes. However, associations between historic redlining and allostatic load remain understudied; this is an essential gap as allostatic load is a multicomponent indicator of the effect of stress on the body. Specifically, there is an overall failure to clearly understand the pathways and processes through which historic redlining may be linked to contemporary health outcomes. Given allostatic load's association with a series of health indicators, understanding the role of historic redlining on allostatic load would allow for a more nuanced understanding of the contemporary spatial patterning of disease. This is important to understand to spark more tailored interventions to improve the health outcomes of urban populations. Therefore, Chapter 2 of this dissertation seeks to examine the relationship between historic redlining and the contemporary patterning of allostatic load risk within a Baltimore-based cohort (Link 11) (Figure 1-2).

Figure 1-2. Conceptual Model Highlighting the Relationship between Institutional Racism and Allostatic Load



Neighborhood Poverty and Health

Historic redlining initiated a series of processes and mechanisms that created neighborhoods characterized by concentrated disadvantage and overall disinvestment. The mechanisms through which historical redlining impacts current health outcomes is important for this dissertation as it helps to illuminate the different hypotheses that will be tested and explored in subsequent chapters. Specifically, chapters 2 and 3 of this dissertation suggest that historic redlining led to neighborhood disinvestment which in turn contributes to contemporary patterns of concentrated poverty. I also explore whether these contemporary drivers of poverty also drive contemporary allostatic load scores.

As previously mentioned, allostatic load and cumulative biological risk are parallel concepts used to represent multiple indicators of health. Existing research has established a positive relationship between neighborhood poverty and CBR among adults (Diez Roux, Ana; Mair, 2010; Schulz et al., 2012). Additionally, research has found that lower household socioeconomic status has been associated with higher levels of AL (Christensen et al., 2018; Friedman et al., 2015; Gruenewald et al., 2012; Gustafsson et al., 2011; Hawkley et al., 2011; Hickson et al., 2012; Lipowicz et al., 2016; Rodriguez et al., 2019; Seeman et al., 2014; Upchurch et al., 2015). Similar research has suggested that people with higher personal socioeconomic statuses had lower AL scores (Lipowicz et al., 2014; Präg & Richards, 2019; Robertson et al., 2014; Robertson & Watts, 2016; M. Weinstein et al., 2003; Xu, 2018). There have also been studies that have examined the relationship between neighborhood-level socioeconomic status and AL. Specifically, a series of studies indicate that higher neighborhood socioeconomic status is associated with lower AL (C. E. Bird et al., 2010; Gene H. Brody et al., 2014; Merkin et al., 2009, 2020; Theall et al., 2012) and CBR scores (Schulz et al., 2013), even after models were adjusted for individual-level socioeconomic status. Specifically, using data from NHANES, Bird and colleagues (2010) found an inverse association between neighborhood socioeconomic status and biological risk, even after adjusting for age, gender, race/ethnicity, marital status, nativity, education, and income to poverty ratio. Merkin and colleagues (2009) build upon Bird et al.'s work to examine these relationships using NHANES. Their models were stratified by race/ethnicity, and their results show that the strongest relationships were found among Blacks and Mexican Americans (Merkin et al., 2009). Furthermore, King and colleagues (2010) examined the relationship between neighborhood context and biological risk factors using the Chicago Community Adult Health Study data. Their analyses found that higher neighborhood socioeconomic status was associated with lower CBR. However, neighborhood disadvantage was not significantly related to CBR, even after adjusting for age, gender, race, immigrant status, education, income, physical activity, fruit/vegetable intake, smoking, and drinking (King et al., 2011). These findings suggest the protective nature of living in a high socioeconomic status neighborhood, even after accounting for multiple individual-level characteristics.

Analyses have also been conducted to explore these relationships, specifically within minoritized cohorts. For example, using data from the Boston Puerto Rican Health Study, Jiménez et al. (2015) examined the impact of baseline neighborhood socioeconomic status (measured at the block group level and allostatic load two years later (Jiménez et al., 2015). Their analyses found that Puerto Ricans who had higher household income than their neighbors had lower allostatic load after two years even after adjusting for neighborhood socioeconomic status, age, gender, individual-level SES, length of residency, and city; however when baseline allostatic load was added into the models, the relationship between neighborhood socioeconomic status and allostatic load became insignificant (Jiménez et al., 2015). Barber and colleagues (2016a) used the Jackson Heart Study data to examine the relationship between neighborhood disadvantage and cumulative biological risk among African American adults in Jackson, Mississippi. Their analyses found a positive relationship between neighborhood disadvantage and cumulative biological risk controlling for age, gender, and individual socioeconomic status. However, health behaviors (diet, active living score, alcohol use, and smoking status) attenuated the relationship, the association between neighborhood socioeconomic status and cumulative biological risk remained significant (Barber et al., 2016a). This suggests that neighborhood socioeconomic status is significantly associated with cumulative biological risk above and beyond individual characteristics and health behaviors. They also found that these relationships were the strongest among the neuroendocrine and metabolic subcomponents of cumulative biological risk but were not significantly related to cardiovascular or inflammatory subcomponents (Barber et al., 2016a). Using data from the Biomarker Project of the Midlife in the United States (MIDUS) study, Robinette and colleagues

(2016) examined whether lower neighborhood socioeconomic status is cross-sectionally related to AL. Their analyses found that neighborhood income was inversely related to allostatic load controlling for individual income, age, gender, perceptions of safety, cohesion, perceived stress, anxious arousal, exercise, smoking, and fast-food consumption (Robinette et al., 2016). Ultimately, their findings suggest that lower socioeconomic status neighborhoods have altered physical and social contextual features, increasing individuals' exposures to stressors, decreasing community-level social support, and decreasing their ability to engage in certain health behaviors (Robinette et al., 2016).

However, paradoxical relationships have been identified by researchers using a Baltimore-based cohort. Using Healthy Aging in Neighborhoods of Diversity data across the Life Span, Waldstein and colleagues (2016) examined the interactive relationship between race and poverty on several cardiovascular indicators. After adjusting for age, gender, race, education, health behaviors, and mental health factors, increases in poverty were associated with significant increases in BMI, Waist Circumference, and HDL cholesterol (Waldstein et al., 2016). They found a significant interaction between race and poverty within this sample (Waldstein et al., 2016). Results showed that African Americans living in poverty had lower BMI and waist circumferences but higher HDL cholesterol than African Americans not living in poverty (Waldstein et al., 2016). However, whites living in poverty had higher BMI than whites not living in poverty (Waldstein et al., 2016). For people who are living in poverty, BMI was higher for whites than for African Americans. However, among those not living in poverty, BMI was higher for African Americans compared to whites (Waldstein et al., 2016). Additionally, African Americans living in poverty had lower waist circumferences than non-poverty African Americans and whites, irrespective of their poverty status (Waldstein et al., 2016). These studies have illustrated the need to parse out these relationships as some of the hypothesized relationships may vary by individual characteristics and racial and ethnic groups.

International studies also support United States based research that finds an inverse relationship between socioeconomic status and allostatic load. Using data from the Northern Swedish Cohort, Gustafsson and colleagues (2014) examined the relationship between the accumulation of neighborhood disadvantages in early to mid-life was related to allostatic load in midlife. Their results showed that neighborhood disadvantage over the life course was associated with higher allostatic load even after controlling for life course living conditions (Gustafsson et al., 2014). Ribeiro and colleagues (2019) examined the association between neighborhood deprivation and allostatic load using data from three cohort studies (CoLaus-Switzerland, EPIPorto-Portugal, Whitehall II-United Kingdom). The results from their models found that those living in the most deprived quintile of neighborhood deprivation were 1.13 times more likely to have a high allostatic load compared to those living in the least deprived quintile after adjusting for age, sex, marital status, smoking status, alcohol consumption, and physical activity (CI=1.09-1.16) (Ribeiro et al., 2019). These relationships were partially modified by individual socioeconomic status, where the relative risk for a higher allostatic load was higher for people with a lower socioeconomic status compared to those with a higher socioeconomic status (Ribeiro et al., 2019).

A series of moderators and mediators of the association between socioeconomic status and either cumulative biological risk or allostatic load have been found within the literature. Using data from the Jackson Heart Study, Barber and colleagues (2016) examined the moderating role of social cohesion on the relationship between neighborhood disadvantage and cumulative biological risk. Their analyses found a statistically significant interaction between neighborhood disadvantage, social cohesion, and gender (Barber et al., 2016b). Their results also found a marginally significant (p-value = 0.06) positive relationship between neighborhood disadvantage and CBR, which was strongest among men living in neighborhoods with the lowest levels of social cohesion (Barber et al., 2016b). This finding was largely driven by the neuroendocrine component of CBR (Barber et al., 2016b). Schulz et al, (2012) also explored the relationship between neighborhood poverty and allostatic load and tested whether perceptions of neighborhood stress mediated this relationship. In their subsequent paper, Schulz et al, (2013) established associations between neighborhood poverty and CBR and whether perceived indicators of neighborhood social and physical environment and observed indicators of neighborhood disorder and deterioration mediated these relationships among a Detroit-based sample.

LeBron and colleagues (2019) examined the impact of four metrics of neighborhood social relationships, including social support, neighborhood satisfaction, social cohesion, and neighborhood participation, on CBR. In models that adjusted for neighborhood poverty, social support (marginally protective p=0.06), neighborhood satisfaction, social cohesion, and neighborhood participation were not statistically associated with CBR (Lebrón et al., 2019). However, their results suggest that increases in individual-level neighborhood satisfaction was protective of CBR after adjusting for neighborhood-level poverty—there were no significant associations found with individual-level social support, social cohesion, and neighborhood participation (Lebrón et al., 2019). In models that included all social indicators, individual-level social support was positively associated with CBR while neighborhood-level social support was protective against increases in CBR (Lebrón et al., 2019).

The relationship between neighborhood socioeconomic status and AL or CBR appears mixed, but more consistent evidence indicates an inverse relationship between socioeconomic status and AL or CBR. Furthermore, this body of literature has also focused on the stress process pathways that conceptualize neighborhood characteristics as potential stressors and examine their associations with CBR and AL as indicators of cumulative stress. While some health behaviors, such as physical activity, have been used as control variables, the presented literature has not examined these behaviors as mediators. Despite using national and local datasets, the relationship between neighborhood socioeconomic status and allostatic load has not been explored among adults living in a large, urban metropolitan-based cohort in the Mid-Atlantic/Eastern region of the United States. Since mixed findings are reported in the literature, there is an opportunity to make the case that there may be local variations in some of the relationships presented in this review. Specific local contexts and histories could shape the potential variation in the relationships between neighborhood contexts and allostatic load. Given the different social, political, and economic histories of these densely populated regions, these relationships may differ from other areas of the United States. Prior findings also highlight the utility of exploring different demographic and contextual variables as potential moderators and mediators of these relationships. Therefore, continued research should explore the relationship between neighborhood socioeconomic status and measures of the impact of stress on health among more local cohorts. Since research has asserted that neighborhoods matter differently for different people, more effort must be spent on parsing these relationships, which would help inform more tailored-to-place interventions and community advocacy efforts.

The Role of Perceptions

Despite growing research on the impact of AL on health indicators, information is limited on the role of subjective perceptions of neighborhood environments and AL. Neighborhood perceptions may also be important as more observed measures of neighborhood environment are measured at a governmental unit of analysis (i.e., census tract, zip code, county) and there is evidence to suggest that individual perceptions of their neighborhood contexts may vary by, for example, race, age, and gender (Aneshensel, 2010; Farley et al., 1994). As a result, incorporating neighborhood perceptions may capture information about neighborhood contexts that more observed measures may not (Andrews et al., 2020; Plunkett et al., 2007; Roosa et al., 2009b). Furthermore, while neighborhoods may have certain shared area-level characteristics, individuals may experience their neighborhood differently—these subjective assessments are hypothesized to have an independent impact on an individual's health (Andrews et al., 2020; Ceasar et al., 2020; A. V. Diez Roux, 2001; Powell-Wiley et al., 2013; Sampson & Raudenbush, 2004). Schulz and colleagues (2012) found significant associations between neighborhood poverty and CBR within Detroit—their analysis found that the relationship between neighborhood poverty and CBR was attenuated with the addition of neighborhood environment stress and acute life events after adjusting for individual characteristics and health behaviors. Also, Schulz and colleagues (2013) found that associations between observed neighborhood characteristics and CBR were attenuated with the addition of neighborhood perceptions in their models for residents of Detroit. Their analyses also found that both observed and perceived indicators of the neighborhood built and social environments mediate the associations between neighborhood poverty and CBR (Schulz et al., 2013). These findings are important as they suggest that while observed neighborhood environments matter (e.g., at the census tract level), subjective or perceived measures of neighborhood environments may offer additional insights in helping to explain the associations between neighborhood economic characteristics and CBR.

Wen and colleagues (2006) also highlight the importance of examining neighborhood perceptions as they note that observed and perceived neighborhood characteristics are "linked yet distinct constructs, both of which are on the pathway from place to health with neighborhood perceptions seemingly more proximate to health" (Wen et al., 2006, p. 2585). Subjective perceptions of neighborhood contexts are also important due to their links to subjective stress (Galaviz et al., 2016; Maisel, 2016; Weden et al., 2008). While observed characteristics have been widely used, perceptions of neighborhoods provide valuable information about neighborhood contexts that observed measures cannot capture (Plunkett et al., 2007; Roosa et al., 2009b). Essentially, neighborhood perceptions are an added factor on the pathway between neighborhood observed conditions and physiologic responses to stress. Understanding the social patterning of differential responses to observed characteristics of the environment can help us to better understand the social patterning of allostatic load and associated health outcomes.

As mentioned, ecological models emphasize that individuals are nested within a series of organizational levels that interact to influence health. It has been noted that individuals process and form beliefs or perceptions of their environmental contexts, which affects how an individual interacts with those environments (Bandura, 1986; Bronfenbrenner et al., 1984; Rutter et al., 1997). Specifically, Roosa and colleagues (2003, 2009b) suggest that perceptions of neighborhood environments mediate the association between observed neighborhood measures and health outcomes. Using their theory, perceptions shape both individual and family processes which directly impact health (Roosa et al., 2003). Since perceptions involve a subjective assessment of surrounding contexts through "cues to care," people living within the same neighborhoods may perceive the same neighborhood conditions differently, leading to differences in health outcomes (Hostetler, 2021; Roosa et al., 2009a). Given that research has suggested that residents of neighborhoods with a higher percentage of Black people are more likely to report less unfavorable perceptions compared with residents of neighborhoods with higher proportions of non-Hispanic whites, examining the impact of perceptions on AL may be necessary for exploring the nuances of this relationship and their implications for health (Boslaugh et al., 2004; W. Li et al., 2017; Powell-Wiley et al., 2013).

Findings from previous research has been consistent with the idea that perceptions of more adverse neighborhoods and the sense of threat that ensues would be related to heightened stress response (Hill & Angel, 2005; Ross & Mirowsky, 2001). Examining the relationship between neighborhood perceptions and AL has been understudied in the literature. To my knowledge, there are a few studies that examine these relationships (Carbone, 2020; Schulz et al., 2012, 2013; Van Deurzen et al., 2016). Of these, it has been consistently suggested that those with more favorable neighborhood perceptions had lower AL scores. These studies have used data from surveys based in Detroit (Schulz et al., 2012, 2013), Texas (Buschmann et al., 2018), national cohorts (Carbone, 2020a, 2020b), international cohorts (Van Deurzen et al., 2016). Others have limited neighborhood perception domains (Carbone, 2020) (Table 1).

Schulz and colleagues (2012) examined the relationship between neighborhood poverty and AL in low to moderate income communities in Detroit Michigan. Their results found that the relationship between neighborhood poverty and AL was mediated by self-reported neighborhood environmental stress (Schulz et al., 2012). Using the same cohort, Schulz and colleagues (2013) examined the role of both observed and perceived neighborhood characteristics in the associations between neighborhood poverty and CBR. Their findings showed that both observed and perceived measures of neighborhood characteristics were associated with CBR even after adjusting for neighborhood poverty, neighborhood racial/ethnic composition, and individual behaviors and demographics (Schulz et al., 2013). Mediation analyses results showed that both observed and perceived measures of neighborhood environments significantly mediated associations between neighborhood poverty and CBR. They were unable to rule out the null hypothesis that perceived environments did not mediate associations between observed indicators of neighborhood environmental risk and CBR (Schulz et al., 2013). This finding lends weight to the argument that perceptions of the environment may reflect dynamics above and beyond the effects of observed neighborhood conditions. With this in mind, there is some evidence that does not rule out the possibility that perceptions may mediate observed indicators (Roosa et al., 2009b). This is an important point to make because it highlights the remaining uncertainties about whether neighborhood perceptions are mediation pathways or whether neighborhood perceptions make an independent contribution to explaining the neighborhood phenomenon and its implications for health. With this in mind, it is important that research examine the role of neighborhood perceptions.

In a separate analysis using a diverse population-based sample in Texas, Buschmann and colleagues (2018) examined the relationship between neighborhood quality and AL using two measures of observed and one measure of perceptions of neighborhood environments. After adjusting for individual-level covariates, neighborhood SES nor objective neighborhood quality were significantly related to AL (Buschmann et al., 2018). Their analyses also found that only perceptions of neighborhood quality was significantly inversely related to AL even after adjusting for individual covariates (age, sex, race/ethnicity, marital status, income, years lived in neighborhood, home ownership, individual neighborhood perceptions, health insurance status, and current health conditions) (Buschmann et al., 2018). Their analyses also found neither stress (as measured by Cohen's perceived stress scale) nor health behaviors mediated these relationships (Buschmann et al., 2018). With this in mind, it is important to note that Cohen's Perceived Stress Scale is generic and does not specifically assess stresses associated with neighborhood characteristics. This limitation could be a part of why stress was not a significant mediator of neighborhood conditions and health outcomes.

Using data from the Midlife Development in the United States study, Carbone (2020b) sought to examine the mediating effect of AL on the relationship between neighborhood perceptions and depression. Their findings showed that there was a portion of the direct relationship between neighborhood perceptions and depression that was mediated by AL (Carbone, 2020b). There were four questions that assessed neighborhood perceptions which were grouped into perceptions of trust and safety. Even after adjusting for age, sex, race/ethnicity, educational attainment, employment status, home occupancy status, and neighborhood characteristics, more favorable neighborhood perceptions were inversely associated with AL (Carbone, 2020a). These findings are similar to those found by van Deurzen et al. (2016). van Deurzen and colleagues (2016) examined the relationship between neighborhood perceptions and AL using data from respondents in Denmark. Their results found gender differences in these relationships—neighborhood perceptions of disorder and pollution remained positively significantly related to AL only for women, after adjusting for age, social class, and the area where respondents lived (Van Deurzen et al., 2016).

On an international scale, researchers have examined perceptions of neighborhood disorder and recreational spaces. Using data from the Jamaica Health and Lifestyle Survey, Cunningham-Myrie et al., (2018) examine the relationship between neighborhood characteristics and cumulative biological risk. In this study, individual neighborhood perceptions were aggregated to the neighborhood level, and perceptions of neighborhood recreational spaces were based on interview reports. After adjusting for age, sex, education, possessions (a list of 20 household items that served as a proxy for socioeconomic status), and smoking status, increases in neighborhood disorder were linked to an increased odds of having a high CBR score among women but not for men (Cunningham-Myrie et al., 2018). However, in both adjusted and unadjusted models, interviewer reports of neighborhood recreational space were related to decreases in the odds of having a high CBR score (Cunningham-Myrie et al., 2018). Taken together, these findings are concordant with stress process frameworks that hypothesize that stressful life environments (i.e. neighborhood environments) can cause a physiological response as the body attempts to deal with disruptions in equilibrium (Schulz et al., 2013). These findings highlight that there is not a universal impact of neighborhood conditions on health outcomes, these studies have found differences in neighborhood impacts on health based on gender and race warranting further examinations to buttress these reports.

Taken together, existing research has not only suggested a relationship between indicators of neighborhood socioeconomic status and allostatic load but suggests the need for more research that examines the potential mediating role of neighborhood perceptions on the direct relationship between neighborhood socioeconomic status and allostatic load. Since existing research has relied upon cross-sectional data, the proposed dissertation research builds upon and contributes to the existing literature to examine the relationship between neighborhood poverty and allostatic load over time. This dissertation research makes a unique contribution to the literature by examining whether neighborhood poverty mediates the relationship between HOLC scores and allostatic load scores. Chapter 3 of this dissertation makes a novel contribution to the literature by examining the differential impact of associations between different indicators of neighborhood socioeconomic status and allostatic load by demographic characteristics and whether these associations are mediated by perceptions of neighborhood characteristics within an urban bi-racial cohort longitudinally (Links 4, 7, and 14) (Figure 3).

Neighborhood Racial Composition and Health

Existing literature linking neighborhood racial composition with a series of health behaviors and health outcomes among Blacks has produced somewhat mixed findings. Using data from the National Health Interview Survey and the National Death Index, Blanchard and colleagues (2004) reported that Black co-ethnic density at the county level was associated with a reduced risk of mortality in nonmetropolitan areas in the South but was not significantly related to reduced mortality in metropolitan non-central city and metropolitan central city areas. Age-specific relationships were also found within the National Longitudinal Mortality Study. After adjusting for age and family income, Blacks between 25 and 44 living in higher Black proportions in census tracts had an increased mortality risk—however, this relationship was not found for older age groups (Jackson et al., 2000). For non-Blacks, living in an area with a lower proportion of Blacks in the census tract was more strongly protective for people between 45 and 64 of age. Non-Black women and non-Black men residing in Black concentrated neighborhoods had a 60% and 30% greater mortality risk compared to those living in areas with lower concentrations of Black residents, respectively (Jackson et al., 2000). Some ecological analyses have shown that increases in Black concentrations are associated with increases in both premature mortality (Cooper et al., 2001) and overall mortality (Erwin et al., 2010). A limitation of this line of research

However, some researchers have taken a more stratified approach relying upon regional or smaller area study samples. Using vital statistics data from Philadelphia, Hutchinson and colleagues (2009) examined associations between neighborhood racial composition and the age-adjusted Black mortality rate on the neighborhood level. Even after adjusting for mean education at the neighborhood level, the proportion of renters, employment rate, the proportion of males, poverty rates, and indicators of social capital, there was a nonlinear relationship between Black ethnic density and mortality rates, with trends leveling off when a neighborhood was about 50% Black (Hutchinson et al., 2009). Their models found that the age-adjusted Black mortality rate was higher by roughly 1,000 excess deaths per 100,000 Black residents in communities in which Blacks made up less than 10% of the population compared to communities in which Blacks made up more than 90% of the population (Hutchinson et al., 2009). Essentially, these findings suggest a potential protective benefit of living in a more homogenous neighborhood concerning all-cause mortality among a regional based cohort in an urban area. Using a sample based in New York City, Inagami et al., (2006) examined the relationship between Black density and all-cause mortality on a zip code level. For both Blacks and whites, living in a racially concordant neighborhood was protective against all-cause mortality rates (Inagami et al., 2006). However, only Latino males who lived in predominately Black areas had increased mortality rates compared to Latinos living in ethnically concordant neighborhoods (Inagami et al., 2006). Their multiple regression results showed that for whites, regardless of age or gender, there was an inverse association between co-ethnic concentration and all-cause mortality, adjusting for zip code level high school graduation, unemployment, and percent below the poverty limit (Inagami et al., 2006). Among whites of all ages and genders, an increase in the proportion of foreign-born was also protective of all-cause mortality (Inagami et al., 2006). The universally protective association between living in a racially concordant neighborhood and all-cause mortality was not found in Black and Latino participants. For example, only among Blacks aged 65 and older was an inverse relationship between co-ethnic concentration and all-cause mortality after adjusting for zip code level characteristics (Inagami et al., 2006). The proportion of foreign-born was protective against all-cause mortality only among Black men between 25 and 64 years of age (Inagami et al., 2006). Among Latinos, an increase in

Latino concentration was protective of all-cause mortality only within younger Latino men after adjusting for zip code level characteristics (Inagami et al., 2006). The proportion of foreign-born was protective of all-cause mortality in every age group and gender except Latino men over 65; however, adjusting for foreign-born proportion attenuated the relationship between Latino concentration and mortality rates (Inagami et al., 2006). These findings suggest a protective benefit of living in a more racially homogenous neighborhood, albeit the extent of these relationships varies by age and gender. Scholars have suggested that the potential protective nature of living in a neighborhood with a higher proportion of people from one's own racial/ethnic background allows those who are marginalized to be shielded from prejudices and to have better access to social support networks and other community resources (Henderson et al., 2005; Inagami et al., 2006; Neeleman et al., 2001). It is important to note that grouping populations together may obscure the ability to examine if the impact of neighborhood racial composition and health in that these associations may vary by other demographics such as age or gender.

Additional research has examined the relationship between Black concentration and cardiometabolic indicators. Using data from the Behavioral Risk Factor Surveillance System and adjusting for both individual and metropolitan statistical area level variables, increasing Black proportions was positively associated with BMI (Chang, 2006). These findings are concordant with analyses using data from NHANES (Do et al., 2007). Using data from Philadelphia, Chang and colleagues (2009) examined the relationship between Black proportion and BMI and obesity at the census tract level. After adjusting for individual and neighborhood variables, significant positive relationships were found between the percent Black at the census tract level and BMI and obesity. However, these relationships were no longer significant when physical disorder (vacant lots, vacant properties, housing code violations, property fires, median residential sales price) was added to the models. This is important because it highlights that associations between neighborhood racial concentration and these outcomes are mediated by physical disorder. This reflects the impact of segregation on neighborhood disinvestment and disorder, with subsequent implications for health outcomes. Further, no relationship, whether unadjusted or adjusted, were found among men in this sample (Chang et al., 2009). Using data from the Black Women's Health Study, Cozier and colleagues (2007) examined the impact of Black concentration and hypertension on the census block group-level. After adjusting for individual characteristics, there was no association between Black density and hypertension (Cozier et al., 2007). These relationships were also found in analyses using the Americans' Changing Lives study and among Black Caribbean residents in New York City with BMI as an outcome (Park et al., 2008; Robert & Reither, 2004). Taken together, exploring relationships between neighborhood racial composition and health outcomes further requires more granular and city-specific analyses. Given the variety of contexts (i.e., both national and regional datasets), the range of Black density that was quantified varied across the studies, which could be a potential reason why some of the studies found significant associations while others did not. There may also be regional differences in what it may mean to live among more co-ethnics as different regions may have variations in discrimination or tolerance for interpersonally mediated racism. Additionally, the evidence indicates mixed results, including more neighborhood indicators focused on social cohesion could further clarify these relationships. Given these questions, more research should explore these relationships using more granular datasets that incorporate neighborhood social indicators with a more comprehensive multi-system dependent variable such as CBR or AL.

There is also a body of research that has examined pathways through which neighborhood social environments (e.g., social controls, collective efficacy) can influence the neighborhood-built environment. For example, a body of research has examined the hypothesis that residents who have a higher attachment to their neighborhoods are more likely to be more involved in protecting their neighborhoods from both violent crimes, crimes against properties, and neighborhood aesthetics as a way to establish social order and safety (Brown et al., 2003; Brown et al., 2004; Comstock et al., 2010; McGuire, 1997; Sampson, 1988; Sampson & Sampson, and Raudenbush, 2001; Stewart et al., 2019). Attempts to establish social order may also include community residents using informal social control interventions in "preventing truancy, public drinking, vandalism…" and other factors within the neighborhood built environment (Kawachi & Berkman, 2009). Increases in informal social control occur when neighbors are socially connected (Kawachi & Berkman, 2015). Similarly, neighborhood collective efficacy can be conceptualized as the ability of the neighborhood to mobilize and undertake collective action (Sampson et al., 1997). When neighbors are connected, mobilizing around a particular neighborhood occurrence is faster, potentially resulting in a solution (Kawachi & Berkman, 2015). Historically, lower-income and non-white racial/ethnic groups are less likely to be politically active (Bartle et al., 2017; Polacko, 2021), which reduces the likelihood that political leaders will be met with opposition if neighborhood services are terminated, or toxic exposures are placed within these communities (Williams & Collins, 2001b). It is important to note that regarding political activism, different neighborhoods have differing inherent political power (e.g., socioeconomic status, residential social class, social networks), which can impact their level of activism. Given that structural factors have caused distinctly different lived realities for Blacks and whites in the United States, it stands to reason that these factors may influence racial disparities in AL within the United States. Specifically, racial segregation has produced neighborhoods that insulate whites from harmful exposures while potentially magnifying exposures for Blacks and other communities of color.

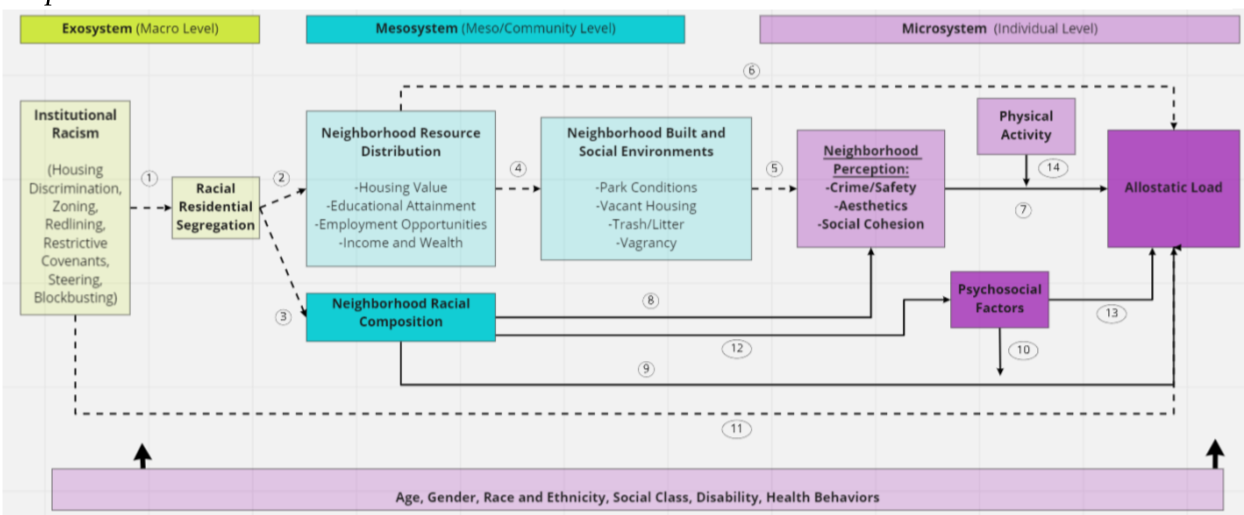
Neighborhood Social Support and Health

Existing literature suggests associations between neighborhood contexts and social relationships within neighborhood settings. Perceived social support is hypothesized to be one of the most significant predictors of health outcomes (Berkman, 2000; Cohen, 1988; Holt-Lunstad et al., 2010; House, 1981; Pinquart & Duberstein, 2010; Uchino, 2004; Uchino et al., 2012). Specifically, people with lower levels of social support are more likely to have higher levels of cardiovascular-related mortality and impaired cardiovascular functioning (Barth et al., 2010; Berkman et al., 1992; Orth-Gomer et al., 1993), cancer (Ell et al., 1992; Pinquart & Duberstein, 2010), infectious disease mortality (Lee & Rotheram-Borus, 2001), and heightened stress reactivity (Stansfeld et al., 1997). This literature suggests that positive social relationships buffer the impact of adverse exposures and stress (Thoits, 2011). Social support, as a specific potential buffer, works by increasing one's ability to cope with their demands, changing their appraisal of a situation, weakening the physiological response, and preventing maladaptive behavioral responses to stressors (Cohen, 2004). One of the significant influences on neighborhood social networks is neighborhood poverty. Research suggests that living in an area with a higher proportion of people living in poverty is associated with weaker social relationships through changing positive social relationships (e.g., social support and access to resources) (Franzini et al., 2005). For example, social networks in impoverished areas are more likely to be smaller, isolated, and composed of similarly disadvantaged people (Cattell, 2001; Moskowitz et al., 2013; Tigges et al., 1998). Resource sharing in the way of shared housing and shared childcare is an important feature of social networks in impoverished settings. Nonetheless, social network membership and shared social supports may not fully offset stressors because people within the network itself have limited resources (Boswell & Stack, 1975; Conrad et al., 1997; Domínguez & Watkins, 2003). This is important in that even in lower-income communities with strong emotional social support, and those networks have fewer resources to draw to provide instrumental support (e.g., borrow money to help make ends meet, rides to work, or doctor visits).

Researchers have examined the relationship between social relationships and CBR using data from a Detroit-based cohort. Specifically, LeBron and colleagues (2019) used four metrics of neighborhood social relationships, including social support, neighborhood satisfaction, social cohesion, and neighborhood participation. After adjusting for neighborhood poverty level, social support (marginally protective p=0.06), neighborhood satisfaction, social cohesion, and neighborhood participation were not statistically associated with AL (Lebrón et al., 2019). Their analyses suggested that increases in individual-level neighborhood satisfaction were associated with decreases in CBR after adjusting for neighborhood-level poverty—there were no significant associations between CBR and social support, social cohesion, and neighborhood participation measured on the individual level (Lebrón et al., 2019). In models that included all social indicators, individual-level social support was positively associated with increases in CBR while neighborhood-level social support was protective against increases in CBR (Lebrón et al., 2019). The existing literature suggests that there may be a relationship between co-ethnic concentration and health outcomes. Despite these findings, little evidence suggests that these relationships would be associated with allostatic load variables. Furthermore, there is limited information on the mediating role of social support and other psychosocial factors (e.g., ethnic discrimination) in the relationship between neighborhood racial composition and allostatic load. <u>Therefore, Chapter 4 of this dissertation seeks to explicitly examine whether associations between neighborhood racial composition and allostatic load may vary by demographic characteristics, whether ethnic discrimination, neighborhood perceptions, or the density of social institutions mediate these</u>

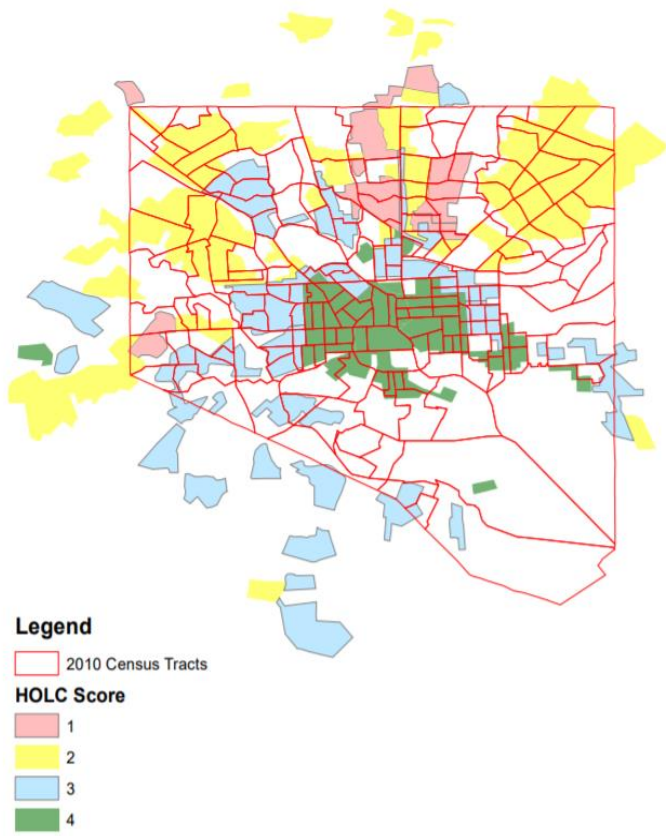
associations, and whether neighborhood racial composition mediates associations between HOLC scores and both allostatic load and neighborhood socioeconomic status within a cohort based in Baltimore, Maryland (Links 9, 10, 12, 13).

Figure 1-3. Conceptual Model Exploring the Relationship between Neighborhood Racial Composition and Allostatic Load



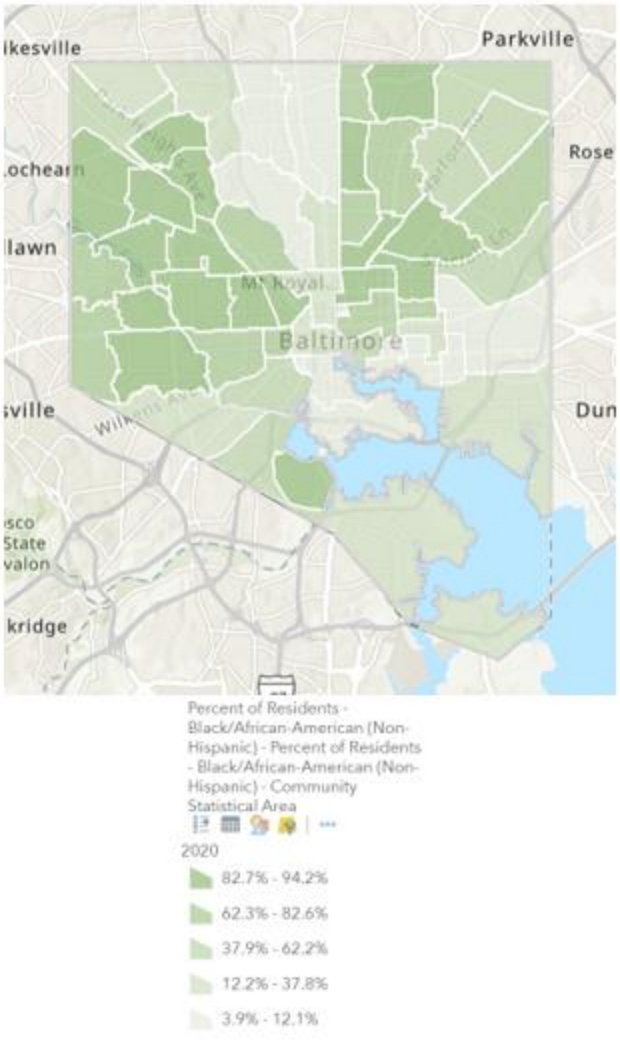
1.2 **The Case for Baltimore, Maryland**

Figure 1-4. HOLC Map overlayed with 2010 Census Tracts in Baltimore, Maryland



Baltimore City, Maryland, is an important context to extend our understanding of neighborhood characteristics and racial disparities in AL. Baltimore is the 30th largest US city based on population. Despite its size, Baltimore has one of the lowest average income levels compared to other cities within the Northeastern United States (Theodos et al., 2019). Data from the state of Maryland indicates that Blacks compared to whites were more than two times more likely not to have health insurance, three times more likely to have end-stage renal disease, and an age-adjusted mortality rate from cardiovascular disease that exceeds whites by 52.1 deaths per 100,000 persons (Baquet & Colgan, 2013). Baltimore City provides an interesting case study for health. Analysis of mortality data from Baltimore City found that half of all premature deaths could be avoided across the city if every resident of Baltimore earned as much as people living in the city's six wealthiest neighborhoods (Perman, 2016). Investment within Baltimore is uneven and is largely guided by what is known as "the Black butterfly", a description of how Black communities are concentrated on Baltimore's eastern and western halves (Lawrence Brown, 2016; Theodos et al., 2019). Poverty rates within Baltimore are not equally distributed as the poverty rate in Baltimore is twice the national average and is largely concentrated in non-white neighborhoods (Theodos et al., 2019). There are also profound disparities in capital flows, with neighborhoods with less than 50% Black residents receiving almost four times the amount of investments than neighborhoods that have over 85% Black residents (Theodos et al., 2019). This particular finding is interesting in light of previous research that found protective effects of increasing co-ethnic concentration (Hutchinson et al., 2009). As previously mentioned, the protective benefits appear to be most consistent for whites living in predominately white neighborhoods, and to vary by ethnicity, gender, and age group for Blacks and Hispanics. They also are likely to vary by the degree of race based residential segregation and associated disinvestment from predominately Black neighborhoods. With this in mind, Baltimore, Maryland makes a good case study to examine whether the relationships that have been found in both national and local areas within the United States can be found in other U.S. cities. Many of the characteristics that have been found in other cities across the country, especially Detroit, can be found in Baltimore. Detroit and Baltimore both have a large African American population that are clustered together and are living in poverty (Schulz et al., 2020; Theodos et al., 2019).

Figure 1-5. The "Black Butterfly" and the white "L" in Baltimore, Maryland



The “Black Butterfly” and the “White L” were coined by researcher Lawrence Brown to symbolize the history of both past and present discrimination and disinvestment in the City of Baltimore (Lawrence Brown, 2016) (Figure 3).[10] Baltimore has a unique history that highlights the impacts of institutional racism on shaping the social, economic, and physical characteristics within the city. In the years leading up to the Civil War, Baltimore had the highest free urban Black

[10] Figure 3 shows the areas in Baltimore where higher proportions of Black/African Americans are concentrated which resembles a butterfly. The areas in central and southern Baltimore have lower concentrations of Black/African Americans which resembles an “L”.

population with roughly 90% of its Black population emancipated from the horrors of slavery (Cashin, 2021). Despite this social environment, largely run by white men, in 1910, Baltimore became the first city in the United States to pass a residential zoning ordinance, laying the foundation for other cities to follow (Brown, 2021). During the 1920's the United States banned European immigrants which provided an opportunity for African Americans from the southern United States to work in industries in major northern cities (Pietila, 2010). Baltimore's local newspaper *The Baltimore Sun* became a primary ally for whites against what was coined the "Negro Invasion" in support of establishing and enforcing the Baltimore Apartheid (Brown, 2021). During the 1920's, *The Baltimore Sun* would publish the home addresses of all Black homeowners which targeted Black homeowners to a series of policing, intimidation efforts, and other forms of harassment (Brown, 2021). The *Housing Act of 1954* set in motion a series of mechanisms that changed Baltimore City. Specifically, the Housing Act of 1954 provided funding to locales to rehabilitate existing homes and improve public infrastructure (Baltimore Urban Renewal and Housing Agency, 1962). The Harlem Park neighborhood of Baltimore was selected for this project and served as the model for national implementation (Blessett, 2020). This project demolished Black communities, but also served as an example of the vulnerability of Black tenancy within Baltimore due to limitations in political, social, and economic capital (Blessett, 2020). In her investigation of Baltimore, Brandi Blessett emphasizes that while whites were impacted by "slum" clearance in Baltimore, Black residents within the city were disproportionately impacted (2020). Specifically, she highlights that a) Blacks continued to occupy dilapidated structures that were not up to code given their limited access to the broader housing opportunities available to whites during this time; b) Black families were not given any financial compensation as a result of eminent domain activities within the city and were also excluded from receiving equivalent, if any, financial assistance to relocate as a result of “slum” clearance; and c) since Black people were barred from the broader homeownership and tenancy options available to whites, Blacks found themselves concentrated in deteriorating neighborhoods including social and aesthetic conditions (Blessett, 2020). While not unique to Baltimore, these mechanisms can be found across the United States.

After the 1970’s, the Housing Authority of Baltimore City chose not to integrate its public housing developments into more racially diverse neighborhoods but instead concentrated public housing in Black neighborhoods or neighborhoods with environmental hazards (Brown, 2021). Essentially, all of those with housing vouchers (formerly known as Section 8) are concentrated in Baltimore’s “Black Butterfly” (Brown, 2021). These are examples of how racial segregation represents what Link and Phelan (1995) and Williams and Collins (2001) have defined as fundamental causes that are manifested in the contemporary context. Government sanctioned segregation continues in Baltimore since Baltimore City has not been compliant with the guidelines set forth by the 1968 Fair Housing Act (Brown, 2021). Specifically, Baltimore leadership continues to approve zoning ordinances blocking affordable housing units from being built in “nicer” neighborhoods and approving the Port Covington project in 2016 without an inclusionary zoning clause that would set aside a percentage of housing units for public housing residents. Ultimately, these actions ensure that whites are insulated from Black neighbors, while Blacks are hyper-segregated in areas of disadvantage and disinvestment (L Brown, 2021). These conditions have kept Black Baltimoreans from accessing quality transportation, employment opportunities, housing, food resources, schools, bank capital, and public goods. Black Baltimoreans, thus, are economically and socially vulnerable as residents of neighborhoods that have been bypassed in investment opportunities (e.g. housing, public goods, education) in favor of more affluent white communities (Brown, 2021). Ultimately, each of these examples reinforces the notion that whites are deserving of more pristine amenities while Black's are devalued and their presence undesirable.

Geronimus and colleagues (2020) raise notable considerations that there are some practices within social epidemiology that are problematic and that inform this dissertation. For example, they note that there is an overall overreliance on conventional proxies of socioeconomic status to explain differences across demographic groups, failure to look at race/ethnicity as a fluctuating variable, and a preference for nationally representative samples that neglect the importance of heterogeneity in the local lived experiences (Geronimus et al., 2020). Therefore, this dissertation proposes to explore the role of neighborhood perceptions, psychosocial measures, and other neighborhood characteristics on allostatic load within a multiethnic cohort in Baltimore, Maryland. With this in mind, it is unknown whether these associations would be found in other diverse populations in other regions of the United States. However, this investigation supports an understanding of the local manifestations of institutional racism and how Baltimore's particular historical, social, and political contexts may contribute to how health disparities unfold on a local level. In this study, I propose to explore these relationships within a cohort based in Baltimore, Maryland.

1.3 **General Aims**

Specifically, using the Healthy Aging in Neighborhoods of Diversity across the Life Span study, this dissertation seeks to examine the following research questions in Chapters 2, 3, and 4:

Chapter 2: Does Time Heal All Wounds? Examining The Lasting Impact Of Historic Redlining On Contemporary Racial Disparities In Allostatic Load In Baltimore, Maryland

2a. Are historic HOLC Redlining Scores associated with allostatic load scores among current residents of Baltimore, MD during Wave IV of HANDLS?

2b. Is the relationship between race and allostatic load scores mediated by HOLC scores?

2c. Is the relationship between historic HOLC Redlining Scores and allostatic load scores mediated by neighborhood deprivation/poverty controlling for demographic characteristics?

Chapter 3: Longitudinal Associations between Neighborhood Socioeconomic Status and Allostatic Load: Exploring the Mediating Pathway of Neighborhood Perceptions

3a. Do associations between neighborhood socioeconomic status and AL vary by age, race, sex, and household poverty over time?

3b. Do associations between neighborhood socioeconomic status and allostatic load remain robust after accounting for physical activity?

3c. Do perceptions of neighborhood characteristics mediate the longitudinal relationship between census tract level neighborhood socioeconomic status, as measured by the American Community Survey during Wave III, and allostatic load, as measured during Wave IV?

Do Your Neighbors Matter?: Examining Associations between Neighborhood Racial Composition and Allostatic Load

4a. Do associations between neighborhood racial composition and allostatic load over time vary by race, gender, and age group controlling for neighborhood-level socioeconomic status?

4b. Does ethnic discrimination mediate associations between neighborhood racial composition and allostatic load over time?

4c. Does perceived neighborhood social environment mediate associations between neighborhood racial composition and allostatic load?

4d. Does perceived neighborhood social environment modify the mediating role of discrimination on associations between neighborhood racial composition and allostatic load?

4e. Does the percentage of a neighborhood that is Black/African American mediate associations between HOLC score and allostatic load?

4f. Do the percentage of a neighborhood that is Black/African American mediate associations between HOLC score and neighborhood socioeconomic status?

Chapter 2 : Does Time Heal All Wounds? Examining The Lasting Impact of Historic Redlining on Contemporary Racial Disparities in Allostatic Load in Baltimore, Maryland

2.1 Introduction

This study examines the relationship between historical redlining and current allostatic load scores using data from the HANDLS cohort based in Baltimore, Maryland. Racial residential segregation, as a manifestation of institutional racism, has shaped neighborhood contexts across the United States (Winling & Michney, 2021). For this investigation, I define institutional racism as "institutional systems and structures in race-based discrimination and oppression" (Braveman et al., 2022, p. 172), which builds upon definitions offered by other scholars (W. E. Burghardt Du Bois, 1900; Fernandez et al., 1993; C. P. Jones, 2000). One of the many mechanisms through which institutional racism was enacted was in the area of home financing and ownership in the form of redlining. Redlining has been defined as the systematic denial of home mortgages and other housing support based on presumed lending risk shaped based on a neighborhoods' racial composition (Winling & Michney, 2021). The term "redlining" was coined from the Home Owners' Loan Corporation's (HOLC) residential security maps and appraisals of neighborhoods during President Roosevelts attempt to stabilize the United States economy during the Great Depression and New Deal era of the 1930s (Cooney & Jackson, 1987; J. Greer, 2013; A. Nardone, Chiang, et al., 2020). Local bankers and other real estate actors appraised and categorized each neighborhood into one of four different categories: the most desirable neighborhoods were labeled "A" and were shaded green, and the least desirable neighborhoods were labeled "D" and shaded red (A. Nardone, Chiang, et al., 2020). “Redlining” refers specifically to neighborhoods labeled “D” and shaded red. Important characteristics that shaped neighborhood risk included neighborhood racial composition, infrastructure, housing quality, neighborhood stability, and proximity to different hazards (Winling & Michney, 2021). Considerable effort was made to create HOLC maps of many major cities and metropolitan areas within the U.S.

Some evidence indicates that not all Redlined neighborhoods were predominantly African American, but all predominantly African American neighborhoods were Redlined (Winling & Michney, 2021). Further, immigrant groups, including people of Mexicans, Chinese, Russian, Italian, and Polish descent, to name a few were largely concentrated in Yellow- and Redlined neighborhoods (Madron, 2022). There is evidence of the lasting impacts of these historic HOLC maps on contemporary neighborhood characteristics. For example, many of the neighborhoods that were yellow (hazardous) or redlined still remain lower-income communities of color, while areas assessed as “desirable” are typically predominately white, higher-income communities (Aaronson et al., 2020; Mitchell & Franco, 2018; A. Nardone, Chiang, et al., 2020). Although formal redlining was outlawed in the United States with the passage of the Fair Housing Act of 1968, these “hazardous” neighborhoods remain predominantly lower-income communities of color, while desirable areas, formerly greenlined neighborhoods, are predominantly white and higher-income (Aaronson et al., 2020; Mitchell & Franco, 2018).

Contemporary census tract-level data about historic HOLC scores are publicly available through the University of Richmond’s Mapping Inequality Project (R. K. Nelson et al., 2018). With that newly available data, emerging literature is linking historic redlining to current health outcomes, including asthma (A. Nardone, Casey, et al., 2020), maternal and child health outcomes (Hollenbach et al., 2021; Huang & Sehgai, 2022; Nancy Krieger, van Wye, et al., 2020; E. E.

Lynch et al., 2021; A. L. Nardone et al., 2020), self-rated health (McClure et al., 2019), mortality rates (Huang & Sehgai, 2022), cancer (Nancy Krieger, Wright, et al., 2020), cardiovascular risk (Mujahid et al., 2021; A. Nardone, Chiang, et al., 2020), COVID-19 (M. Li & Yuan, 2022), and emergency department visits/hospitalization (Benns et al., 2020; D. Li et al., 2022). Redlining has also been linked to current neighborhood contexts, including sustained disinvestment (E. E. Lynch et al., 2021), lending discrimination (E. E. Lynch et al., 2021), unhealthy food environments (Huang & Sehgai, 2022; Sadler et al., 2021), increased concentration of firearm assaults and violent crimes (Jacoby et al., 2018), and reduced access to health-promoting resources (Alexander & Currie, 2017; Mendez et al., 2011; O'Campo et al., 1997; B. Wilson et al., 2018). Discriminatory housing and transportation policies have largely placed extensive highway networks in former communities of color (Mohl, 2012; A. Nardone, Chiang, et al., 2020). Each of the aforementioned neighborhood contexts can be linked to health and health outcomes through shaping the environments and stimuli that a person is repetitively exposed to, thus leading to adverse health outcomes.

Collectively, these studies using a diverse set of health outcomes, paint a picture of systematic disinvestment that contributes to neighborhood conditions that are detrimental to health and associated with multiple adverse health outcomes. These findings are consistent with fundamental cause theories arguing that race-based residential segregation is linked to multiple health outcomes through multiple pathways (see Williams & Collins, 2001). As stated by fundamental cause theory, redlining "concentrates risks and limits opportunities for communities of color" (A. Nardone, Chiang, et al., 2020, p. 110). In order to understand the historical and current drivers of contemporary racial inequities in health, it is critical to examine the implications of redlining and disinvestment processes for the creation and continuance of health inequalities over multiple decades.

To be consistent with race definitions used in the HANDLS database for this study, I use African American throughout to refer to people who identify as Black or African American. Exceptions to this general rule will occur in discussion of literature that uses the term Black, in which case I will use language concordant with the referenced article.

The Case for Baltimore, Maryland

As the 30th largest city in the United States, Baltimore, Maryland, has one of the lowest average income levels compared to other northeastern cities, and poverty levels are primarily concentrated in non-white neighborhoods (Theodos et al., 2019). Baltimore also remains geographically segregated into what is known as “the Black butterfly,” a description of how predominantly Black residents are concentrated on the eastern and western sides of the city, while whites are concentrated in what is known as the “white L” in the center and southern areas of the city (Lawrence Brown, 2016; Theodos et al., 2019). Given that existing research has suggested limitations in using nationally representative samples as they obscure the heterogeneity in the local lived experiences (Arline T. Geronimus et al., 2020), examining the proposed associations within a local cohort could help illuminate potential associations between variables.

2.2 **Specific Aims and Hypotheses**

In this chapter, I examine whether institutional racism in the form of redlining in the 1930s and 1940s is associated with racial differences in allostatic load (i.e., physiological dysregulation within multiple bodily systems) among current residents of Baltimore, Maryland. As described below, I examine three linked research questions to address this overarching research question.

Q1: Are historic HOLC Redlining Scores associated with allostatic load scores among current residents of Baltimore, MD?

H1: Contemporarily, African American residents of Baltimore will be more likely to live in formerly Redlined areas than white residents of Baltimore.

H2: HOLC scores will be associated with allostatic load scores, with residence in historically Redlined neighborhoods associated with higher allostatic load scores measured during Wave IV (2013-2017). These relationships will vary by age group and race.

Q2: Do HOLC scores mediate the relationship between race and allostatic load scores in Wave IV of HANDLS?

H1: Race is significantly associated with allostatic load scores among residents of Baltimore, using HANDLS data from Wave IV (2013-2017)

H2: The relationship between race and allostatic load observed in H1 is mediated by HOLC scores accounting for the interaction between race and HOLC score.

Q3: Is the relationship between historic HOLC Redlining Scores and allostatic load scores mediated by neighborhood deprivation/poverty controlling for demographic characteristics?

H1: The relationship between HOLC Scores and allostatic load (as assessed in Q1) will be mediated by neighborhood deprivation/poverty.

2.3 **Methods**

The HANDLS study is a cohort of 3,720 white and African American residents from socioeconomically diverse communities in Baltimore, who were between 30 and 64 years of age at baseline (2004-2009). Participants are from a fixed cohort of samples from 13 neighborhoods based on area probability sampling. There are five waves of data from the HANDLS study, Wave 1: August 2004-March 2009, Wave II: April 2006-October 2011, Wave III: June 2009-July 2013, Wave IV: September 2013-September 2017, and Wave V: September 2017-December 2021. Data from Wave IV were used for this investigation as it is the most recent wave that is available. Participants were geocoded, allowing us to locate the census tracts in which respondents live and to match place of residence with historic HOLC scores for that census tract. Other study design and methodology-related materials for HANDLS have been published in detail elsewhere (Evans et al., 2010). The analytic sample for this study includes participants who: a) lived in Baltimore during Wave IV of HANDLS; b) have an allostatic load measurement; c) live in a census tract where historic HOLC scores have been calculated; and d) have an observation for every included covariate.

Independent Variable: Redlining

Historic HOLC score data was downloaded from the Inter-University Consortium for Political and Social Research website housed at the University of Michigan (Meier & Mitchell, 2021). Historic HOLC score maps were overlaid with 2010 and 2020 census tracts for cities across the U.S. HOLC scores were multiplied by a weighting factor based on the area of the census tracts, whereby higher scores indicate redlined areas while lower scores correspond to Greenlined areas. HOLC score data from 2010 census tract boundaries were used (Meier & Mitchell, 2021). HOLC scores range from 1 (Greenlined) to 4 (Redlined). A higher score corresponds with a greater proportion of the census tract being Redlined.

Dependent Variable: Allostatic Load

Allostatic load was computed using methods described by Seeman and colleagues (T. Seeman et al., 2008). Given that this measure is made up of secondary mediators, our iteration of allostatic load is an indicator of multisystem risk reflecting physiological dysregulation within multiple bodily systems (T. Seeman et al., 2008). Components include cardiovascular (systolic and diastolic blood pressure, pulse rate), metabolic (total cholesterol, HDL-C, HbA1c, waist-to-hip ratio), and inflammatory (albumin CRP) indicators (Beydoun et al., 2019). Risk scores were assigned as follows:

Table 2-1. Allostatic Load Indicator Criteria

	High-Risk Clinical
Albumin (g/dL)	<3.8
C-reactive protein (mg/dL)	≥ 0.3
Waist: Hip	>0.9 for men; > 0.85 for women
Total Cholesterol (mg/dL)	≥240
HDL (mg/dL)	<40
Glycated hemoglobin (%)	≥6.4
Resting heart rate (beat/min)	≥90
Systolic Blood Pressure	≥140
Diastolic B.P.	≥90

Covariates

Covariates include age (35-44 [ref], 45-54, 55-64, 65-76), race (white [ref] vs. African American), sex (female [ref] vs. male), physical activity (measured by the question *"How many minutes per day do you walk or cycle to and from work or shopping?" <5 min [ref], 5-15 min, 15-30 min, 30-45 min, >45 min)*, current tobacco smoking status (never tried [ref], tried, never used regularly, former user, current user), and poverty status (PIR<125%:below poverty; PIR ≥125%: above poverty [ref]).

Neighborhood Level

Neighborhood level covariates include a neighborhood deprivation index and the percent of families living in poverty; both measured on the census tract level. Neighborhood deprivation was measured using neighborhood socioeconomic deprivation calculated using previously published methods on the census tract level (Powell-Wiley et al., 2020; Neally et al., 2022) drawn from the 2017 (5-Year Estimates) American Community Survey to align with Waves 4 data collection Specifically, estimates from the American Community Survey include median household income, median housing value, the percentage of individuals over 25 with a high-school diploma, the percentage of individuals over 25 with a bachelor's degree, the percentage of employed people (age 16 and older) working in management, business, science, and arts, the percentage of households below the federal poverty limit, the percentage of families receiving public assistance, the percentage of female-headed households with children under 18, and the percentage that receive interest, dividends, or rental income was downloaded from the American Community Survey. Variables were z-standardized, and reverse coded as necessary so that the sum of these variables would result in a continuous score with higher scores representing more deprivation or a lower socioeconomic status census tract.[11] In addition to the composite NDI score, the percentage of families with incomes falling below the federal poverty limit will also be tested as an additional indicator of neighborhood socioeconomic status.

[11] The percent of people over 25 with a high school diploma, the individuals over 25 with a bachelor's degree, the percentage of employed people (age 16 and older) working in the management, business, science, and arts, and the percentage of houses that receive interest, dividends, or rental income were reverse coded in the dataset to reflect a deprivation approach.

Statistical Analysis

Descriptive statistics were performed on all variables included in the analyses. Regressions for each study aim were conducted using ordinary least squares models with clustered standard errors and multilevel models. However, only the illustration and interpretation of the multilevel models are presented (OLS models with clustered standard error models will be included in the appendix). Since each participant is one observation clustered in a census tract, some of the characteristics of the individual may be concordant with others within the cluster (R. A. Rose, 2018). Given this, multilevel models are a unique method to examine these relationships. Specifically, a multilevel approach was selected using an independent variable and random intercept variation. Structural equation models were also used to examine mediating relationships and provide data on the strength of the indirect pathways between the variables StataSE 17 (StataCorp, College Station, TX, USA) was used to conduct all analyses.

2.4 **Results**

There were 1,013 participants who had measures for the main exposure, outcome, and covariates for this study. Table 2-2 presents the descriptive statistics for each of the variables included in the study. The mean allostatic load score for study participants was 1.95 (min =1, max=6), and the mean HOLC score was 2.78 (min=1 [greenlined], max=4 [redlined]). 11.21% of were between 35-44 years old, 30.01% were between 45 and 54 years old, 36.81% were between 55 and 64 years old, and 21.97% were between 65 and 76 years old. Nearly 70% of the sample was African American, and nearly 60% of the sample was female. For physical activity, 31.69% of participants reported getting less than 5 minutes, while 23.49% indicated 15-30 minutes, 20.73% indicated 5-15 minutes, 13.13% indicated more than 45 min, followed by 10.96% indicated 30-45 min. Smoking status varied, with 42.74% of study participants being current users, 25.67% former users, 20.14% never tried, and 11.45% tried but never used regularly. 62.69% of participants were above the poverty threshold, while 37.31% were below. As mentioned, statistical models were run using OLS with clustered standard errors and multilevel models. Despite these two analytic approaches, the patterns were similar. Therefore, the multilevel models and interpretation are presented in the chapter, and clustered standard error models will be included in the appendix.

Table 2-2. Demographic characteristics of Participants in Wave IV (2013-2017) of HANDLS, who met the inclusion criteria for this study.

	Mean(SD) Range (n= 1,013)
Allostatic Load	1.95 (1.19) 0-6
HOLC Score	2.78 (0.62) 1-4
	N (%)
Age Category	
35-44	198 (11.21)
45-54	530 (30.01)
55-64	650 (36.81)
65-76	388 (21.97)
Race	
White	306 (30.21)
African American	707 (69.79)
Sex	
Female	580 (57.26)
Male	433 (42.74)
Physical Activity	
<5 min	321 (31.69)
5-15 min	210 (20.73)
15-30 min	238 (23.49)
30-45 min	111 (10.96)
>45 min	133 (13.13)
Smoking Status	
Never Tried	204 (20.14)
Tried, never used regularly	116 (11.45)
Former User	260 (25.67)
Current User	433 (42.74)
Poverty Status	
Above Poverty Threshold	635 (62.69)

Below Poverty Threshold	378 (37.31)

Table 2-3. Frequency Distributions of Race of Participants included in this study by HOLC Category of census tract of residence.

	HOLC Score				
	Greenlined	*Bluelined*	*Yellowlined*	*Redlined*	*Total*
Race					
African American	*7* *0.99%*	*252* *35.64%*	*353* *49.93%*	*95* *13.44%*	*707*
White	*5* *1.63%*	*57* *18.63%*	*220* *71.90%*	*24* *7.84%*	*306*

Using frequency distributions, I explored the concentration of racial groups in the HANDLS 2013-2017 sample by the HOLC classification of the census tract in which they resided. I used a Pearson chi^2 test to test the null hypothesis that the distribution by race in 2013-2017 was independent of historic HOLC classification at the census tract level. Chi squared results indicate a score of 44.93 and a p=0.000. Based on these scores, I reject the null hypothesis of no association between race and historic HOLC classification for census tracts. Relatively few HANDLS participants resided in formerly greenlined neighborhoods with just 0.99% of African American participants and 1.63% of White participants living in these areas. African American participants in the HOLC study were nearly twice as likely as whites (33.64% compared to 18.63%) to reside in formerly bluelined neighborhoods. Nearly half (49.93%) of African American participants and nearly three-quarters (71.90%) of white participants lived in formerly yellowlined neighborhoods. Finally, 13.44% of African Americans lived in formerly redlined neighborhoods compared to 7.84% of whites (Table 2-3).

HOLC Score and Allostatic Load

In unadjusted multilevel models (MLM), a positive but insignificant association was found between HOLC scores and allostatic (β=0.07, p=0.21) (Table 2-4, Model 1). As shown in Table 2-4, Model 2, this association became significant after adjusting for age group, race, sex, physical activity, smoking status, and poverty status (β=0.14, p=0.02) (Table 2-4). Patterns were similar for models using clustered errors and are shown in Appendix A. For example, as HOLC scores increase, allostatic load scores also increased among study participants.

Table 2-4. Results from Multilevel Models Regressing Allostatic Load on HOLC Score Controlling for Age, Race, Sex, Physical Activity, Smoking Status, and Poverty Status.

	Model 1		Model 2	
	B(SE)	P	B(SE)	P
Intercept	1.82 (0.16)	0.00	1.42 (0.22)	0.00
Level 2 (Neighborhood)				
HOLC Score	0.07(0.06)	0.21	**0.14 (0.06)**	**0.02**
Level 1 (Individual)				
Age Category	--	--		
35-44 (ref)	--	--	--	--
45-54	--	--	0.22 (0.13)	0.09
55-64	--	--	0.33 (0.13)	0.01
65-76	--	--	0.29 (0.14)	0.03
Race	--	--		
White (ref)	--	--	--	--
African American	--	--	0.10 (0.08)	0.23
Sex				
Female (ref)	--	--	--	--
Male	--	--	-0.39 (0.08)	0.00
Physical Activity				
<5 min (ref)	--	--	--	--
5-15 min	--	--	0.14 (0.10)	0.17
15-30 min	--	--	0.09 (0.10)	0.38
30-45 min	--	--	-0.12 (0.13)	0.37
>45 min	--	--	-0.24 (0.12)	0.05
Smoking Status				
Never Tried (ref)	--	--	--	--
Tried, never used regularly	--	--	-0.04 (0.14)	0.79
Former User	--	--	-0.02 (0.11)	0.89
Current User	--	--	-0.04 (0.10)	0.72
Poverty Status				
Above Poverty Threshold (ref)	--	--	--	--

Below Poverty Threshold	--	--	0.05 (0.08)	0.56

Age Differences in HOLC Score and Allostatic Load

I investigated whether the relationship between HOLC score and allostatic load varies by age category by running models that included an interaction term between HOLC Score and age category. As shown in Table 2-5, there is a significant interaction between HOLC Score and Age Group 3 (55-64) (β= 0.39 p=0.048) (Table 2-5). Since the dummy variable is the youngest age group (35-44), this suggests that associations between HOLC Score and allostatic load for those in the 55-64 age group are significantly different and more positive than these associations in the youngest age group. I do not find evidence of a significant difference in associations between HOLC scores and allostatic load for those in the 45-54 or the 65-76 age categories compared to those in the youngest age category. Due to the interaction, the effect of HOLC score on allostatic load is different based on age category; specifically, the association between HOLC score and allostatic load is stronger for those aged 55-64 compared with those aged 35-44 (Table 2-5).

Table 2-5. Results from Multilevel Models Regressing Allostatic Load on the interaction between HOLC Score and Age Category Controlling for Race, Sex, Physical Activity, Smoking Status, and Poverty Status

	B(SE)	P
Intercept	2.17 (0.51)	0.00
Level 2 (Neighborhood)		
HOLC Score	-0.13 (0.17)	0.46
Level 1 (Individual)		
Age Category		
35-44 (ref)		
45-54	-0.65 (0.59)	0.27
55-64	-0.77 (0.57)	0.18
65-76	-0.15 (0.61)	0.80
Age Category * HOLC Score		
35-44 * HOLC Score (ref)		
45-54 * HOLC Score	0.31 (0.20)	0.13
55-64 * HOLC Score	**0.39 (0.20)**	**0.048**
65-76 * HOLC Score	0.16 (0.21)	0.46
Race		

White (ref)		
African American	0.10 (0.08)	0.22
Sex		
Female (ref)		
Male	-0.39 (0.08)	0.00
Physical Activity		
<5 min (ref)		
5-15 min	0.15 (0.10)	0.16
15-30 min	0.07 (0.10)	0.45
30-45 min	-0.11 (0.13)	0.40
>45 min	-0.24 (0.12)	0.05
Smoking Status		
Never Tried (ref)		
Tried, never used regularly	-0.05 (0.14)	0.69
Former User	-0.01 (0.11)	0.92
Current User	-0.03 (0.10)	0.75
Poverty Status		
Above Poverty Threshold (ref)		
Below Poverty Threshold	0.04 (0.08)	0.64

Race Differences in HOLC Score and Allostatic Load

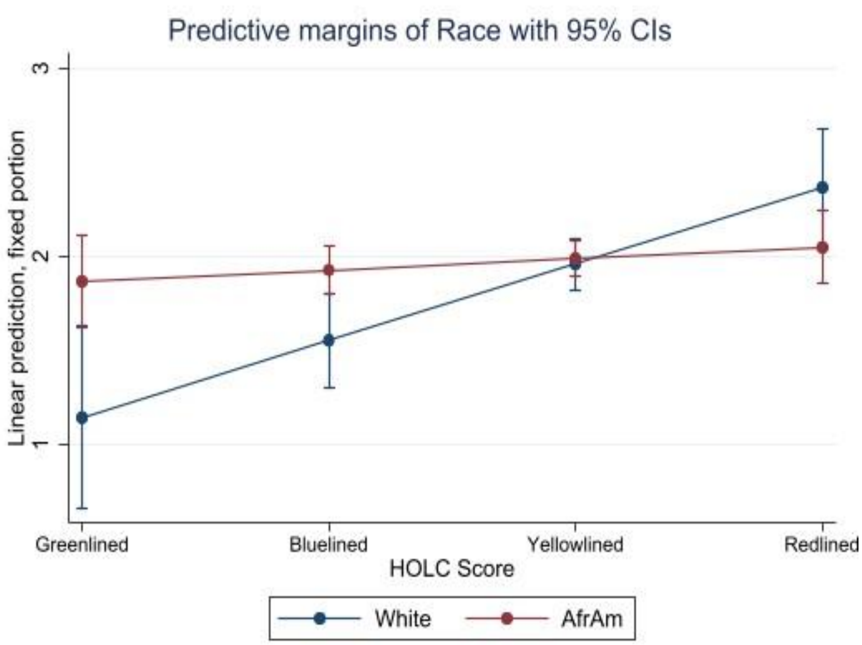
To test whether the relationship between HOLC score and allostatic load varies by race, I ran models that included an interaction between HOLC score and race. As shown in Table 2-6, the interaction term between HOLC Score and race was significant (β= -0.36 p=0.01). Because of the negative moderating effect, as expressed in the -0.36 relationship in the interaction between race and HOLC score, the slope examining the relationship between HOLC score and allostatic load is less steep compared to whites (Figure 2-1).

Table 2-6. Results from Multilevel Models Regressing Allostatic Load on the interaction between HOLC Score and Race Controlling for Age, Sex, Physical Activity, Smoking Status, and Poverty Status

	B(SE)	P
Intercept	0.64 (0.38)	0.10
Level 2 (Neighborhood)		
HOLC Score	0.42 (0.13)	0.01
Level 1 (Individual)		
Race		

White (ref)		
African American	1.11 (0.41)	0.01
HOLC * African American	**-0.36 (0.14)**	**0.01**
Age Category		
35-44 (ref)		
45-54	0.23 (0.13)	0.07
55-64	0.33 (0.13)	0.01
65-76	0.30 (0.14)	0.03
Sex		
Female (ref)		
Male	-0.39 (0.08)	0.00
Physical Activity		
<5 min (ref)		
5-15 min	0.15 (0.10)	0.14
15-30 min	0.08 (0.10)	0.41
30-45 min	-0.10 (0.13)	0.42
>45 min	-0.24 (0.12)	0.05
Smoking Status		
Never Tried (ref)		
Tried, never used regularly	-0.08 (0.14)	0.58
Former User	-0.04 (0.11)	0.74
Current User	-0.07 (0.10)	0.53
Poverty Status		
Above Poverty Threshold (ref)		
Below Poverty Threshold	0.04 (0.08)	0.58

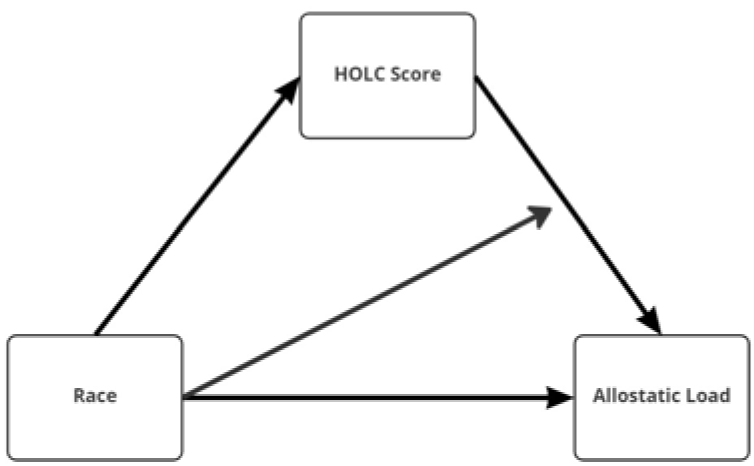
Figure 2-1. Variations in the associations between HOLC score and Allostatic Load by Race



HOLC Score as a Mediator

In the earlier exploration of the possible mediating role of HOLC score in the relationship between race and allostatic load, I specified each variable according to traditional mediation methods. Based on the results from Table 2-6, there is evidence to suggest that race *moderates* the relationship between HOLC score and allostatic load. Given this information, the relationship between HOLC and allostatic load differs based on race. As a result, models testing for mediation effects included the effect modification between race and HOLC score. Based on Hayes (2018), I specified models in which race was both an independent and moderating variable (Figure 2-2) (Hayes, 2018).

Figure 2-2. Conceptual Model exploring Race as an independent and moderating variable.



Mediation models explored whether HOLC score mediates the relationship between race and allostatic load controlling for demographic and behavioral factors (Table 2-8). Race was significantly indirectly associated with allostatic load via HOLC Score adjusting for age category, sex, physical activity, smoking status, and poverty status (paths ab = -0.11, p=0.02 for whites;

paths ab= -0.06, p=0.02 for African Americans) (Table 2-8). Race was significantly and negatively associated with HOLC Score (β= -0.15, p =0.00) (Table 2-7). Higher HOLC score was positively associated with allostatic load adjusting for age category, sex, physical activity, smoking status, poverty status, and the interaction between HOLC score and race (β= 0.75, p < 0.01) (Table 2-8). Associations between race and allostatic load were not significant (β= 0.06, p=0.42) [path c], but this relationship became significant when the mediator and interaction between Race and HOLC were added to the models (β= 1.07, p=0.01) [path c'] (Path 2-7). This suggests that while African American respondents had higher AL scores, the strength of the association between HOLC score and AL differed, with stronger effects for whites included in this sample than among African Americans.

Table 2-7. Tests of direct effects of race on allostatic load and tests of neighborhood HOLC scores as a mediating pathway among HANDLS participants (n=1,013)

	Path c: Association between Race and AL			**Path a: Association between Race and HOLC score**			**Path b: Association between HOLC score and AL**			**Association between Race and AL, accounting for HOLC Score**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
M: HOLC Score	0.06	0.07	0.42	-0.15	0.04	0.00	0.75	0.26	0.00	1.07	0.41	0.01

Note: IV: Independent variables. DV: Dependent variable. M: Mediators. All models were adjusted for age category, sex, poverty status, physical activity, and smoking.

Table 2-8. Tests of indirect effects of race on allostatic load by race among HANDLS participants (n=1,013)

	Indirect Effect		
	beta	S.E.	p-value
White	-0.11	0.05	0.02
African American	-0.06	0.03	0.02

Neighborhood Deprivation Indices as Mediators

Results from models testing whether measures of neighborhood socioeconomic status mediate the relationship between HOLC score and allostatic load are shown in Table 2-9. These mediation models explored whether neighborhood deprivation index (NDI) and the percentage of families in poverty mediate the relationship between HOLC Score and allostatic load controlling for socio-behavioral factors (Table 2-9). HOLC Score was significantly indirectly associated with allostatic load via both neighborhood deprivation and the percent of families in poverty with the strongest effects being found among whites (β= 0.17, p=0.03 and β= 0.31, p=0.00, respectively). Higher HOLC Score was positively associated with both the neighborhood deprivation index and the percent of families in poverty adjusting for age category, race, sex, physical activity, smoking status, poverty status, and the interaction between race and NDI (β= 1.40, p=0.00 and β= 7.34, p=0.00, respectively) (Table 2-10). Increasing scores on both the neighborhood deprivation index and the percent of families in poverty were positively associated with allostatic load (β= 0.12, p=0.01 and β= 0.04, p=0.00, respectively). HOLC Score was significantly associated with allostatic load (path c [direct effect]) but became marginally insignificant when the neighborhood deprivation index was added (path c' [total effect]) (Table 2-9), suggesting a potential mediating effect of neighborhood deprivation. In contrast, percent of families in poverty was added (path c [total effect]) did not attenuate the association between HOLC Score and allostatic load (path c' [direct effect]) (Table 2-9).

Table 2.2-9. Tests of direct effects or HOLC score and allostatic load, and tests of measures of neighborhood socioeconomic status as mediating pathways in HANDLS participants (n=1,013)

	Path c: Association between HOLC and AL			**Path a: Association between HOLC and SES indicator**			**Path b: Association between SES indicator and AL**			**Association between HOLC and AL accounting for SES indicator**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value

M: Neighborhood Deprivation Index	0.14	0.06	0.03	1.40	0.15	0.00	0.12	0.05	0.01	0.13	0.06	0.05
M: % of Families in Poverty	0.14	0.06	0.03	7.34	0.47	0.00	0.04	0.01	0.00	0.16	0.07	0.02

Note: IV: Independent variables. DV: Dependent variable. M: Mediators. All models were adjusted for age category, sex, poverty status, physical activity, and smoking. The interaction between race and HOLC score was accounted for.

Table 2-10. Tests of indirect effects of HOLC on allostatic load by race among HANDLS participants (n=1,013)

	Indirect Effect					
	NDI			**% of Families in Poverty**		
	beta	S.E.	p-value	beta	S.E.	p-value
White	0.17	0.08	0.03	0.31	0.11	0.00
African American	0.08	0.04	0.03	0.14	0.05	0.01

<u>Discussion</u>

This study investigated the relationship between historic redlining and contemporary allostatic load in a biracial cohort. Results from analyses using the full sample are consistent with the hypothesis that historic HOLC score at the census tract level is associated with allostatic load for contemporary participants in the sample. Consistent with hypothesis 1 for question 1, I tested and confirmed that there is a difference in the distribution of racial groups across neighborhoods by their former HOLC score. I also explored whether the relationship between HOLC score, and allostatic load would vary based on age group and race. Based on exploratory analyses, I found significant interactions between HOLC score and both age group and race. Tests of mediation models suggest that race is predictive of HOLC score; these associations also account for and substantially explain associations between race and allostatic load among contemporary residents of Baltimore, Maryland. Further tests of mediation models suggest that historical HOLC scores predict contemporary neighborhood deprivation and concentrations of poverty. Neighborhood deprivation, but not the percentage of families in poverty, serve as a mediator of associations between historic HOLC scores and allostatic load among residents of Baltimore, Maryland. Thus, HOLC scores are implicated in shaping contemporary indicators of social determinants of health (e.g., neighborhood socioeconomic disadvantage), which mediate associations between HOLC scores and allostatic load.

In the following paragraphs, the results are examined in greater detail.

Spatial Distribution of Participants by Race

Results reported here found that the distribution of HANDLS study participants across HOLC neighborhoods differed by race. Based on visual inspection of these distributions, African Americans were more likely to be concentrated in formerly bluelined areas than whites, who are more likely to be concentrated in yellowlined areas. White participants were disproportionately found in formerly greenlined areas. However, the small numbers of either African American or white participants in greenlined areas preclude a determination of race differences for this HOLC grade category. More African Americans reside in formerly redlined neighborhoods compared to white participants. In the nearly 90 years since HOLC maps were used to characterize neighborhoods, housing patterns within the Baltimore, MD area have changed where African Americans are now living in areas from which they were previously denied access (Pett, 2021). Gaining access to more geographic diversity for African Americans seems parallel for whites in the sample, who are more likely than African Americans to live in formerly yellowlined areas.

The distribution of the study sample is in part consistent with existing literature. For example, evidence suggests that historically redlined neighborhoods remain predominantly communities of color, while greenlined areas remain predominantly white (Aaronson et al., 2020; Mitchell & Franco, 2018). Based on 2017 estimates from the American Community Survey (ACS) and HOLC maps from the University of Richmond, evidence suggests that contemporary housing patterns have changed. Specifically, Blacks rank third among all contemporary racial/ethnic groups living in formerly redlined areas, with Latinos or Hispanics ranking first and whites ranking second (Perry et al., 2018). Cities like New York, Chicago, Los Angeles, San Francisco, and Boston, to name a few have larger contemporary proportions of people who are not Black living in redlined areas. However, based on 2017 ACS data, Baltimore has roughly equal proportions of both Blacks and whites living in historically redlined areas (Perry et al., 2018). Recent evidence indicates that correlations between increased HOLC scores and census tract concentrations of people of color are less distinct in Baltimore (Pett, 2021). Several formerly green- and bluelined neighborhoods, across the nation, are largely non-white, while some formerly redlined neighborhoods are largely white (Pett, 2021). Jonathan Pett (2021) attributes these relationships in Baltimore to white flight, blockbusting, and urban removal of African Americans to facilitate the construction of Charles Center (a business district in downtown Baltimore) and the Inner Harbor (seaport and tourist attraction). An alternative explanation could be that since historically redlined neighborhoods tended to be concentrated in the city center, these areas were targeted for significant investment and gentrification ensued in these areas changing the racial demographics of these neighborhoods. While I did not explicitly examine the current characteristics of formerly redlined neighborhoods in Baltimore, our chi^2 tests suggest that a greater proportion of African Americans than white participants in the sample used for this analysis were living in formerly redlined areas. However, these findings differ from those reported by Aaronson et al. (2020) and Mitchell & Franco (2018) but are consistent with results reported by Pett (2021) in that whites in the HANDLS sample were more likely to be concentrated in "yellowlined" neighborhoods, which were considered more unfavorable places to live. A potential explanation of these differences could lie in the samples used for these investigations. Aaronson et al. (2020) and Mitchell & Franco (2018) used data from cities across the United States. Since each city across the United States has different and unique histories related to development, redevelopment, and urban renewal, a more granular approach to this phenomenon is warranted. However, Pett (2021) specifically examines HOLC score distributions within Baltimore, Maryland. Given that our work and Pett (2021) uses the same geographic region, the similarities in our results are more apparent. The possibility that these results reflect the HANDLS sample used and are an artifact of the set of respondents recruited within the predetermined neighborhoods in Baltimore, is intriguing and bears further investigation.

In a recent study, Sadler and colleagues (2021) investigated the role of redlining, blockbusting, and gentrification on food access in Baltimore. The patterns of housing discrimination identified in that study are relevant to our discussion. Specifically, they suggest that some of their findings are complicated because the people who endured historical housing discrimination may no longer live in these areas (Sadler et al., 2021). This examination suggests that while African Americans remain more likely to reside in formerly redlined neighborhoods than whites, those relationships may change over time as processes of gentrification, urban renewal, and urban removal result in population transitions.

HOLC Score and Allostatic Load

After accounting for socio-behavioral factors, multilevel models found a significant positive relationship between HOLC score and allostatic load. These findings are consistent with the hypothesis that HOLC scores are positively associated with allostatic load, above and beyond individual demographic and behavioral characteristics. Although this is the first study of which I am aware to examine the association between HOLC scores and allostatic load explicitly, findings are concordant with the burgeoning body of research linking HOLC scores with adverse health outcomes more generally. A few studies have explicitly examined the relationship between HOLC scores and self-rated health, chronic disease, or mental health. Using an ecological approach, Nardone and colleagues (2020) examined the correlations between HOLC scores and various outcomes using data from the CDC's 500 Cities Project. Their results found a positive relationship between HOLC score and diabetes, stroke, and high blood pressure prevalence. While not examining allostatic load explicitly, these health outcomes reflect similar biological pathways as allostatic load, bolstering the evidence of the potential positive associations between historic redlining and adverse cardiovascular health. While the literature explicitly examining associations between HOLC score and allostatic load is limited, more evidence has found associations between racial residential segregation and allostatic load. Briefly, I am conceptualizing redlining, as measured by HOLC scores, as a specific mechanism created by, and which reinforces neighborhood racial residential segregation. Using HOLC score moves beyond traditional segregation measures on contemporary health outcomes since we are looking at the long-lasting, and in some cases multigenerational, impacts of historical racism in the development of current cities and the spatial patterning of disease within these municipalities.

Using HOLC scores instead of segregation explicitly tests existing research that notes that many Redlined neighborhoods remain lower to moderate-income communities of color compared to Greenlined areas that are typically higher-income white neighborhoods (Aaronson et al., 2020; Mitchell & Franco, 2018). Further, HOLC scores drove disinvestments in communities creating an active pathway for conditions of poverty through limited housing stock and access to financial funds to improve the quality of existing housing. Since segregated, predominately African American neighborhoods in the modern era are not exclusively lower-income or disinvested areas, HOLC scores provide a unique opportunity to examine the cumulative effects of institutional racism on contemporary health.

Bellatore and colleagues (2011) examined relationships between racial residential segregation and allostatic load. Using data from Wave III of the National Health and Nutrition Examination Survey, they found positive relationships between the dissimilarity index and normalized exposure index, both segregation measures, on allostatic load. These relationships remained significant after adjusting for sociodemographics (Bellatorre et al., 2011). Additional prior studies suggest positive associations between segregation and cardiometabolic risk. The combined impact of these results highlights the importance of "fundamental causes," and confirms that neighborhood environmental contexts can be linked to adverse health behaviors and outcomes, increasing an individual's exposure to and frequency of stressors.

Age differences in associations between HOLC and Allostatic Load.

I found a significant interaction term between age category and HOLC score, with the only significant interaction being found among people 45 and 54 years old, although in the expected direction for other age groups when compared to the youngest age category, persons 35-44 years. This finding is supported, to a certain extent, by existing research. For example, using data from the CARDIA (Coronary Artery Risk Development in Young Adults) study, Reddy and colleagues examined associations between residential segregation and cardiovascular disease risk over a 15-year period among adults between 18 and 30 at baseline (Reddy et al., 2022). Those living in less segregated neighborhoods had lower odds of developing coronary artery calcification after 15 years of follow-up than those living in medium or highly segregated areas. While not explicitly measuring allostatic load, these findings suggest that racial residential segregation has a lasting impact on health outcomes through impairing earning potential (Havranek et al., 2015; Lindley et al., 2021; Virani et al., 2021), decreased housing values and constraining wealth accumulation (Akbar et al., 2019), and the early activation of stress pathways at younger ages leading to premature development of adverse health conditions (Matthews et al., 2006; Seldenrijk et al., 2012). While the sample consists of a slightly younger cohort, older adults in the CARDIA study correspond with the youngest group of people in the HANDLS cohort, where a significant interaction between age and HOLC score on allostatic load in the HANDLS study was found.

The impact of racial residential segregation on health, particularly among young-to-middle (35-54 years) to older adults (adults who are 55 years old and older), remains less clear (Smith et al., 2022). Segregation has been linked to poorer health outcomes among older adults, including mortality (Collins & Williams, 1999; Jackson et al., 2000; Sudano et al., 2013), cardiovascular disease (Morse, 2015), cancer (Poulson et al., 2021), self-rated health (T. C. Yang et al., 2017), physical activity (Armstrong-Brown et al., 2015), and emotional well-being (Liu et al., 2015). Further, some studies have found a protective effect of segregation on health by reducing mortality (Inagami et al., 2006), increasing physical activity (Armstrong-Brown et al., 2015), and increasing social cohesion (Henderson et al., 2005; Kershaw & Albrecht, 2015). Other evidence suggests that racial residential segregation is not associated with health (Robert & Ruel, 2006; Usher et al., 2018) and that there may be other explanations for health disparities that do not include segregation (Robert & Ruel, 2006). While none of these studies explicitly focus on allostatic load as a measure of stress, findings reported in this chapter contribute to a set of studies elucidating differential impact of historic racial residential segregation on contemporary health outcomes by age group. Given that these study populations are overlap, to a certain degree, with the sample population for these analyses, these relationships are relevant to this investigation. Findings reported in this chapter also suggest that neighborhood contexts and exposures do not evenly impact health outcomes across the lifespan noting that some age groups may be more sensitive than others.

One appropriate theory to contextualize these results would be the Strength and Vulnerability Integration model. This model asserts that as people age, physiological resiliency decreases, making it more challenging to cope with stress (S. T. Charles, 2010; S. T. Charles & Piazza, 2009). Applying this model to our results, it may be the case that those in the youngest age group may be more able to recover from stressful events, resulting in lower allostatic load and weaker associations between external stressors and allostatic load than in the other age categories. Given that there are also racial differences there is a differential effect by race on the speed with which physiological aging occurs may differ based on the lived experience of racialized groups. With that in mind, this finding is consistent with fundamental cause theory which considers the combined impact of multiple stressors on health over the life course. The relationship between HOLC score and allostatic load is insignificant for younger adults. Alternatively, this finding could be attributed to the lag time in the activation of allostatic load processes (B. McEwen, 1998). Future studies examining longitudinal associations between HOLC score and allostatic load would be useful in examining the extent to which residents of neighborhoods with higher HOLC scores are more likely to develop allostatic load at earlier ages compared to those living in neighborhoods with lower HOLC scores.

It is important to highlight that allostatic load is a manifestation of more rapid aging associated with stressful life conditions. Stress process models theorize that physiologic stress takes a toll on physiologic systems, including the cardiovascular and metabolic systems that are components of the allostatic load calculation. Those living in more economically deprived neighborhoods may experience more rapid biological aging compared with those living in less economically deprived neighborhoods (Geronimus et al., 2010; Guidi et al., 2020; McEwen & Wingfield, 2010; Yegorov et al., 2020). This is important for this investigation because I hypothesize that chronic stress is associated with HOLC scores and the subsequent disinvestment and poverty within these areas. These chronic stressors may not manifest in increased allostatic load at younger ages, but as residents experience chronic stress, and their bodies become unable to maintain allostasis as a result of these stressors. This may manifest in more rapid biological aging among those in the 55 to 64-year-old age group. By the age of 65 to 74, those in less economically deprived areas may "catch up" in biological aging to those in more economically privileged neighborhoods.

Race differences in associations between HOLC and Allostatic Load.

I found a significant interaction term between race and HOLC score, with the impact of HOLC score on allostatic load varying by race. Specifically, for Blacks, allostatic load scores were higher than whites irrespective of HOLC score. Simultaneously, among whites, redlining was more strongly associated with allostatic load compared with African Americans. The weathering literature is consistent with the finding that African Americans have a higher allostatic load than whites. This hypothesis asserts that Blacks experience health deterioration earlier than whites through the accumulation of social disadvantages and exposures due to their race (Geronimus, 1992). Again, this important work by Geronimus (1992) speaks directly to the argument throughout this investigation regarding more rapid aging due to stressful life conditions. Specifically, it is not just that African Americans have higher allostatic load, but that African Americans age more rapidly due to the constant exposures associated with living in poorer and disinvested neighborhoods and stressors that impact their physiologic systems. Using cross-sectional data from NHANES, Bird and colleagues (2010) found that Blacks had the highest allostatic load compared to Mexican Americans and whites. Other scholars have reported similar findings using NHANES data (Chyu & Upchurch, 2011; Kaestner et al., 2009) and the Texas City Stress and Health Study (Peek et al., 2010).

Notably, our findings are concurrent with the work of Mujahid and colleagues who examined race-specific associations between historic redlining scores and ideal cardiovascular health (as measured by cholesterol, blood glucose, blood pressure, smoking, body mass index, physical activity, and diet) among participants in the Multi-Ethnic Study of Atherosclerosis (Mujahid et al., 2021). Controlling for sociodemographic characteristics, Blacks living in formerly Redlined areas had less favorable cardiovascular health scores than Blacks living in Greenlined areas. No relationship was found among whites. While these results are paradoxical to our findings, a possible explanation is that the MESA study has participants from multiple cities. In contrast, our investigation includes participants from Baltimore, MD. This highlights the importance of understanding unique differences in each city's history and development characteristics. Also, while I examined HOLC score as a continuous variable and did not stratify our results, these findings highlight how redlining differentially impacts health based on race. Further, other studies have examined the role of other historical institutions and factors on cardiovascular disease. For example, Kramer et al. explored associations between slave concentrations in 1860 and cardiovascular mortality between 1968 and 2014. Their results found that Blacks who lived in counties with high proportions of enslaved people in 1860 had a slower decline in cardiovascular mortality between 1968 and 2014 compared to the general population during the same periods (Kramer et al., 2017).

Thus, our findings illuminate the complex relationship between exposure to institutional racism through racial residential segregation and health outcomes. While ample evidence suggests racial health disparities exist, the role of residential segregation on health disparities appears mixed. On the one hand, studies have found that segregation can be beneficial for health by reducing mortality (Inagami et al., 2006), increasing physical activity (Armstrong-Brown et al., 2015), and increasing social cohesion (Henderson et al., 2005; Kershaw & Albrecht, 2015). Other evidence suggests that racial residential segregation is not associated with health (Robert & Ruel, 2006; Usher et al., 2018) and that there may be other explanations for health disparities that do not include segregation (Robert & Ruel, 2006). As previously mentioned, and acknowledging both the similarities and differences between HOLC scores and segregation, HOLC scores offer a more precise way of understanding disinvestment in some, but not all, racially segregated communities.

Mediation Results

HOLC Score as a Mediator of Associations between Race and Allostatic Load.

I tested whether HOLC scores mediate the relationship between race and allostatic load. After adjusting for age, sex, physical activity, smoking, poverty status, and the interaction between race and HOLC score, HOLC scores partially mediated the relationship between race and allostatic load. While the indirect effect of HOLC score on these relationships is significant for whites and African Americans, I see a greater effect for whites than African Americans. This greater indirect effect for whites may suggest that other factors may be important for shaping allostatic load scores among African Americans that are less important for whites. Based on the literature, these might include discrimination (Brondolo et al., 2011), institutional racism (Carlson & Chamberlain, 2005; Geronimus et al., 2006; Mays et al., 2007), internalized racism (Brondolo et al., 2011), and educational attainment (Rogers et al., 2022).

Based on results reported in this chapter, I found evidence of a suppression effect of the impact of HOLC score on allostatic load when behavioral and household socioeconomic status are added to the models. Anthony Conger presents a widely accepted definition of suppression effects which occurs when a variable is added to a model that increases the predictive validity of another variable or set of variables (Conger, 1974). A positive but insignificant relationship was observed between race and allostatic load (not shown) in models controlling only demographic variables. However, this association became significant after adjusting for physical activity and household poverty. This change in the strength of the effect suggests that the pathways between HOLC score and allostatic load were obscured in models not accounting for those behavioral and economic variables. This finding suggests a potential stress process effect consistent with the conceptual model used to guide this analysis. This moves our explanation of adverse health outcomes more upstream from being an individual choice to suggest that historical and contemporary institutional racism indirectly affects health disparities. In other words, race may be connected to allostatic load through factors above and beyond behavioral factors, including interpersonal stress and other forms of discrimination which were not explored in this investigation. As indicated above, pathways linking race to allostatic load include discrimination and educational attainment.

Neighborhood Socioeconomic Indices as Mediators of associations between HOLC scores and Allostatic Load

Results reported in this chapter contribute to the growing literature on the mediating effects of indicators of neighborhood socioeconomic status on the relationship between HOLC score and allostatic load. Findings are consistent with the hypotheses, that the neighborhood deprivation index explained the relationship between HOLC Score and allostatic load. There are also racial differences in the indirect effect of both NDI and the percentage of families in poverty, where the indirect effects are larger for whites than for African Americans. To ensure that these findings are not taken out of context, in this sample, as in other literature (Geronimus et al., 2006), African Americans have been observed to have higher allostatic load scores than whites. The consistency of these findings in the literature, combined with the literature examining multiple determinants of racial health inequities, suggests that while neighborhood disinvestment and poverty are critical determinants of health for African Americans, African Americans also experience multiple other determinants of poor health outcomes (Noonan et al., 2016; Weinstein et al., 2017). Contemporary patterns of racial residential segregation have been primarily rooted in institutional and interpersonal racism (Popescu et al., 2018b). A wealth of research has examined the relationship between segregation and neighborhood socioeconomic status, with results indicating multiple pathways, including restricted access to quality education, job opportunities, health care, and other resources regarded as crucial components of "fundamental cause" theories (D. Williams & Collins, 2001a). A recent report from the National Community Reinvestment Coalition explored the relationship between redlining and neighborhood health (J. Richardson et al., 2020). Richardson and colleagues found that increased HOLC scores were associated with current neighborhood characteristics, including increased proportions of historically minoritized populations, higher concentrations of poverty, and higher social vulnerability. This association between HOLC score and neighborhood socioeconomic status is concurrent with our results which suggested a significant and positive association between these variables. As Williams and Collins (2001) suggest, historic disinvestment and underinvestment in these neighborhoods have lasting impacts on the residents within these communities by restricting their access to resources that may be protective of health and increasing the occurrence and frequency of stressors deleterious to health and behavior. Increased stressors and the inability to cope with these stressors have direct impacts on health through increased allostatic load.

Another potential mechanism that may help to contextualize these results is the concept of opportunity hoarding. Charles Tilly asserts that opportunity hoarding is a mechanism of social inequality whereby members of a specific demographic category acquire access to a valuable resource and use this as a basis to exclude non-members (Rury & Saatcioglu, 2011; Tilly, 1998). While this concept is broad in nature, its application to the current dissertation is that by virtue of institutionalized racism, whites acquire access to economic, social, and built environmental resources that restrict access based on race or ethnicity. Together with our results, HOLC scores have shaped available opportunities and access–such as mortgages, loans, quality schools–hoarded in greenlined neighborhoods. As a result of opportunity hoarding, these resources are accessible to the predominantly white residents within these neighborhoods. Based on our finding that increasing HOLC scores are associated with increased allostatic load, this may suggest that the characteristics of whites that live in areas with high HOLC scores may be different than other whites in other ways that are not measured in this investigation. This may also suggest that whites that live in areas with high HOLC scores disproportionately benefit from hoarding opportunities within their neighborhoods, and that when whites live in neighborhoods where these resources are not hoarded or readily available, they experience worse health outcomes.

While the literature on HOLC score and allostatic load is relatively new, there is an existing body of literature examining the impact of segregation on allostatic load, which I can rely on to support our findings. The neighborhood deprivation index (NDI) comprises ten variables related to income, housing, employment, and education which are fundamental causes that impact health outcomes. Existing literature has also drawn associations between neighborhood socioeconomic status and allostatic load. I consistently found a significant and positive association between each neighborhood socioeconomic status indicator and allostatic load controlling for covariates. The literature supports this positive relationship between indices of neighborhood socioeconomic status and allostatic load (Barber et al., 2016a; Bird et al., 2010; Robinette et al., 2016; Schulz et al., 2012, 2013). Taken together, this exploration has suggested a positive and significant relationship between indices of neighborhood socioeconomic status and allostatic load above and beyond individual socio-behavioral characteristics. The indirect pathways between HOLC score, NDI and the percent of families in poverty, and allostatic load are significant. This supports the notion of HOLC score, a potentially historic and tangential measure of racial residential segregation, serve as a fundamental cause of health disparities through impaired neighborhood conditions and access to goods and services. These findings may also suggest that behavioral pathways could also serve as potential mediators in the relationship between HOLC score and allostatic load. These findings relate to one of our guiding theories, the Stress Process Model. In this context, our results suggest that a potential explanation involves examining the impact of structural racism on health disparities and health outcomes. The hypothesis could explain the positive relationship between indices of neighborhood socioeconomic status and allostatic load in that lower socioeconomic status neighborhoods may create stressful environments through impaired conditions, including crime, safety, noise, air pollution, and overcrowding, to name a few. The frequent exposure to stressful neighborhood conditions activates physiological responses that, over time, accumulate, placing individuals at an increased risk of premature morbidity and mortality (McEwen, 1998; Robinette, Charles, and Gruenewald, 2017). Racial differences in the indirect effect of indices of neighborhood poverty on allostatic load suggest that there may be more potential pathways between neighborhood poverty and health that may differ by race for participants in the HANDLS cohort. With this, other factors such as behaviors, environmental factors, or social support may help explain some of these findings and indicate the need for additional studies to explore these hypothesized pathways.

2.5 **Strengths and Limitations**

This study has several strengths as well as limitations. Strengths of this investigation include the fact that I had adequate numbers of African Americans in the sample, which allowed for sufficient statistical power to investigate racial differences among the variables in the study. To my knowledge, this was also the first study to explicitly examine the relationship between HOLC score and contemporary allostatic load in an urban area and to explore whether age and race moderate these relationships. Further, this investigation explored the mediation effects of measures of neighborhood socioeconomic status on allostatic load over time. However, the sample is limited to those with allostatic load scores and census tract metrics. A potential cause of this limitation can be attributed to the sampling strategy of the HANDLS cohort. HANDLS participants were selected from 13 pre-determined neighborhoods within Baltimore, Maryland. A visual comparison between these 13 neighborhoods and the historic HOLC maps for Baltimore suggest that while some of the 13 neighborhoods fall within historic HOLC score designated areas, many census tracts do not. Study participants who lived in one of the non-HOLC scored census tracts would have been omitted from the analytic sample for this study. With this in mind, the associations between HOLC score and allostatic load within this cohort only can be attributed to the subset of neighborhoods for which HOLC scores were created. Therefore, the findings are not generalizable to areas that were not scored as part of the HOLC process, including many other cities and areas of the United States. Careful inspection of the cross-tabulation of race by HOLC score suggests that while the sample is sufficiently large, the data may have limitations. Precisely, irrespective of race, a small number of participants live in greenlined areas, and there is not much variation in where whites live as they are concentrated in yellowlined neighborhoods. Finally, despite significant interaction terms between HOLC score and race and age group, I cannot conduct a three-way interaction that considers the interaction between these variables due to small sample sizes. While I adjust for a series of individual and neighborhood-level covariates, there could be additional contextual factors that I have not considered in this analysis that could influence these results.

2.6 **Implications**

There are several important implications of the findings reported above. This work contributes to an emerging topic exploring the impact of historic redlining on current health outcomes. Specifically, findings reported here examined the associations between HOLC residential security maps and contemporary stress response markers, which has not been done in the literature to date. This is important to highlight because these findings suggest that historic forms of institutional racism remain relevant for the health and wellbeing of populations decades after they were enacted and even overturned. The findings can be used for various purposes, including informing advocacy and additional housing strategies to address some of these structural issues. Specifically, findings here suggest that HOLC scores may differentially matter based on age and race, consistent with a Stress Process Model framework. With that in mind, investing equitable resources in these formerly redlined neighborhoods could potentially mitigate the deleterious impact of living in formerly redlined communities.

This chapter has highlighted both limitations of this dataset and the need for future research on these pathways. Given that these associations differ based on demographic characteristics highlights the need to consider intersectional identities to better examine the ways in which the intersections of social positionalities may place certain groups at higher risk for adverse health outcomes. Further, insufficient racial representation in formerly greenlined areas may hinder our understanding of the relationship between HOLC score and allostatic load. Additional research should target the recruitment of study participants to ensure adequate statistical representation of study subjects across neighborhood HOLC score categories. This dissertation chapter has specifically tested the mediation pathway that hypothesizes that historic redlining is associated with neighborhood disinvestment (i.e., historic redlining manifests in socioeconomic indicators some decades later) and that these processes affect the health of contemporary residents, many of whom may not have been living in these areas when the HOLC maps were created, and these neighborhoods were assessed. This means that we should focus on addressing the characteristic of the neighborhoods since they impact health even when the individuals residing in those neighborhoods are not the same.

With these findings in mind, it is important that these results not be taken out of context. While I have seen the mediation impact of HOLC score and indices of neighborhood socioeconomic status matter more for whites than African Americans, we must understand that African Americans already have higher allostatic load scores than whites. This suggests that other factors beyond those I measured may influence adverse health outcomes among African Americans. Additional social environmental characteristics (including neighborhood policing, crime, economic pressures due to gentrification, and violence) and characteristics of an individuals' network may buffer some of the hypothesized deleterious health impacts of neighborhood characteristics on health compared to whites.

Further, additional research should build upon these mediation results to consider additional structural-level mediators (i.e., neighborhood racial composition, economic development/investment) that may also be important in helping to understand the pathways through which historic redlining is associated with contemporary health measures. These relationships can also inform interventions and other city-level policies to address some of these health outcomes. When considering these city or national level policies, it is important to consider health in policy decisions. Considering health in all policies involves establishing collaborative interdisciplinary relationships with the goal of capacity building, governance and accountability and shared resourcing to examine the ways in which public policy has consequences for health while holding policy makers accountable for the health and wellbeing of their constituents (Baum et al., 2014; Green et al., 2021; Hastings & Snowden, 2019; McDaid, 2012; World Health Organization, 2010). Specifically, these results highlight historical decisions made to disinvest in African American and other neighborhoods with high proportions of people of color, which have impacts on both former and current residents of Baltimore, Maryland. This is important despite the fact that current populations were not impacted initially by actions taken by the Home Owner's Loan Corporation in the 1930s and 1940s.

These findings can be used to create policies impacting the pathways between neighborhood contexts and health outcomes. Specifically, investment in the educational systems and workforce development should occur within these historically dis- and underinvested neighborhoods. As posited by the Robert Wood Johnson Foundation, there are additional steps that can be taken to advance neighborhood equity (Robert Wood Johnson Foundation, 2022) . One strategy would be to increase local base-building through helping local organizations in deepening their relationships within the community, increasing attention specifically on actions needed to address health inequalities, and creating grassroots solutions with the intent of dismantling structural racism. Related to housing justice, the same report highlights the need to support and bolster the efforts of low-income minoritized renters in their pursuit to make sure that their needs are being acknowledged and reflected in more local decision-making efforts around housing affordability, community conditions, and the wellbeing of residents within these communities. Further, there are also existing bills being considered by Congress that could also help rectify the long-standing negative impacts of HOLC score and housing discrimination both in Baltimore and within the United States. For example, Senator Elizabeth Warren introduced the *American Housing and Economic Mobility Act of 2019* which would allow the Department of Housing and Urban Development to provide grants to state and local governments to remove barriers to building affordable housing units, provide assistance to those with negative home equity, and providing homebuying assistance to low-income residents (*American Housing and Economic Mobility Act of 2019*, 2019). This concrete governmental action may be an important step in not only acknowledging historic discriminatory practices within this country but trying to rectify these actions through providing equity to those systemically excluded from access to housing resources.

The equitable investment of high-quality and sustainable resources and support in historically dis- and underinvested communities have the potential to mitigate some of the adverse effects of neighborhood contexts on health outcomes. Additionally, there should be increased financial support given to families within dis- and underinvested neighborhoods to ensure that they can increase their household income and improve their housing conditions without removing these residents from environments they may be socially connected to. Finally, results reported here highlight that allostatic load scores are connected to health outcomes primarily driven by social determinants and institutional racism, suggesting the importance of addressing institutionalized racism as a fundamental driver of inequitable health outcomes.

Chapter 3 : From Streets To Stress: Longitudinal Pathways between Neighborhood Socioeconomic Status and Allostatic Load

3.1 Introduction

A series of studies have established associations between measures of neighborhood poverty and both cumulative biological risk (Diez Roux et al., 2010; Schulz et al., 2013) and allostatic load (C. E. Bird et al., 2010; G. H. Brody et al., 2014; Merkin et al., 2009, 2020; A. J. Schulz et al., 2012; Theall et al., 2012). Reviews of the existing literature have generally found that living in an economically deprived neighborhood is associated with adverse health outcomes despite the strength of these associations varying across studies (Diez Roux et al., 2010). Ultimately, research to date has reported findings indicating that regardless of whether income was measured at the neighborhood or individual level, socioeconomic status is linked to health through a variety of both behavioral and physiological pathways (House, 2002; Bruce G. Link et al., 2008; Phelan et al., 2010; Schulz et al., 2012).

Emerging research examines the relationship between neighborhood socioeconomic status, allostatic load, and cumulative biological risk in minoritized and international cohorts. This is particularly important because physiological response to stressful contexts may result in changes to multiple bodily systems, including altering both cardiovascular (Kaplan & Keil, 1993; Seeman et al., 1994; Tzourio et al., 1999; Zelinski et al., 1998) and metabolic systems (B. K. Lee et al., 2007; G. Li et al., 2006; Lupien et al., 1994; T. Seeman et al., 2010; Teresa E. Seeman et al., 1997). Studies in the United States have found that increases in neighborhood socioeconomic status were protective against higher allostatic load and cumulative biological risk scores among Puerto Ricans in Boston, MA (Jiménez et al., 2015) and African Americans in Jackson, MI (Barber et al., 2016a). These findings are consistent with research conducted with cohorts based in Sweden (Gustafsson et al., 2014), Switzerland, Portugal, and the United Kingdom (Ribeiro et al., 2019). It has been hypothesized that managing chronic illnesses may make it difficult for individuals of lower socioeconomic statuses to move out of lower socioeconomic status neighborhoods through limiting employment opportunities, straining financial resources, and increasing their reliance on both neighborhood services and social ties (Arcaya, Subramanian, Rhodes, & Waters, 2014; Arcaya & Schnake-Mahl, 2019). Therefore, an approach examining allostatic load, a precursor to adverse cardio and cerebrovascular events, may be important to explore the mechanisms through which neighborhood socioeconomic status may be linked to health outcomes and, more importantly, to consider potential points of intervention.

Neighborhood perceptions may be an important phenomenon to measure in the attempt to understand the role of space and place on health outcomes. Subjective measures of neighborhood environments may capture information about these environments differently than traditional observed measures of neighborhood environments (i.e., crime statistics, density of certain neighborhood characteristics) (Plunkett et al., 2007; Roosa et al., 2009b). Evidence suggests that neighborhood contexts may vary based on demographics, including race, age, and gender (Aneshensel, 2010; Farley et al., 1994). This variability highlights the potential benefit of using subjective measures to assess neighborhood contexts.

Though associations between neighborhood socioeconomic status and allostatic load have been reported across multiple studies, populations, and contexts, the potential mediating role of neighborhood perceptions in these relationships remains understudied. This is important since links between subjective perceptions of neighborhood environments have been linked to individual health (Andrews et al., 2020; Ceasar et al., 2020; A. V. Diez Roux, 2001; Powell-Wiley et al., 2013; Sampson & Raudenbush, 2004). To my knowledge, only two studies examine the mediating role of neighborhood perceptions on these linkages. Schulz and colleagues (2012) tested the relationship between neighborhood poverty and allostatic load within a low- to moderate-income multiracial community in Detroit, Michigan, using cross-sectional data. Their multilevel models found that neighborhood poverty was positively associated with allostatic load, controlling for covariates, and perceptions of neighborhood environments mediated these relationships. Similar results were also found in the Schulz and colleagues 2013 publication. Building upon these identified research gaps, this dissertation investigation examines these associations longitudinally while assessing the factors that may influence neighborhood perceptions and their associations with allostatic load will be essential to understand the mechanisms through which neighborhood contexts shape individual health outcomes above and beyond individual behaviors. For this research study, I ask several important research questions.

The Case for Baltimore

Baltimore, Maryland, as the 30th largest city within the United States, has some of the lowest average incomes when compared to other northeastern cities with poverty levels disproportionality affecting non-white neighborhoods (Theodos et al., 2019). Baltimore's geographic segregation is apparent in what is referred to as "the Black butterfly," where Black residents are primarily concentrated on the eastern and western sides, where whites are clusters in the "white L" in the central and southern regions of the city (Lawrence Brown, 2016; Theodos et al., 2019). To address some of the limitations of using nationally representative samples, local cohort studies are important as they can shed light onto potential associations between variables considering more contextual factors (Geronimus et al., 2020).

3.2 Specific Aims and Hypotheses

In this study, I examine whether measures of neighborhood socioeconomic status, as measured by estimates from the American Community Survey, are associated with allostatic load among current residents of Baltimore, Maryland. As described below, I examine three research questions and related hypotheses to address this overarching research question.

Q1. Do associations between neighborhood socioeconomic status and allostatic load (AL) vary by age, race, sex, and household poverty over time?

> *H1.1: Associations between the neighborhood deprivation index and allostatic load differ by individual characteristics, including age, race, gender, and household poverty status for study participants over time.*
>
> *H1.2: Associations between the percentage of families in poverty at the census tract level and allostatic load differ by individual characteristics, including age, race, gender, and household poverty status for study participants over time.*
>
> *H1.3: Associations between median home value at the census tract level and allostatic load differ by individual characteristics, including age, race, gender, and household poverty status for study participants over time.*
>
> *H1.4: Associations between the percentage of people at the census tract level without a BA degree and allostatic load differ by individual characteristics, including age, race, gender, and household poverty status for study participants over time.*

Q2. Do associations between neighborhood socioeconomic status and allostatic load remain significant after accounting for health-related behaviors (e.g., physical activity)?

H2.1: Associations between neighborhood deprivation index and allostatic load will remain significant after controlling for physical activity.

H2.2: Associations between the percentage of families in poverty at the census tract level and allostatic load will remain significant after controlling for physical activity.

H2.3: Associations between median home value at the census tract level and allostatic load will remain significant after controlling for physical activity.

H2.4: Associations between the percentage of people without a BA degree at the census tract level and allostatic load will remain significant after controlling for physical activity.

Q3: Do perceptions of neighborhood characteristics mediate the longitudinal relationship between census tract level neighborhood socioeconomic status, as measured by indicators in the American Community Survey during Wave III, and allostatic load, as measured during Wave IV?

H3.1: Neighborhood perceptions will mediate the relationship between census tract level neighborhood deprivation and allostatic load over time.

H3.2: Neighborhood perceptions will mediate the relationship between census tract level percentage of families in poverty and allostatic load over time.

H3.3: Neighborhood perceptions will mediate the relationship between census tract level median home value and allostatic load over time.

H3.4: Neighborhood perceptions will mediate the relationship between census tract level percentage of people without a BA degree and allostatic load over time.

3.3 **Methods**

Data from the Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study were used for this analysis. HANDLS involves a cohort of 3,720 white and African American adults between 30- and 64 years old at baseline living in 13 neighborhoods in Baltimore, Maryland. Data collection began in August 2004; I will be using Wave III, collected between June 2009 and July 2013, and Wave IV, collected between September 2013 and September 2017. Participants were excluded if they moved between Wave III and Wave IV or were missing variables used in the study. More information on the study design and methods has been published in detail (Evans et al., 2010).

Allostatic Load

Allostatic load (AL) was computed using methods outlined by existing studies based on the HANDLS dataset (Beydoun et al., 2019), using clinical cut points to define high and low-risk biomarkers. In keeping with the allostatic load literature, I include cardiovascular (systolic and diastolic blood pressure, pulse rate), metabolic (total cholesterol, HDL-C, HbA1c, waist-to-hip ratio), and inflammatory (albumin CRP) indicators (Beydoun et al., 2019) as components of AL taken from Wave IV data. Risk scores were assigned as follows:

Table 3-1. Allostatic Load Indicator Criteria, based on Beydoun et al., 2019.

	High Risk Clinical
Albumin (g/dL)	<3.8
C-reactive protein (mg/dL)	≥ 0.3
Waist: Hip ratio	>0.9 for men; > 0.85 for women
Total Cholesterol (mg/dL)	≥240

HDL (mg/dL)	<40
Glycated hemoglobin (%)	≥6.4
Resting heart rate (beat/min)	≥90
Systolic Blood Pressure	≥140
Diastolic BP	≥90

Neighborhood Socioeconomic Status

This analysis used four measures to assess neighborhood socioeconomic status, all constructed at the census tract level. These include: a neighborhood deprivation index, the percentage of households with incomes below the poverty line, the neighborhood education and median home value. Each variable is described in greater detail below.

The Neighborhood Deprivation Index (NDI) is a composite measure of neighborhood socioeconomic status. This index was created on the census tract level using 2013 5-year estimates from the American Community Survey within the U.S. Census Bureau to reflect census tract level socioeconomic levels during Wave III of HANDLS data collection. Neighborhood deprivation was measured using neighborhood socioeconomic deprivation calculated using previously published methods on the census tract level (Powell-Wiley et al., 2020; Neally et al., 2022). Specifically, estimates from the American Community Survey include median household income, median housing value, the percentage of individuals over 25 with a high-school diploma, the percentage of individuals over 25 with a bachelor's degree, the percentage of employed people (age 16 and older) working in management, business, science, and arts, the percentage of households below the federal poverty limit, the percentage of families receiving public assistance, the percentage of female-headed households with children under 18, and the percentage that receive interest, dividends, or rental income was downloaded from the American Community Survey. Variables were z-standardized and reverse coded as necessary so that the sum of these variables would result in a continuous score with higher scores representing more deprivation or a lower socioeconomic status census tract.[12] As an additive scale, each of the z-standardized scores were combined into a composite score where higher scores are associated with more deprivation.

In addition to the NDI, I assessed the association between three individual components of the NDI, as indicators of socioeconomic status and AL. Specifically *neighborhood poverty* was assessed as the percentage of families with incomes below the federal poverty limit at the census tract level. *Neighborhood education* was assessed as the percentage of adults over 25 without a BA degree at the census tract level.[13] *Median home value* was assessed at the census tract median home value, reported by owner-occupied residents, reported per $10,000.

Adverse Neighborhood Perceptions

A series of questions were drawn from the neighborhood questionnaire that HANDLS participants completed during Wave III assessing perceptions of their neighborhood. Each of the response items were scaled on a 5-point Likert scale. Using factor analysis, I identified three factors, 1) Perceived Physical Environment (11 items assessing perceived physical environmental

[12] The percent of people over 25 with a high school diploma, the individuals over 25 with a bachelor's degree, the percentage of employed people (age 16 and older) working in the management, business, science, and arts, and the percentage of houses that receive interest, dividends, or rental income were reverse coded in the dataset to reflect a deprivation approach.
[13] Models were also tested with the percentage of people on a census tract level that do not have a High School Diploma as sensitivity analyses (models not shown) and the models were not significantly different than those included in this dissertation.

characteristics of the neighborhood), 2) Perceived Social Environment (5 items assessing perceived social relationships within the neighborhood), and 3) Perceived Community Action (3 items assessing perceived likelihood that neighborhood residents would take action to intervene in a series of neighborhood events). Each perception domain was tested in the mediation models. Scales are scored in a manner whereby higher scores indicate more adverse neighborhood conditions. Results from the factor analysis and the questions that pertain to each factor domain are shown in Table 2.

Table 3-2. Rotated factor loading scores and mean Likert scale response to the questions that loaded into each factor.

Factor	Item	Mean (SD)	Range
Physical Environment (Factor 1)			
Frequency of graffiti in neighborhood		2.57 (1.22)	1-5
Frequency of litter in neighborhood		3.74 (1.16)	1-5
Frequency of drug dealers, drug users or drunks in neighborhood		3.28 (1.34)	1-5
Frequency of unemployed adults loitering in neighborhood		3.07 (1.34)	1-5
Frequency of gang activity in neighborhood		2.13 (1.23)	1-5
Frequency of disorderly or misbehaving teens or children in neighborhood		2.92 (1.19)	1-5
Frequency of prostitution in neighborhood		2.26 (1.36)	1-5
Frequency of vacant, abandoned, or boarded up buildings in neighborhood		2.83 (1.43)	1-5
Frequency of broken windows in neighborhood		2.43 (1.30)	1-5
Frequency of serious crime such as assault, mugging, or robbery in neighborhood		3.35 (1.03)	1-5
Frequency of houses or yards not kept up in neighborhood		3.08 (1.13)	1-5
Social Environment (Factor2)			
People in my neighborhood are willing to help their neighbors		2.52 (1.14)	1-5

Live in a close-knit neighborhood	2.84 (1.24)	1-5
People in my neighborhood can be trusted	2.95 (1.20)	1-5
People in my neighborhood generally do not get along with each other	2.49 (1.10)	1-5
People in my neighborhood do not share the same values	3.07 (1.21)	1-5
Community Action (Factor 3)		
Take action if children spray paint	2.38 (1.22)	1-5
Take action if children disrespect adult	2.66 (1.22)	1-5
Take action if fight in front of house	2.46 (1.20)	1-5

Physical Activity

Physical Activity was assessed using responses about physical activity that respondents completed in Wave III. This concept was measured by the question, *"Past month modest physical activity for 10-60 minutes per week?".* Responses to this item are *"No" and "Yes".*

Covariates

Covariates include age (35-44, 45-54, 55-64, 65+), race (white vs. African American), sex (male vs. female), current tobacco smoking status (never tried, tried, never used regularly, former user, current user), household poverty status (Federal Poverty Guidelines <125%:below poverty; ≥125%: above poverty), and allostatic load as recorded during Wave III.

3.4 **Statistical Analysis**

Descriptive statistics were calculated for all variables included in the analyses. Regressions for each aim of this paper were conducted using multilevel models. Since each participant is one observation clustered in a census tract, some of the characteristics of the individual may be concordant with others within the cluster (R. A. Rose, 2018). Given this, multilevel models are a unique method to examine these relationships. Specifically, a multilevel approach was selected using an independent variable and random intercept variation. Mediation models, with Sobel's and bootstrapping estimates, were also used to examine mediating relationships and provide data on the strength of the indirect pathways between the variables under study using. StataSE 17 (StataCorp, College Station, TX, USA) was used to conduct all analyses. The illustration and interpretation of the multilevel models are presented (OLS models with clustered standard error models were also conducted, and results from OLD models are included in the appendix [Appendix B: Tables B1 – B7).

3.5 Results

Six hundred and eighteen participants had measures for this study's main exposure, outcome, and covariates and did not move between study waves. Table 3 presents the descriptive statistics for each variable included in the study. The mean allostatic load score for study participants during Wave 4 was 1.90 (min=0, max=6), the baseline allostatic load during Wave 3 was 1.92 (min=0, max=6), roughly one fifth of the study participants were between 35 and 44 years old, about one third were between 45 and 54 years old and 55 and 64 years old, respectively, and just over one in ten were between 65 and 76 years old. Approximately 51% of the sample was African American, and nearly 60% of the sample was female. For physical activity, less than half of the sample (46.93%) reported engaging in between 10 and 60 minutes of daily physical activity. Smoking status varied, with 22.82% of study participants being current users, 11.97% former users, 28.80% never tried, and 36.41% tried but never used regularly. Sixty-nine percent of participants were above the poverty threshold. The mean neighborhood perception score around the physical environment was 2.88 (min= 1.27; max=4.73), the mean social cohesion score was 2.76 (min=2.76; max=5), and the mean community action score was 2.50 (min=1; max=5). On the neighborhood level, the mean Neighborhood Deprivation Index score was 11.77, (range= 2.55-22.26), the mean percent of families in poverty at the census tract level was 24.53% (range= 2.0-60.80), the mean scaled median home value, in thousands, was 12.69 (in other words, the median home value at the census tract level was $126,900, range= 4.38-39.70), and the mean percentage of people without a BA degree was 90.50 (in other words, on average, at the census tract level, 90.5% of residents did not have a bachelor's degree, range= 58.03-98.97).

Table 3-3. Mean, Standard Deviation, and Range for Participant Demographic characteristics of Participants in Wave III of HANDLS

N=618	Mean(SD)	Range (if applicable)
Individual Level Variables		
Allostatic Load (Wave 4)	1.90 (1.21)	0-6
Baseline Allostatic Load (Wave 3)	1.92 (1.23)	0-6
	N (%)	
Age Category		
35-44	114 (18.45)	
45-54	228 (36.89)	
55-64	204 (33.01)	
65+	72 (11.65)	
Race		
white	301 (48.71)	
African American	317 (51.29)	
Sex		
Female	367 (59.39)	
Male	251 (40.61)	
Physical Activity		
No	328 (53.07)	
Yes	290 (46.93)	
Smoking Status		
Never Tried	141 (22.82)	
Tried, never used regularly	74 (11.97)	
Former User	178 (28.80)	
Current User	225 (36.41)	
Household Poverty Status		
Above Poverty Threshold	432 (69.90)	

Below Poverty Threshold	186 (30.10)	
Neighborhood Perceptions		
Factor 1- Physical Environment	31.72 (9.21)	14-52
Factor 2: Social Cohesion	13.81 (4.42)	5-25
Factor 3: Community Action	7.49 (3.25)	3-15
Neighborhood Level Variables		
Neighborhood Socioeconomic Status Indicators (Census Tract)		
Neighborhood Deprivation Index	11.77 (3.61)	2.55 - 22.36
% Without a BA degree	90.50 (6.59)	58.03 - 98.97
Median Home Value	12.69 (5.76)	4.38 - 38.70
% of Families in Poverty	24.53 (12.12)	2.00 - 60.80

Do associations between neighborhood socioeconomic status and allostatic load differ based on demographic indicators? In this section, I present results related my first research question, including results from tests of hypotheses examining whether associations between four indicators of socioeconomic status and allostatic load differ by age, race, sex, or household poverty status.

Age Specific Relationships

Table 4 shows results from multilevel models asking whether associations between the four neighborhood socioeconomic status measures and allostatic load measures varied by age group. Specifically, the associations between the four neighborhood socioeconomic status indicators and allostatic load differ significantly for those older than 65 compared to those in the youngest (35-44) age group. Table 4 shows an interaction between the constructs of neighborhood deprivation index (β= 0.09, p=0.03) and the percentage of families in poverty (β= 0.03, p=0.01), both at the census tract level and categorical age. For both variables, the association between neighborhood socioeconomic status and AL was stronger for those aged 65-74 when compared with those aged 35-44.

Table 3-4. Allostatic load regressed on four indicators of neighborhood SES, with and without interactions between neighborhood SES indicators and Categorical Age, controlling for Race, Sex, Physical Activity, Smoking Status, Baseline Allostatic Load, and Household Poverty Status

	Model 1: Census tract level neighborhood deprivation index		Model 2: Census tract percent poverty		Model 3: Census tract median home value		Model 4: Census tract percent without a BA	
	B(SE)	P	B(SE)	P	B(SE)	P	B(SE)	P
Level 2- Neighborhood Level								
Neighborhood Deprivation Index	-0.01 (0.03)	0.67	--	--	--	--	--	--
% of Families in Poverty	--	--	-0.00 (0.01)	0.24	--	--	--	--
Median Home Value	--	--	--	--	-0.03 (0.01)	0.07	--	--
% without a BA	--	--	--	--	--	--	0.01 (0.01)	0.36
Level 1- Individual Level								
Age Category								
35-44 (ref)								
45-54	0.24 (0.39)	0.53	-0.04 (0.25)	0.88	-0.35 (0.29)	0.22	1.65 (1.59)	0.30
55-64	-0.23 (0.38)	0.55	-0.23 (0.25)	0.36	-0.13 (0.30)	0.67	0.18 (1.55)	0.91
65-76	-0.83 (0.51)	0.10	-0.52 (0.33)	0.12	-0.29 (0.34)	0.39	1.12 (1.82)	0.54
Age Category * SES indicator								
35-44 * SES indicator (ref)								
45-54 * SES indicator	-0.02 (0.03)	0.55	0.00	0.77	0.03 (0.02)	0.14	-0.02 (0.02)	0.31
55-64 * SES indicator	0.02 (0.03)	0.44	0.01	0.19	0.01 (0.02)	0.51	-0.00 (0.02)	0.94
65-76 * SES indicator	**0.09 (0.04)**	**0.03**	**0.03**	**0.01**	0.04 (0.02)	0.09	-0.01 (0.02)	0.62

Using Figures 1 and 2 as a reference, there is a significantly stronger association for those over 65 years old compared to those in the 35-44 years old for the neighborhood deprivation index and the percentage of families in poverty. However, for those in the middle-aged groups, the slopes are not significantly different than the reference group. Among older adults, increases in neighborhood deprivation index and the percentage of families in poverty are associated with decreases in allostatic load, suggesting that older age groups experience more adverse effects of high NDI on AL compared to the referent group. Further, I tested whether the model including the interaction term between age category and both the neighborhood deprivation index and the percentage of families in poverty was a better fit than models without the interaction term. Based on a p-value of 0.16 (not shown), models including the interaction between age category and the neighborhood deprivation index were not a better fit in modeling these associations than models without the interaction term. Based on a p-value of 0.18 (not shown), models including the interaction between age category and the percentage of families in poverty were not a better fit in modeling these associations than models without the interaction term.

Figure 3-1. Differences in the association between NDI and AL by Categorical Age

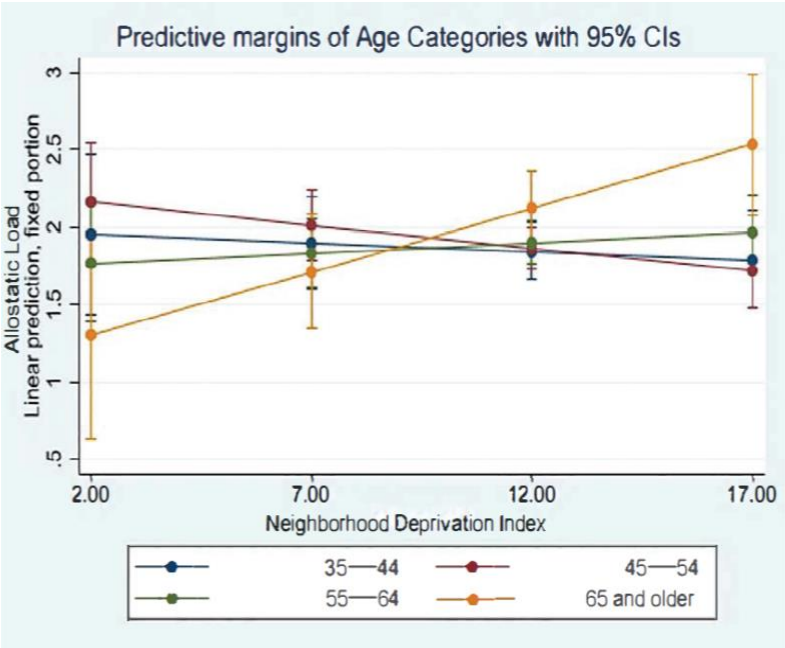
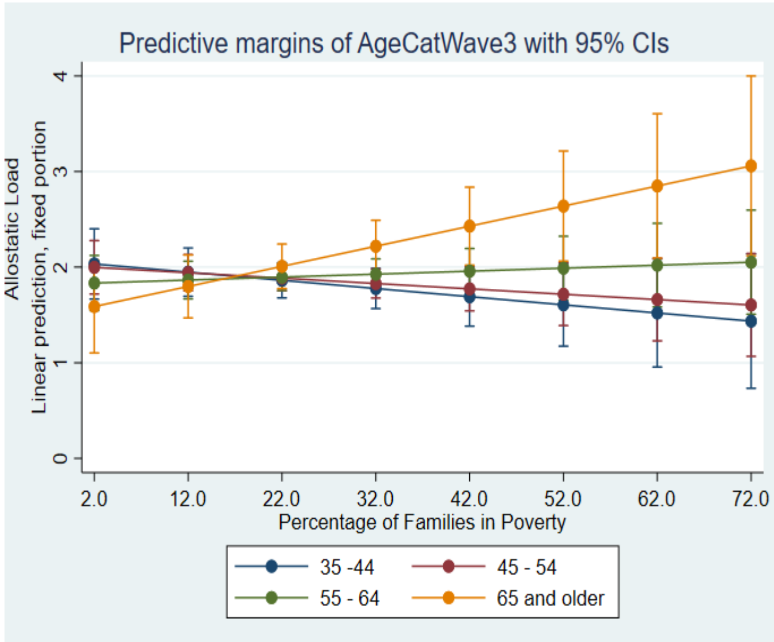


Figure 3-2. Variations in the associations between census tract level poverty and AL by Categorical Age



<u>*Race Specific Associations*</u>

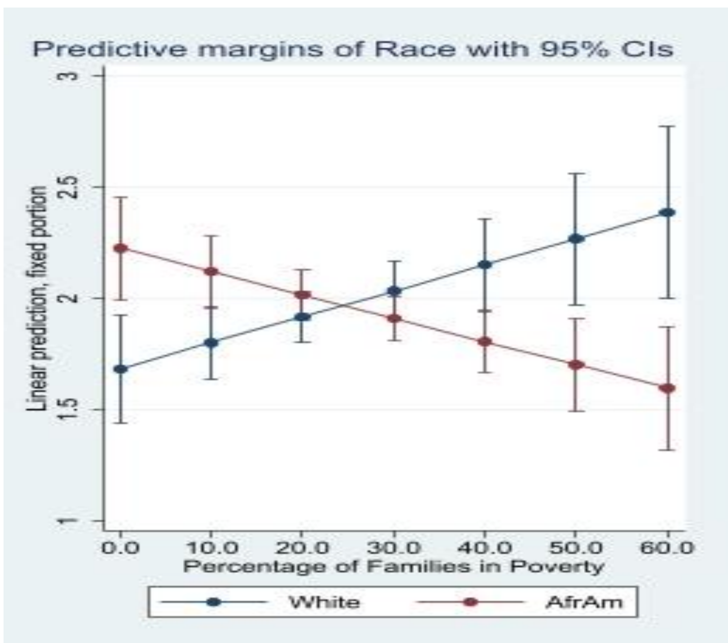
Table 3-5 shows results from multilevel models asking whether associations between four distinct measures of neighborhood socioeconomic characteristics and allostatic load measures differed by race. Table 5 shows a significant interaction term between the percent of families in poverty and race (β= -0.02 p=0.00). However, there was no significant interaction between neighborhood deprivation index (β= -0.04, p=0.06), median home value and race (β=-0.01 p=0.67), and the percent of people without a BA degree and race (β= -0.01 p=0.42) (Table 3-5). The significant negative interaction between race and percent of families in poverty suggests that the association between percent poverty and AL is positive for whites while showing an inverse association for African Americans. In contrast, the slopes for whites and African Americans are not different for associations between the neighborhood deprivation index, median home value, or the % of people without a BA degree and AL.

Table 3-5. Results from Multilevel Models Regressing Allostatic Load on the interaction between SES Indicators and Race Controlling for Categorical Age, Sex, Physical Activity, Smoking Status, Baseline Allostatic Load, and Household Poverty Status

	Model 1: Census tract level neighborhood deprivation index		Model 2: Census tract percent poverty		Model 3: Census tract median home value		Model 4: Census tract percent without a BA	
	B(SE)	P	B(SE)	P	B(SE)	P	B(SE)	P
Level 2- Neighborhood Level								
NDI	0.02 (0.02)	0.18	--	--	--	--	--	--
% of Families in Poverty	--	--	0.01 (0.01)	0.01	--	--	--	--
Median Home Value	--	--	--	--	0.00 (0.01)	0.94	--	--
% without a BA	--	--	--	--	--	--	0.00 (0.01)	0.74
Level 1- Individual Level								
Race								
White (ref)								
African American	-0.04 (0.28)	0.11	0.53 (0.18)	0.00	0.16 (0.20)	0.42	-0.49 (1.17)	0.68
SES indicator * African American	-0.04 (0.02)	0.06	**-0.02 (0.01)**	**0.00**	-0.02 (0.01)	0.25	0.00 (0.01)	0.71

Because of the negative moderating effect of race on the association between the percent of families in poverty (β= -0.02 p=0.00) and allostatic load, for African Americans, increasing proportions of families in poverty in the neighborhood are associated with decreases in allostatic load: Plotting these slopes, it becomes clear that these differences are not significant until concentrations of poverty become extreme, above 50% of household below the poverty line (see Figure 3-3). However, for whites, it appears that increases in the percentage of people living in poverty at the census tract level are associated with increased allostatic load, again only at the highest levels of poverty (Figure 3-3). In contrast, African Americans living in areas with very low poverty have heightened AL compared with whites living in similar neighborhoods. The slope lines converge at more moderate levels of neighborhood poverty. However, in areas with a neighborhood poverty index over 50%, the significance difference in AL between African American and white participants appears. Upon further observation, associations for whites in the sample living in neighborhoods with high concentrations of poverty may be obscured due to small numbers of observations suggesting the inability to accurately measure these associations at higher poverty levels for whites. Further, I tested whether the model including the interaction term between race and percentage of families in poverty was a better fit than models without the interaction term. Based on a p-value of <0.001 (not shown), models including the interaction between race and the percentage of families in poverty was a better fit in modeling these associations.

Figure 3-3. Variations in the associations between census tract level poverty and AL by Race



<u>*Sex-Specific Associations*</u>

To test whether the relationship between each socioeconomic status indicator and allostatic load varies by sex, I tested whether there was an interaction between each indicator of neighborhood socioeconomic status and sex. Table 3-6 shows a significant interaction between the neighborhood deprivation index and sex (β=-0.05 p=0.04) and the neighborhood percent of families in poverty and sex (β= -0.02 p=0.02). However, there was no significant interaction between either median home value and sex (β= 0.01 p=0.52) or the percent of people without a BA degree and sex (β= 0.00 p=0.86) (Table 3-6). Since the referent group is females, associations between the neighborhood deprivation index and the percentage of families in poverty on AL significantly differ from the associations between these variables for men. Specifically, increasing neighborhood deprivation is associated with decreased allostatic load among men compared with women. However, for women, those in neighborhoods with lower scores on the deprivation index have lower allostatic load scores compared to women living in higher deprivation index scored neighborhoods. Further, I tested whether the model including the interaction term between sex and both the neighborhood deprivation index and the percentage of families in poverty was a better fit than models without the interaction term. Based on a p-value of 0.04 (not shown), models including the interaction between sex and the neighborhood deprivation index were a better fit in modeling these associations compared to models without the interaction term. Similarly, based on a p-value of 0.02 (not shown), models including the interaction between sex and the percentage of families in poverty was a better fit in modeling these associations compared to models without the interaction term.

Table 3-6. Allostatic Load regressed on four indicators of SES, with an interaction between SES and Sex, Controlling for Categorical Age, Race, Physical Activity, Smoking Status, Baseline Allostatic Load, and Household Poverty Status

	Model 1: Census tract level neighborhood deprivation index		Model 2: Census tract percent poverty		Model 3: Census tract median home value		Model 4: Census tract percent without a BA	
	B(SE)	P	B(SE)	P	B(SE)	P	B(SE)	P
Level 2- Neighborhood Level								
NDI	0.02 (0.01)	0.16	--	--	--	--	--	--

% of Families in Poverty	--	--	0.01 (0.00)	0.16	--	--	--	--
Median Home Value	--	--	--	--	-0.01 (0.01)	0.16	--	--
% without a BA	--	--	--	--	--	--	0.00 (0.01)	0.55
Level 1- Individual Level								
Sex								
Female (ref)								
Male	0.36 (0.28)	0.19	0.19 (0.18)	0.30	-0.30 (0.20)	0.13	0.38 (1.11)	0.73
SES Indicator * Male	**-0.05 (0.02)**	**0.04**	**-0.02 (0.01)**	**0.02**	0.01 (0.01)	0.52	0.00 (0.01)	0.86

Figures 3-4 and 3-5 show the effects of neighborhood deprivation and poverty on allostatic load, but not education and home value, are modified by sex. Increases in both the neighborhood deprivation index and the percentage of families in poverty are associated with greater decreases in allostatic load for men compared with women. However, increases in these measures are more positively associated with allostatic load among women than with men (Figures 3-4 and 3-5). At lower levels of NDI and neighborhood poverty, there are not statistically significant differences in AL for women and men (based on overlapping confidence intervals in Figures 3-4 and 3-5). However, at the highest levels of NDI and in areas with extreme concentrations of poverty (above 30%), AL scores for women and men are different, suggesting that in areas with more concentrated economic disadvantage, men have lower levels of AL compared to men in more economically privileged areas and compared with women of all economic areas. These findings could be attributed to the fact that there are fewer males in neighborhoods with high scores on the neighborhood deprivation index and in areas with higher percentages of people in poverty (distributions were tested, but not shown). The small representation of men in more economically deprived neighborhoods could obscure the ability to accurately measure these associations.

Figure 3-4. Variations in the associations between NDI and AL by Sex

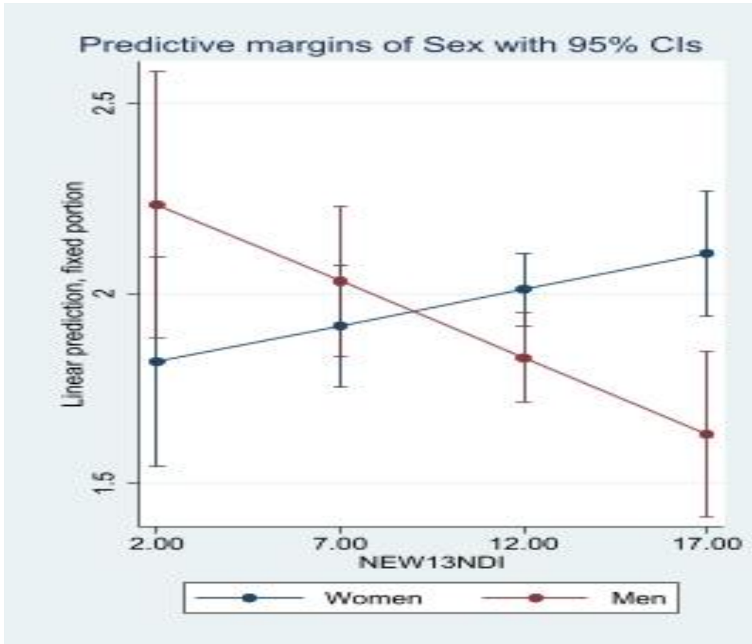
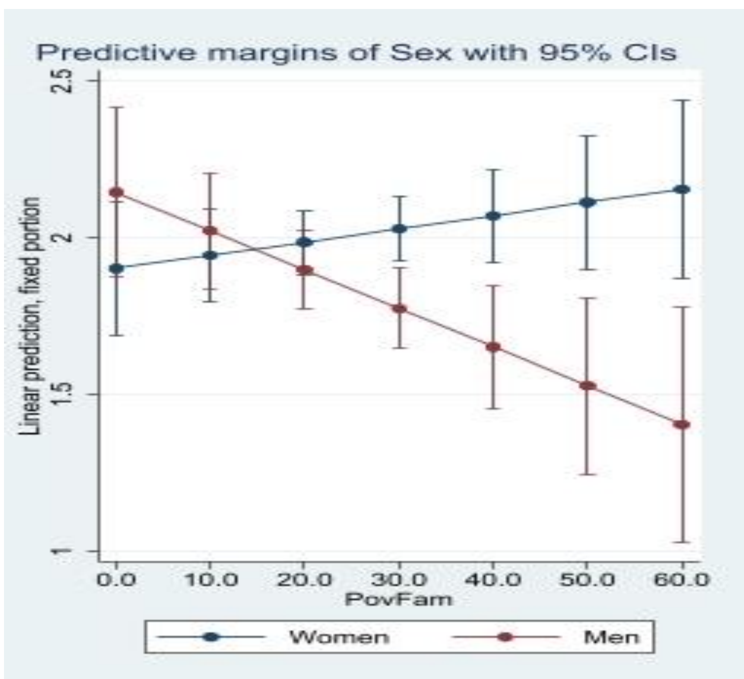


Figure 3-5. Variations in the associations between census tract level poverty and AL by Sex



<u>*Household Poverty Specific Associations*</u>

To test whether the relationship between each socioeconomic status indicator and allostatic load varies by household poverty status, I tested whether there was an interaction between socioeconomic status indicator and household poverty status. As shown in Table 3-7, there is no significant interaction term between each index of neighborhood socioeconomic status and household poverty. Specifically, the association between each of the four neighborhood socioeconomic status indicators and allostatic load does not differ significantly for households above the poverty limit compared with those below the poverty limit (Table 3-7).

Table 3-7. Allostatic Load regressed on each of four measures of neighborhood socioeconomic status, including an interaction between the neighborhood socioeconomic status indicator and Household Poverty Status, controlling for Categorical Age, Race, Sex, Physical Activity, Baseline Allostatic Load, and Smoking Status.

	Model 1: Census tract level neighborhood deprivation index		Model 2: Census tract percent poverty		Model 3: Census tract median home value		Model 4: Census tract percent without a BA	
	B(SE)	P	B(SE)	P	B(SE)	P	B(SE)	P
Level 2- Neighborhood Level								
NDI	0.01 (0.01)	0.38	--	--	--	--	--	--
% of Families in Poverty	--	--	0.00 (0.00)	0.36	--	--	--	--
Median Home Value	--	--	--	--	-0.00 (0.01)	0.64	--	--
% without a BA	--	--	--	--	--	--	0.00 (0.01)	0.54
Level 1- Individual Level								
Household Poverty Status								
Above Poverty Threshold (ref)								
Below Poverty Threshold	0.34 (0.30)	0.24	0.28 (0.20)	0.16	0.21 (0.21)	0.32	-0.30 (1.22)	0.81
SES Indicator * Below Poverty Threshold	-0.03 (0.02)	0.26	-0.01 (0.01)	0.16	-0.01 (0.01)	0.35	0.00 (0.01)	0.79

Do associations between neighborhood socioeconomic status and allostatic load remain robust after accounting for physical activity?

To test the second research question addressed in this chapter, I ran multilevel models examining the extent to which associations between indices of neighborhood socioeconomic status and allostatic load at Wave IV remain robust after accounting for physical activity adjusting for age, race, sex, household poverty status, smoking status, and allostatic load during Wave III. Results from tests of the hypotheses that associations between neighborhood socioeconomic status and allostatic load will remain significant after adjusting for physical activity are presented in Tables 3-8a – 3-8d.

Table 3-8a. Allostatic load regressed on census tract level Neighborhood Deprivation Index and physical activity, Controlling for Age, Race, Sex, Household Poverty, Smoking Status, and Baseline Allostatic Load

Neighborhood Deprivation Index				
	Model 1a		Model 1b	
	B(SE)	P	B(SE)	P
Level 2-Neighborhood Level				
Neighborhood Deprivation	-0.00 (0.01)	0.74	0.00 (0.01)	0.91
Level 1-Individual Level				
Age Category				
35-44 (ref)				
45-54	0.10 (0.11)	0.34	0.03 (0.11)	0.81
55-64	0.15 (0.11)	0.17	0.06 (0.12)	0.64
65-76	0.25 (0.13)	0.06	0.22 (0.15)	0.15
Race				
White (ref)				
African American	0.02 (0.07)	0.81	-0.05 (0.08)	0.52
SES Indicator*Race	--	--	--	--
Sex				
Female (ref)				
Male	-0.20 (0.07)	0.00	-0.18 (0.08)	0.03
Household Poverty Status				
Above Poverty Threshold (ref)				
Below Poverty Threshold	0.08 (0.08)	0.33	0.03 (0.09)	0.71
Smoking Status				
Never Tried (ref)				
Tried, never used regularly	0.09 (0.13)	0.50	0.05 (0.14)	0.75
Former User	0.03 (0.10)	0.74	-0.06 (0.11)	0.59
Current User	0.07 (0.10)	0.47	0.04 (0.11)	0.72
Baseline Allostatic Load	0.08 (0.08)	0.33	0.55 (0.03)	0.35
Physical Activity				
No (ref)				
Yes	--	--	-0.08 (0.08)	0.35

As shown in Table 8a Model 1, consistent with models presented earlier in this chapter, results do not indicate a significant association between neighborhood deprivation and allostatic load (β= -0.00, p=0.74). The association between neighborhood deprivation and allostatic load remains insignificant with the inclusion of physical activity in the models (β= 0.00, p=0.91).

Table 3-8b. Allostatic load regressed on census tract level percent of families in poverty and physical activity, Controlling for Categorical Age, Race, Sex, Household Poverty Status, Smoking Status, and Baseline Allostatic Load

% of Families in Poverty				
	Model 1a		Model 1b	
	B(SE)	P	B(SE)	P
Level 2				
% of Families in Poverty	**0.01 (0.00)**	**0.04**	**0.01 (0.01)**	**0.01**
Level 1				
Age Category				
35-44 (ref)				
45-54	0.10 (0.11)	0.33	0.03 (0.11)	0.79
55-64	0.16 (0.11)	0.13	0.08 (0.12)	0.52
65-76	0.22 (0.13)	0.09	0.19 (0.15)	0.21
Race				
White (ref)				
African American	0.50 (0.16)	0.00	0.51 (0.18)	0.01
SES Indicator*Race	-0.02 (0.01)	0.00	-0.02 (0.01)	0.00
Sex				
Female (ref)				
Male	-0.20 (0.07)	0.01	-0.18 (0.08)	0.03
Household Poverty Status				
Above Poverty Threshold (ref)				
Below Poverty Threshold	0.07 (0.08)	0.39	0.02 (0.09)	0.80
Smoking Status				
Never Tried (ref)				
Tried, never used regularly	0.05 (0.13)	0.71	-0.02 (0.14)	0.91
Former User	0.01 (0.10)	0.91	-0.09 (0.11)	0.44
Current User	0.05 (0.10)	0.60	0.01 (0.11)	0.96
Baseline Allostatic Load	0.53 (0.03)	0.00	0.54 (0.03)	0.00
Physical Activity				
No (ref)				
Yes	--	--	-0.08 (0.08)	0.31

As shown in Table 3-8b, Model 1a, associations between neighborhood percent poverty and allostatic load were statistically significant (B=0.01, p-0.04) in multilevel models adjusting for individual-level age, race, sex, household poverty status, smoking status, the interaction between race and the census tract percent of families in poverty, and baseline allostatic load. The associations between neighborhood poverty and AL remain significant after accounting for physical activity (Model 1b).

Table 3-8c. Allostatic load regressed on census tract level Median Home Value and physical activity, Controlling for Categorical Age, Race, Sex, Household Poverty Status, Smoking Status, and Baseline Allostatic Load

Median Home Value		
	Model 1a	Model 1b

	B(SE)	P	B(SE)	P
Level 2				
Median Home Value	-0.01 (0.01)	0.35	-0.01 (0.00)	0.24
Level 1				
Age Category				
35-44 (ref)				
45-54	0.10 (0.11)	0.34	0.03 (0.11)	0.80
55-64	0.15 (0.11)	0.17	0.05 (0.12)	0.64
65-76	0.26 (0.13)	0.05	0.22 (0.15)	0.14
Race				
White (ref)				
African American	0.01 (0.07)	0.88	-0.06 (0.08)	0.47
SES Indicator*Race	--	--	--	--
Sex				
Female (ref)				
Male	-0.20 (0.07)	0.01	-0.18 (0.08)	0.03
Household Poverty Status				
Above Poverty Threshold (ref)				
Below Poverty Threshold	0.08 (0.08)	0.33	0.04 (0.09)	0.67
Smoking Status				
Never Tried (ref)				
Tried, never used regularly	0.08 (0.13)	0.53	0.04 (0.14)	0.78
Former User	0.04 (0.10)	0.71	-0.05 (0.11)	0.64
Current User	0.06 (0.10)	0.58	0.02 (0.11)	0.83
Baseline Allostatic Load	0.53 (0.03)	0.00	0.04 (0.09)	0.36
Physical Activity				
No (ref)				
Yes	--	--	-0.08 (0.08)	0.36

Model 1a, Table 3-8c, presents results from multilevel models examining associations between census tract median home value and allostatic load, adjusting for age, race, sex, household poverty status, smoking status, and baseline allostatic load. Consistent with findings presented earlier in this chapter, associations between median home value and allostatic load are insignificant (B= -0.01, p=0.35). Adjusting for physical activity (Model 1b) does not change this non-significant association (B= -0.01, p=0.24).

Table 3-8d. Allostatic load regressed on census tract level percent of adults without a BA degree and physical activity, Controlling for Categorical Age, Race, Sex, Household Poverty Status, Smoking Status, and Baseline Allostatic Load

% Without a Bachelor's Degree				
	Model 1a		Model 1b	
	B(SE)	P	B(SE)	P
Level 2				
% without a BA	0.00 (0.01)	0.51	0.01 (0.01)	0.41
Level 1				
Age Category				
35-44 (ref)				
45-54	0.10 (0.11)	0.35	0.03 (0.11)	0.83

55-64	0.15 (0.11)	0.17	0.05 (0.12)	0.65
65-76	0.26 (0.13)	0.05	0.22 (0.15)	0.14
Race				
White (ref)				
African American	0.01 (0.07)	0.89	-0.06 (0.08)	0.47
SES Indicator*Race	--	--	--	--
Sex				
Female (ref)				
Male	-0.20 (0.07)	0.01	-0.18 (0.08)	0.03
Household Poverty Status	--	--		
Above Poverty Threshold (ref)				
Below Poverty Threshold	0.07 (0.08)	0.35	0.04 (0.09)	0.69
Smoking Status				
Never Tried (ref)				
Tried, never used regularly	0.08 (0.13)	0.54	0.04 (0.14)	0.78
Former User	0.03 (0.10)	0.73	-0.06 (0.11)	0.60
Current User	0.06 (0.10)	0.56	0.03 (0.11)	0.79
Baseline Allostatic Load	0.53 (0.03)	0.00	0.55 (0.03)	0.00
Physical Activity				
No (ref)				
Yes	--	--	0.04 (0.09)	0.69

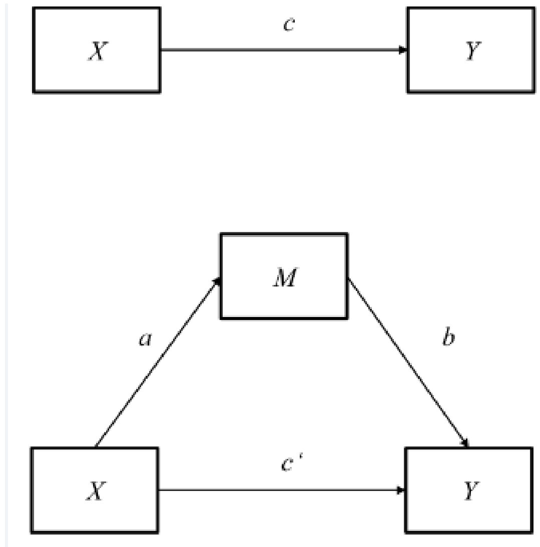
Model 1a, Table 3-8d presents results from multilevel models examining associations between census tract percentage of people without a BA degree and allostatic load, adjusting for age, race, sex, household poverty status, smoking status, and baseline allostatic load (β= 0.00, p=0.51). Adding physical activity to the models (Model 1b) does not change this association (β= 0.01, p=0.41).

<u>Do neighborhood perceptions mediate associations between neighborhood socioeconomic indicators and allostatic load?</u>

In this section, I examined the extent to which different perceptions of neighborhood characteristics serve as mediators of the relationship between census tract-level indicators of socioeconomic status and allostatic load. As part of the first research question in this chapter, I tested interactions between neighborhood socioeconomic status and race. In keeping with the findings presented above, which indicated a significant interaction between neighborhood poverty and race, models examining the neighborhood percentage of families in poverty and allostatic load include an interaction between race and the percentage of people in poverty.

Results from tests of the hypotheses that neighborhood perception domains mediate associations between neighborhood socioeconomic status and allostatic load are presented in the following tables (Tables 3-9-3-16). Based on the results above, I found a significant association between the percentage of families in poverty and allostatic load after including the interaction between the percentage of families in poverty and race; therefore, models examining associations between the percentage of families in poverty and allostatic load will include this interaction. I present four tables, each examining the pathways between one of the four indicators of neighborhood socioeconomic status and allostatic load and each of the three potential mediation pathways. In Figure 3-6, "X" corresponds to the predictor variable, which includes NDI, the percentage of families in poverty, median home value, and the percentage of people with a BA degree, "M" corresponds to the mediator, which are the neighborhood perception domains, "Y" corresponds to allostatic load. Path A examines the effect of X on M, Path B explores the effect of the mediator on Y, Path C examines the direct effect of X on Y, and Path C' examines the direct effect of X on Y, including the mediator. The following figure corresponds to the presentation of results in the following tables (Figure 3-6).

Figure 3-6. Diagram expressing the potential Mediation Pathways of Neighborhood Perceptions on the Relationship between Neighborhood SES indices and allostatic load.



<u>*Mediation Results for Neighborhood Deprivation Index (NDI) and Allostatic Load*</u>

Results from models testing whether perceptions of neighborhood environments mediate the relationship between NDI and allostatic load are shown in Table 9. To test pathway a, I ran separate models with each of the three measures of neighborhood perception (e.g., physical environment, social environment, community action). NDI was significantly and positively associated with physical environment (β= 0.91, p=0.00), perceived social environment (β= 0.27, p=0.00), and community action (β= 0.26, p=0.00) (Table 3-9). To test pathway b, allostatic load was regressed on each measure of neighborhood perception. Relationships between allostatic load and physical environment (β= 0.00, p=0.89), social environment (β=0.01, p=0.61), and community action (β= -0.02, p=0.21) were not significant (Table 3-9). The direct relationship between NDI score and allostatic load was insignificant (path c) (β= 0.00, p=0.83) and remained insignificant when physical environment, social environment, and community action were added into their respective models (path c') (β= -0.00, p= 0.96; β= 0.00, p= 0.88; and β= 0.00, p= 0.88, respectively). Tests of indirect effects of neighborhood perception domains on associations between NDI and allostatic load show that neither physical environment (β= 0.00, p= 0.89), social environment (β= 0.00, p= 0.61), nor community action (β= -0.00, p= 0.22) significantly mediate these associations (Table 3-10).

Table 3-9. Tests of direct effects of NDI on allostatic load and test of neighborhood perception scores as a mediating pathway among HANDLS participants

	Path c: Association between NDI and AL			**Path a: Association between NDI and Mediator**			**Path b: Association between Mediator and AL**			**Path c': Association between NDI and AL accounting for Mediator**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
M: Factor 1- Physical Environment	0.00	0.01	0.83	**0.91**	**0.11**	**0.00**	0.00	0.01	0.89	-0.00	0.01	0.96
M: Factor 2: Social Environment	0.00	0.01	0.83	**0.27**	**0.06**	**0.00**	0.01	0.01	0.61	0.00	0.01	0.88
M: Factor 3: Community Action	0.00	0.01	0.83	**0.26**	**0.04**	**0.00**	-0.02	0.01	0.21	0.01	0.01	0.61

Note: M: Mediators. All models were adjusted for age category, sex, household poverty status, physical activity, and smoking. The interaction between race and SES indicator was accounted for.

Table 3-10. Tests of indirect effects of neighborhood perception domains on the direct relationship between NDI on allostatic load among HANDLS participants

	Indirect Effect								
	Factor 1: Physical Environment			**Factor 2: Social Environment**			**Factor 3: Community Action**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
Indirect Effect	0.00	0.01	0.89	0.00	0.00	0.61	-0.01	0.00	0.22

<u>Percent of Families in Poverty and Allostatic Load Mediation Results</u>

Results from models testing whether perceptions of neighborhood environments mediate the relationship between the percentage of families in poverty and allostatic load are shown in Table 3-11. To test pathway a, I ran separate models with each of the three measures of neighborhood perception (e.g., physical environment, social environment, community action). the percentage of families in poverty was significantly and positively associated with physical environment (β= 0.23, p=0.00), perceived social environment (β= 0.05, p=0.01), and community action (β= 0.06, p=0.00) (Table 3-11). To test pathway b, allostatic load was regressed on each measure of neighborhood perception. Relationships between allostatic load and physical environment (β= -0.00, p=0.99), social environment (β=0.00, p=0.63), and community action (β= -0.02, p=0.19) were not significant (Table 3-11). The direct relationship between the percentage of families in poverty score and allostatic load was significant (path c) (β= 0.04, p=0.01) and remained significant when physical environment, social environment, and community action were added into their respective models (path c') (β= 0.04, p= 0.01; β= 0.04, p= 0.00; and β= 0.04, p= 0.00, respectively). Tests of indirect effects of neighborhood perception domains on associations between the percentage of families in poverty and allostatic load show that neither physical environment (β= -0.00, p= 0.99), social environment (β= 0.00, p= 0.63), nor community action (β= -0.00, p= 0.21) significantly mediate these associations (Table 3-12).

Table 3-11. Tests of direct effects of % of families in poverty on allostatic load and test of neighborhood perception scores as a mediating pathway among HANDLS participants

	Path c: Association between % of families in poverty and AL			**Path a: Association between % of families in poverty and Mediator**			**Path b: Association between Mediator and AL**			**Path c': Association between % of families in poverty and AL accounting for Mediator**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
M: Factor 1-Physical Environment	**0.04**	**0.01**	**0.01**	**0.23**	**0.03**	**0.00**	-0.00	0.01	0.99	**0.04**	**0.01**	**0.01**
M: Factor 2: Social Environment	**0.04**	**0.01**	**0.01**	**0.05**	**0.02**	**0.01**	0.00	0.01	0.63	**0.04**	**0.01**	**0.00**
M: Factor 3: Community Action	**0.04**	**0.01**	**0.01**	**0.06**	**0.01**	**0.00**	-0.02	0.01	0.19	**0.04**	**0.01**	**0.00**

Note: M: Mediators. All models were adjusted for age category, sex, household poverty status, physical activity, and smoking. The interaction between race and SES indicator was accounted for.

Table 3-12. Tests of indirect effects of neighborhood perception domains on the direct relationship between the % of families in poverty on allostatic load by race among HANDLS participants

	Indirect Effects								
	Factor 1: Physical Environment			**Factor 2: Social Environment**			**Factor 3: Community Action**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
Indirect Estimate	-0.00	0.00	0.99	0.00	0.00	0.63	-0.00	0.00	0.21

<u>Median Home Value and Allostatic Load Mediation Results</u>

Results from models testing whether perceptions of neighborhood environments mediate the relationship between neighborhood median home value and allostatic load are shown in Table 3-13. To test pathway a, I ran separate models with each of the three measures of neighborhood perception (e.g., perceived physical environment, perceived social environment, perceived community action). Neighborhood median home value was significantly and negatively associated with perceived physical environment (β= -0.41, p=0.00), perceived social environment (β= -0.13, p=0.00), and perceived community action (β= -0.12, p=0.00) (Table 3-13). To test pathway b, allostatic load was regressed on each measure of neighborhood perception. Relationships between allostatic load and perceived physical environment (β= -0.00, p=0.99), perceived social environment (β=0.00, p=0.65), and perceived community action (β= -0.02, p=0.19) were not significant (Table 3-13). The direct relationship between neighborhood median home value and allostatic load was insignificant (path c) (β= -0.01, p=0.20) and remained insignificant when perceived physical environment, perceived social environment, and perceived community action were added into their respective models (path c') (β= -0.00, p= 0.57; β= -0.01, p= 0.53; and β= -0.01, p= 0.41, respectively). Tests of indirect effects of neighborhood perception domains on associations between neighborhood median home value and allostatic load show that neither perceived physical environment (β= 0.00, p= 0.99), perceived social environment (β= -0.00, p= 0.66), nor perceived community action (β= 0.00, p= 0.21) significantly mediate these associations (Table 3-14).

Table 3-13. Tests of direct effects of median home value on allostatic load and tests of neighborhood perception scores as a mediating pathway among HANDLS participants

Median Home Value												
	Path c: Association between median home value and AL			**Path a: Association between median home value and Mediator**			**Path b: Association between Mediator and AL**			**Path c': Association between median home value and AL accounting for Mediator**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
M: Factor 1- Physical Environment	-0.01	0.01	0.20	**-0.41**	**0.07**	**0.00**	-0.00	0.01	0.99	-0.00	0.01	0.57
M: Factor 2: Social Environment	-0.01	0.01	0.20	**-0.13**	**0.04**	**0.00**	0.00	0.01	0.65	-0.01	0.01	0.53
M: Factor 3: Community Action	-0.01	0.01	0.20	**-0.12**	**0.03**	**0.00**	-0.02	0.01	0.19	-0.01	0.01	0.41

Note: M: Mediators. All models were adjusted for age category, sex, household poverty status, physical activity, baseline allostatic load, and smoking.

Table 3-14. Tests of indirect effects of neighborhood perception domains on the direct relationship between median home value on allostatic load by race among HANDLS participants

	Indirect Effects								
	Factor 1			**Factor 2**			**Factor 3**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
Estimates	0.00	0.00	0.99	-0.00	0.00	0.66	0.00	0.00	0.21

Percent without a BA degree and Allostatic Load Mediation Results

Results from models testing whether perceptions of neighborhood environments mediate the relationship between the percentage of people without a BA degree and allostatic load are shown in Table 3-15. To test pathway a, I ran separate models with each of the three measures of neighborhood perception (e.g., physical environment, social environment, community action). The percentage of people without a BA degree was significantly and positively associated with perceived physical environment (β= 0.31, p=0.00), perceived social environment (β= 0.14, p=0.00), and perceived community action (β= 0.11, p=0.00) (Table 3-15). To test pathway b, allostatic load was regressed on each measure of neighborhood perception. Relationships between allostatic load and perceived physical environment (β= 0.00, p=0.94), perceived social environment (β= 0.00, p=0.63), and perceived community action (β= -0.02, p=0.20) were not significant (Table 3-15). The direct relationship between the percentage of people without a BA degree and allostatic load was insignificant (path c) (β= 0.01, p=0.35) and remained insignificant when perceptions of physical environment, social environment, and community action were added into their respective models (path c') (β= 0.00, p= 0.78; β= 0.01, p= 0.72; and β= 0.01, p= 0.48, respectively). Tests of indirect effects of neighborhood perception domains on associations between the percentage of people without a BA degree and allostatic load show that neither perceived physical environment (β= 0.00, p= 0.94), perceived social environment (β= 0.01, p= 0.64), nor perceived community action (β= -0.00, p= 0.21) significantly mediate these associations (Table 3-16).

Table 3-15. Tests of direct effects of % without a BA degree on allostatic load and tests of neighborhood perception scores as a mediating pathway among HANDLS participants

	% without a BA degree											
	Path c: Association between % without a BA degree and AL			**Path a: Association between % without a BA degree and Mediator**			**Path b: Association between Mediator and AL**			**Path c': Association between % without a BA degree and AL accounting for Mediator**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
M: Factor 1- Physical Environment	0.01	0.01	0.35	**0.31**	**0.06**	**0.00**	0.00	0.01	0.94	0.00	0.01	0.78
M: Factor 2: Social Environment	0.01	0.01	0.35	**0.14**	**0.03**	**0.00**	0.00	0.01	0.63	0.00	0.01	0.72
M: Factor 3: Community Action	0.01	0.01	0.35	**0.11**	**0.02**	**0.00**	-0.02	0.01	0.20	0.01	0.01	0.48

Note: M: Mediators. All models were adjusted for age category, sex, household poverty status, physical activity, baseline allostatic load, and smoking.

Table 3-16. Tests of indirect effects of neighborhood perception domains on the direct relationship between the percentage of people without a BA degree on allostatic load by race among HANDLS participants

	Indirect Effects								
	Factor 1			**Factor 2**			**Factor 3**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
Estimates	0.00	0.00	0.94	0.01	0.00	0.64	-0.00	0.00	0.21

3.6 **Discussion**

This chapter engaged three research questions about potential pathways linking neighborhood socioeconomic status to allostatic load over time. These included: 1) Whether associations between neighborhood socioeconomic characteristics (i.e., neighborhood deprivation, the percentage of families in poverty, median home value, and the percentage of people without a bachelor's degree) and allostatic load vary by individual-level demographic characteristics, including age, race, and sex, or by household poverty; 2) Whether associations between neighborhood socioeconomic status and allostatic load over time remain robust after accounting for physical activity (that may be linked to neighborhood socioeconomic characteristics); and 3) The extent to which individual self-reports of neighborhood stressors/characteristics mediate associations between indicators of neighborhood socioeconomic status and allostatic load. Below I discuss the findings from these analyses and consider their implications for future research and public health practice.

Age, Neighborhood SES and Allostatic Load Findings

Limited studies have examined the relationship between indicators of neighborhood socioeconomic status and allostatic load by age group within the U.S. context. The analyses presented here suggest significant interactions between categorical age and associations between the neighborhood deprivation index and the percentage of families in poverty with allostatic load. Specifically, individuals in the 65-74 age group show a significantly stronger positive association between both the neighborhood deprivation index and the percentage of families in poverty when compared with those 35 to 44 years old. Levels of AL for those in the oldest age group are lowest at low levels of both NDI and neighborhood poverty. According to the overlapping confidence intervals, they are not statistically different from those in other age groups. Given the small number of older adults across both of these socioeconomic status indicators, I may be limited in accurately estimating the true associations between these variables.

Differences in associations between indices of neighborhood socioeconomic status and allostatic load may be relevant for conversations concerning the concept of weathering (Ribeiro et al., 2019). To my knowledge, there have been no studies that have explicitly tested age-specific associations between neighborhood socioeconomic status and allostatic load, which precludes a specific discussion of these associations. However, this discussion will focus on the existing research that has examined the main effects of different measures of neighborhood socioeconomic status and allostatic load. For example, Geronimus and colleagues (2006) found that young adulthood may be a critical developmental period for differential biological risks associated with to stressors (A. Geronimus et al., 2006; L. J. Richardson et al., 2021). This study also suggested that racial health disparities become more apparent after young adulthood (A. Geronimus et al., 2006). In relation to this study, I did detect significant interaction terms between those 65 to 76 years of age compared with the referent age group (age 35-44) and neighborhood deprivation index and the percentage of families in poverty, in predicting AL. Specifically, the slopes on these indices of neighborhood socioeconomic status and allostatic load were significantly steeper for those older than 65 compared those younger than 44. A Swedish study using data from the Northern Swedish Cohort found that neighborhood disadvantage between 16 and 43 years old was associated with higher allostatic load at 43 years old (Gustafsson et al., 2014). Despite these findings suggesting that associations between neighborhood disadvantage and AL vary by age, the study also relied upon a Swedish cohort in which the association between neighborhood socioeconomic status, age, and allostatic load may operate differently. This study is also limited in its comparison to the results presented in this discussion. Specifically, Gustafsson and colleagues (2014) found effects for those between 16 and 43 years of age, while the current study found an interaction effect demonstrating that effects for those older than 65 differed from those younger than 44, suggesting the need to examine age-specific associations into middle and older adulthood. Since the hypothesized relationships were concordant with these results, I expect that the significant relationships between indicators of socioeconomic status and allostatic load would also be significant in older age groups. Using weathering as a guide, it can be understood that those in the oldest age group are experiencing the manifestation of stressors experienced over the life course. The null findings for the interaction between age and either median home value or the percentage of people without a bachelor's degree could be attributed to external factors not accounted for in these models. This null finding could also suggest that these indicators are less strongly associated with health among participants in this study. Since chronic diseases typically present in midlife, the finding that neighborhood deprivation and the percentage of people below poverty were positively associated with allostatic load, and that these effects were strongest among older adults, may reflect the accumulation of stressors that people may be experiencing within their neighborhoods over the life course.

Race and Allostatic Load Findings

My analyses found a negative interaction between the percentage of families in poverty and race, suggesting that increases in the percentage of families in poverty were associated with decreased allostatic load among African Americans. At the same time, the inverse is true for whites. However, I did not find significant interactions between associations with neighborhood deprivation index, median home value, or the percentage of people without a BA degree and race in predicting AL suggesting that associations between these variables on AL are comparable between whites and African Americans. The paradoxical findings regarding the race specific associations between the percentage of families in poverty and allostatic load may be attributed to the small number of observations from white participants living in high poverty neighborhoods. Therefore, these findings should be interpreted with caution. However, scant literature has explored racial differences in associations between median home value, the percentage of people without a BA degree, and allostatic load, consistent evidence has suggested positive associations between neighborhood deprivation indices and allostatic load, which is contrary to the findings presented in this chapter. For example, using data from the 1997 National Longitudinal Survey of Youth, Christie-Mizell examined associations between neighborhood disadvantage and self-reported health over time (Christie-Mizell, 2022). In this study, Christie-Mizelle conceptualizes neighborhood disadvantage using three indicators, the percentage of poor female-headed houses, the unemployment rate, and the serious crime rate per 100,000 (i.e., murder, robbery, etc.), which were standardized and then summed into an index. Despite finding associations in the expected directions within the full sample, their results found that Blacks in the most disadvantaged areas appear to be protected from adverse neighborhood conditions compared to whites (Christie-Mizell, 2022). Christie-Mizell (2022) attributes these findings through four different potential mechanisms, a) the “health paradox”, which is discussed in more detail below; b) Blacks are more likely to live in economically disadvantaged areas and the stigma associated with living in such neighborhoods may be less relevant for health than it may be for whites; c) Blacks may be less sensitive to neighborhood conditions that do not emphasize the white middle-class trajectory (i.e., employment, educational attainment); and d) the intergenerational trauma and coping skills that Blacks have developed intergenerationally may protect Blacks from the adverse effects of living in lower socioeconomic communities. The current investigation did not reveal significant differences in associations between a neighborhood deprivation index and allostatic load in this investigation. The differences in associations between the neighborhood deprivation index used in this dissertation and the index used in Christie-Mizell (2022) could be attributed to the fact that the neighborhood deprivation index uses many more indicators of neighborhood socioeconomic status suggesting that the number of indicators in an index may have implications for measuring associations between neighborhood socioeconomic status and allostatic load. Merkin and colleagues (2009) examined associations between neighborhood SES and AL using data from Wave III of NHANES. Neighborhood socioeconomic status was measured using a composite measure of six neighborhood socioeconomic status measures: percentage of family households with children not headed only by a female, percentage of male population ages 16 and older that is employed, percentage of households that do not receive public assistance income, percentage of households with income higher than the poverty threshold, median household income, and percentage of population ages 25 and older with high school diploma or higher education. Their analyses found that Blacks who lived in the lowest SES neighborhoods had a higher risk of a high AL than Blacks in the higher SES strata (Merkin et al., 2009). This income-stratified approach within a Black sample could suggest the need for future research to examine these relationships to explore within-group differences in these associations on AL. Further, Bird and colleagues examined associations between neighborhood SES and AL using data from Wave III of NHANES (C. E. Bird et al., 2010). They found a significant inverse association between SES and AL. However, significance disappeared for both groups when their models were stratified by race/ethnicity. Upon further inspection, their neighborhood socioeconomic status indicator was composed of six census tract level variables (percent of adults older than 25 with less than a high school education, percent male unemployment, percent of households with income below the poverty line, percent of households receiving public assistance, percent of female-headed households with children and median household income). Despite their neighborhood socioeconomic status indicator being similar to my neighborhood deprivation index, there could be differences in my findings attributed to the neighborhood deprivation index using more indicators of neighborhood socioeconomic position than those used in Bird and colleagues' 2010 investigation and that their study relied upon cross-sectional, national data from NHANES III which was collected between 1988 and 1994. Using a national dataset could overestimate these associations in some areas while underestimating these associations in others, supporting the need for more granular explorations on how neighborhood factors are broadly associated with allostatic load and health. Data from Bird and colleagues 2010 investigation were also collected over 30 years ago. Given the age of the data, the associations between neighborhood socioeconomic status and allostatic load decades ago may not be how these relationships may operate in the more modern era due to inflation, gentrification, and changes in the economic conditions of cities over time.

In the current study, the beta values for the interaction term between the percentage of families in poverty and race is negative, suggesting that the slope of these relationships for African Americans in the sample is negative compared with whites. Specifically, increases in the percentage of families in poverty were associated with decreases in allostatic load among African Americans. In models including an interaction term, both the main effect of neighborhood poverty and the interaction term with race on allostatic load are significant. Given the inadequate numbers of whites living in areas with high poverty, there may not be enough statistical power to measure these associations. This paradoxical finding with the percentage of people in poverty on allostatic load joins mixed findings reported elsewhere in the literature. For example, Brody and colleagues (2014), examined whether living in a neighborhood with increasing poverty was associated with an 8-year longitudinal increase in allostatic load among African American youth aged 11 at baseline from rural Georgia. Neighborhood poverty was measured at baseline, where poverty concentrations were geocoded with participants' residences. After controlling for individual-level characteristics, their analyses suggest that youth who lived in neighborhoods where poverty levels increased over the study period had a statistically significant increase in allostatic load; however, this association was not found among youth who noted higher emotional support (Gene H. Brody et al., 2014). Despite this positive association, this study sample relies on youth living in rural Georgia and given that rural areas may have unique contexts that may differ from the exposures in urban areas, the findings and their implications may not be generalizable to adults or people who reside in urban areas. The attenuation of models, including emotional support, may indicate that deleterious impacts associated with living in areas of concentrated poverty may be buffered by social support. Further, in a study seeking to examine associations between neighborhood socioeconomic status and allostatic load among a Detroit-based cohort (Schulz et al., 2012) did not find differences in associations between neighborhood poverty and allostatic load by race. Schulz and colleagues (2012) conceptualized neighborhood poverty as the percentage of households below the poverty line at the census block group level. The null finding could reflect to the fact that the average neighborhood poverty level did not vary across racial/ethnic groups and that racial and ethnic differences in associations between neighborhood poverty and allostatic load are influenced by high proportions of African Americans living in poverty (Merkin et al., 2009; A. J. Schulz et al., 2012). However, in the current dissertation study, African Americans live in areas with higher percentages of poverty than whites in the sample. If the associations between these variables followed the notion that there are racial differences in these associations, I would anticipate that for both races, increases in neighborhood poverty would be positively associated with allostatic load. These limitations warrant further investigation using larger sample sizes of participants living in neighborhoods with high concentrations of poverty. While neighborhood social support may be an important factor in buffering some of the effects of stress on the neighborhood level, I do not believe that social support could be the only factor explaining these paradoxical findings. However, some rationales for these paradoxical findings will be discussed in greater detail in subsequent paragraphs.

Potential pathways through which living in a socioeconomically deprived neighborhood is linked to adverse health. Prior work indicates that these socioeconomically deprived neighborhoods offer fewer physical activity and recreational facilities (Gordon-Larsen et al., 2006), inadequate access to affordable healthy food (Horowitz et al., 2004; Moore & Diez Roux, 2006; Powell et al., 2006), substandard access to preventative healthcare (Pappas et al., 1997), and higher exposure to stressful life events (Attar et al., 1994). However, in the models, including an interaction term, the highest levels of poverty were associated with decreased allostatic load among African Americans compared with whites. It is important to note that levels of AL were higher for African Americans than for whites, but the interactions between race and neighborhood poverty differed where increasing poverty was associated with increases in AL for whites, while there were decreases among African Americans. This suggests a health paradox. A health paradox exists when people who are known to be at an increased risk for the deleterious impact of accepted stressors (in this case, neighborhood deprivation) demonstrate outcomes that are equal to, if not better, than those with lower exposure to certain risk factors (Boynton-Jarrett et al., 2008; Christie-Mizell, 2022; Thomas Tobin et al., 2022b). With that in mind, I would hypothesize that African Americans in the sample would be more likely to live in more deprived neighborhood conditions, which would relate to increased allostatic load. For three of the four measures of neighborhood socioeconomic status used in this analysis, the association between nSES and allostatic load did not differ by race. For one indicator, , the percentage of people in poverty, the association with AL was lower for African Americans compared with whites: These differences were statistically significant only at the higher levels of poverty. Some have conjectured that such racial health paradoxes may be associated with African Americans' having personal and collective coping mechanisms resulting from centuries of institutional and interpersonal discrimination (Christie-Mizell et al., 2022; Omenka et al., 2020; Patterson, 2010; Thomas Tobin et al., 2022a). Such suggestions are discussed in the following paragraphs and warrant further investigation (see Chapter 4 of this dissertation).

Elements of the racial paradox in relation to neighborhoods have been discussed in George Lipsitz's work *How Racism Takes Place* (2011). In talking about what he coins the "Black Spatial Imaginary," Lipsitz talks about how the "white Spatial Imaginary" is primarily concerned with controlling the exchange value of their neighborhoods and keeping resources and amenities hoarded in predominantly white communities (2011). In the Black spatial imaginary, African Americans and other communities of color have found ways to increase the value of neighborhoods and other spaces they frequent by creating collective strategies such as pooling resources and exchanging services (Lipsitz, 2011, Chapter The Black Spatial Imaginary). In being able to create these social networks, African Americans have been able to "turn segregation into congregation…by relying on each other for bartered services and goods…and by using the commonalities of race and class as a basis for building pan-neighborhood alliances with residents of similar neighborhoods to increase the responsibility, power, and accountability of local government" (Lipsitz, 2011, p. 56). Honoring the Black spatial imaginary could be another mechanism through which living in neighborhoods with observed measures of high concentrations of poverty could be associated with decreased allostatic load among African American participants in the sample. The inverse may be true whereby African Americans living in areas with less concentrated poverty may be exposed to other types of stressful life conditions—for example, more common encounters with racial discrimination or limited opportunities for relational building due to stigmatization—which may be harmful to the health and wellbeing of African Americans within these communities.

Further, Christie-Mizell (2022) theorizes that due to Blacks being historically marginalized within the U.S., the stigmas associated with living in more economically deprived communities may be less relevant to health outcomes than whites (Christie-Mizell, 2022). Finally, the finding that increased proportions of families in poverty is associated with lower allostatic load among African Americans may reflect the concept of negative place stereotyping. Building on the work of Lippman (1922), Bonam, Bergsieker, and Eberhardt assert that generalized stereotypes about Black neighborhoods are linked to perceptions of how the broader public views neighborhoods with higher concentrations of African Americans (C. M. Bonam et al., 2016). These stereotypes that are held and perpetuated throughout white social networks about African American neighborhoods result in decreased connections and the devaluation of assets within communities of color (C. M. Bonam et al., 2016). With that in mind, increases in neighborhood poverty might be expected to be associated with increased health risks. However, the inverse finding suggests that financial characteristics of neighborhoods may not be as pertinent for health among Blacks/African Americans as it is for whites.

Recognizing that neighborhood socioeconomic status measures are formulated based using observed metrics of neighborhood environments, there could be other factors within Black/African American neighborhoods (e.g., social support and social networks) that buffer the hypothesized effects of neighborhood socioeconomic status on health. While not studied in this chapter, African American residents of lower socioeconomic status neighborhoods might not be exposed to specific unpleasant or discriminatory interactions that may elicit a stress response. To be clear, there was no interaction by race for three of the four indicators. Two of the four neighborhood socioeconomic status indicators had no significant direct effect on allostatic load after controlling for covariates. The differences in the main effect suggest that these associations are nuanced and that different measures of neighborhood socioeconomic position may capture different nuances of neighborhood characteristics, some of which are more broadly associated with allostatic load and health than others.

These mechanisms highlight the potential pathways through which: a) increases in neighborhood stressors are associated with allostatic load; or b) increases in social support may serve as a potential buffer to health through protecting against the adverse effects of living in areas of low socioeconomic status.

Findings for Sex and Allostatic Load

I explored whether the relationship between indices of neighborhood socioeconomic status and allostatic load varied by sex. Based on the significant interaction between sex and the neighborhood deprivation index and the percentage of families in poverty, increases in both the neighborhood deprivation index and the percentage of families in poverty are associated with decreased allostatic load for men compared to women. Increases in neighborhood deprivation and the percentage of families in poverty were significantly more positively associated with allostatic load for women than for men. However, my analyses were inconsistent with the hypothesis that there are sex differences in associations between neighborhood median home value or the percentage of people without a BA degree and allostatic load. The finding that the associations between the neighborhood deprivation index and AL were significantly tempered among men compared with women is less studied in the literature. These findings are consistent with evidence that living in poorer neighborhoods is more detrimental to women's health than men's since women are more likely to be targeted for violence (Baker & O'Connell, 2022; E. Bassett & Moore, 2013; Stansfield & Doherty, 2019). There is additional evidence that may support these paradoxical findings. For example, Bird and colleagues (2010) examined associations between neighborhood SES and AL using data from Wave III of NHANES. While they found a significant inverse association between neighborhood SES and AL, when their models were stratified by gender, the significance disappeared (C. E. Bird et al., 2010).

Findings reported here may be informed by results reported by Barber and colleagues (2016) who examined the relationship between neighborhood disadvantage and cumulative biological risk within the Jackson Heart Study. They found that the relationship between neighborhood disadvantage and cumulative biological risk was strongest among men in neighborhoods with lower levels of social cohesion (Barber et al., 2016b). Taken together, these findings illuminate the differential impact of neighborhood stressors on allostatic load and suggest that the impact of external stressors varies by demographic factors as well as by indicators of social relationships such as social cohesion. Further, these findings in relation to the existing literature suggest the need to include psychosocial factors (e.g., social cohesion), which may help to illuminate these relationships further.

Findings for Household Poverty Status and Allostatic Load

Testing interactions between each index of neighborhood socioeconomic status and household poverty status did not identify significant interactions between any of the measures of socioeconomic status with household poverty. Some of the findings reported here differ from those reported elsewhere in the literature. For example, the protective role of neighborhood home values has been discussed within the literature. Mehdipanah and colleagues explored whether housing values moderated associations between neighborhood contexts on health within the Detroit metropolitan area (Roshanak Mehdipanah et al., 2017). Their results suggest increased housing values were associated with lower disability and all-cause mortality. While Mehdipanah and colleagues (2017) examined the moderating effects of neighborhood housing values and the current study examines the main effect, their results are still relevant to this discussion. Lower home values have also been linked to increased neighborhood blight (Immergluck & Smith, 2006a; Whitaker & Fitzpatrick IV, 2013), reduced safety (Immergluck & Smith, 2006b), and reduced neighborhood investment (Mathur, 2008). These mechanisms highlight the argument for the protective nature of median home value on allostatic load among people living below the poverty limit. Although not explicitly tested, the idea of neighborhood investment (i.e., neighborhoods with higher home values may invest more in their communities) may be a potential mechanism that could help us explain these findings. Neighborhood investment could manifest in having more material resources and health-promoting outlets, which could be associated with decreased stress and, thus, allostatic load.

Neighborhood SES , Physical Activity, and Allostatic Load

To begin, paths c and c' (Table 3-9) were not significant in models looking at neighborhood deprivation index, median home value, and the percentage of people without a BA degree on allostatic load, but were significant for the percentage of families in poverty on allostatic load adjusting for sociodemographic characteristics and the interaction between race and the percentage of people in poverty. The findings for paths c and c' for most indicators differ from findings reported in the existing literature. For example, a wealth of research has established a positive relationship between neighborhood deprivation and allostatic load that remains even after adjusting for sociodemographic characteristics (Barber et al., 2016a, 2016b; C. E. Bird et al., 2010; Gene H. Brody et al., 2014; Gustafsson et al., 2014; King et al., 2011; Merkin et al., 2009; Robinette et al., 2016; A. J. Schulz et al., 2012, 2013). Findings reported in this chapter may differ from existing literature given the longitudinal nature of relationships examined in this chapter compared with cross-sectional analyses (Barber et al., 2016a, 2016b; C. E. Bird et al., 2010; King et al., 2011; Merkin et al., 2009; Robinette et al., 2016; A. J. Schulz et al., 2012, 2013). My findings relate to some of the limited longitudinal investigations exploring the associations between neighborhood socioeconomic status and allostatic load. Brody and colleagues (2014) examined the effects of changes in neighborhood poverty on allostatic load among 420 youth residing in rural Georgia, United States. They found that increasing neighborhood poverty, as measured by the proportion of households below the federal poverty level, was positively associated with allostatic load (Brody et al., 2014). My findings regarding associations between neighborhood poverty and allostatic load are concordant with these relationships, but differ for findings reported when using the other indicators of neighborhood socioeconomic status. This may suggest that some measures of neighborhood socioeconomic status are more closely associated with allostatic load than others. However, the null associations between a neighborhood deprivation index and allostatic load over time contradict the work of Gustafsson and colleagues (2014) who examined whether neighborhood socioeconomic disadvantage at different time points were cumulatively associated with allostatic load in mid-adulthood using a cohort of adults in northern Sweden. Increases in their composite index of neighborhood-level socioeconomic status variables were positively associated with allostatic load in mid-adulthood (Gustafsson et al., 2014). The null findings in the association between neighborhood deprivation and allostatic load in the study reported in this chapter could suggest a need to examine the components that comprise the composite index instead of looking at the accumulation of a series of indicators in relation to allostatic load, specifically within the United States context. This cross-cultural examination is important to consider given that Sweden and the United States have differences in their histories of marginalization and economic disinvestment from marginalized communities which may impact the differences observed between these studies. Findings presented in this chapter may also reflect characteristics of the study sample, discussed in greater depth in the "limitations" section of this chapter.

After adjusting for socio-behavioral covariates, I found that physical activity did not attenuate the relationship between neighborhood socioeconomic status and allostatic load. This finding is somewhat counterintuitive to the literature. For example, the findings reported in this study are consistent with results reported by Schulz and colleagues (2012, 2014) who found that physical activity did not attenuate associations between neighborhood poverty and either allostatic load (Schulz et al., 2012) and cumulative biological risk (Schulz, et al., 2013). However, I hypothesize that neighborhoods with lower socioeconomic status will be associated with higher allostatic load due to the accumulation of stressors within this environment. Physical activity may serve as a potential buffer which, in theory, would reduce the effect of neighborhood socioeconomic status on allostatic load. The stress-buffering effect of physical activity for the ill effects of stress on health has been documented (Klaperski & Fuchs, 2021; Latimer et al., 2005; O'Dougherty et al., 2012). A potential explanation as to why I did not see an attenuating effect of physical activity could be because their neighborhood environment is just one area that people are exposed to daily. There could be other relevant health-related stressors (i.e., work and educational environments) than those experienced at the neighborhood level. The indicator of physical activity used in the HANDLS study may not be as sensitive or nuanced enough to detect differences. Furthermore, the indices included in this study are calculated from observed measures of neighborhood socioeconomic status. It stands to reason that including individual perceptions around the specific stressors individuals face within their neighborhood could help us better measure neighborhood stress's role on allostatic load.

Neighborhood Perceptions as Mediators

Stress process models suggest that stressful life conditions may affect health through pathways that include wear and tear on the body's ability to regulate physiologic systems: Specifically, that chronic exposure to stressful life conditions may result in a constant state of heightened allostatic response and impaired ability to return to allostasis. Results reported in this section are inconsistent with the hypothesis that perceptions of neighborhood characteristics or conditions may mediate – or help to explain – associations between neighborhood socioeconomic status and allostatic load.

After testing each index of neighborhood socioeconomic status on allostatic load, none of the three indicators of neighborhood perceptions – perceived physical environment, perceived social environment, perceived community action -were significant mediators of these associations.

Mediation Results

The results from the mediation tests were not consistent with the hypothesis that associations between measures of neighborhood SES and AL are mediated or explained by perceptions of neighborhood characteristics. The direct relationship between the percentage of people in poverty and allostatic load was significant in models that considered the interaction between race, socioeconomic status indicators, and the addition of each perception domain.

Neighborhood perceptions did not mediate the direct relationship between measures of neighborhood socioeconomic status and allostatic load. However, each socioeconomic status indicator (NDI, neighborhood percent poverty, median household income, neighborhood percent with BA degree) was significantly related to each of the three measures of perceived neighborhood characteristics. This finding is consistent with existing literature proposing linkages between neighborhood socioeconomic status and neighborhood environmental conditions (Caughy et al., 2001; Odgers et al., 2012; A. J. Schulz et al., 2013). Observed characteristics of a neighborhood can influence what individuals have access to or are exposed to, ultimately impacting their perceptions of their neighborhood environments. However, research has continued to rely on these observed measures of neighborhoods as proxies for neighborhood exposures.

Specifically, Schulz and colleagues (2012) using data from a Detroit, Michigan cohort, examined the mediating role of psychosocial stress on the relationship between neighborhood poverty and allostatic load. They found a significant and positive association between indicators of neighborhood poverty and perceptions of neighborhood stress, as well as significant associations between perceptions of neighborhood environmental characteristics and allostatic load. The Schulz and colleagues (2012) investigation was different from the current study in several respects, including the use of cross-sectional data, how perceived neighborhood stress was measured, and the use of poverty estimates measured at the census block group level versus the census tract level as in this study. These differences, in addition to the contextual settings of both cities, suggest potential explanations for differences in observed relationships. Using data from a cross-sectional study of adults in the United States, Giles-Corti and Donovan (2002) examined both observed and perceived neighborhood environmental characteristics on physical activity levels. Their analyses indicated that people in lower socioeconomic status neighborhoods were more likely to have more unfavorable perceptions of their neighborhood environments and were deemed as less suitable for walking than those in higher socioeconomic status neighborhoods (Giles-Corti & Donovan, 2002). These concordant results may illustrate an individual's appraisal of their neighborhood environments where more socioeconomically deprived neighborhoods may have more adverse conditions and fewer resources. More research is needed around linkages between neighborhood socioeconomic status and neighborhood perceptions. However, evidence to date indicates an inverse relationship between neighborhood socioeconomic status and allostatic load.

There is also emerging evidence of neighborhood perceptions as mediators of the link between neighborhood socioeconomic status and health. For example, my findings are discordant with the work of Kress and colleagues, who examined the role of perceptions of neighborhood-level social cohesion as a mediator of relationships between neighborhood characteristics and health using the German Socioeconomic Panel (Kress et al., 2020). Specifically, social cohesion significantly mediated direct relationships between built (e.g., land zoning usage, types of houses, and the state of repairs) and environmental characteristics (e.g., bothersome noise pollution, air pollution, and greenspace shortages) on both mental and physical health. The null findings could be attributed to the fact that Kress and colleagues (2020) examined more structural and built aspects of the neighborhood, while the present study focused on more economic measures of neighborhood environments.

While not examining my specific relationships directly, existing literature that may help illuminate the proposed relationships and findings. For example, using an international cohort, researchers examined the mediating role of neighborhood perception on the relationship between neighborhood socioeconomic status and health-related quality of life (Drukker & van Os, 2003). Their mediation models found that perceptions of neighborhood social contacts, neighborhood coziness, and housing conditions significantly mediate the relationship between socioeconomic deprivation and vitality. In contrast, only perceptions of neighborhood social contacts and perceptions of housing conditions were significant mediators of the relationship between socioeconomic deprivation and mental health among this international cohort (Drukker & van Os, 2003). The findings from this international cohort highlight the potential mediating role that neighborhood perceptions may have on relationships between neighborhood socioeconomic status and health. The differences in my results compared to these international studies could be attributed to differences in how neighborhood perceptions are measured within each of these studies, as well as differences in contexts between each of these cohorts.

Additionally, using data from the Resilience for Eating and Activity Despite Inequality study, Van Dyck and colleagues explored the mediating role of perceptions on the relationship between observed measures of the environment (i.e., street connectivity and destination density) and transportation and recreational walking among women from socioeconomically deprived neighborhoods (Van Dyck et al., 2013). Their findings suggested a positive association between street connectivity/destination density and walking for transportation, while there was a negative association between street connectivity/destination density and leisure time walking (Van Dyck et al., 2013). Perceptions of the physical activity environment, aesthetics, personal safety, and social cohesion were all identified as mediators of these relationships. While this study does not explicitly examine neighborhood socioeconomic indicators on allostatic load, Van Dyck and colleagues' (2013) findings highlight the potential role of neighborhood perceptions as mediators of the relationship between neighborhood characteristics and health and health behaviors. This investigation bolsters the emerging literature that explores potential mediators of the linkages between indices of neighborhood socioeconomic status and health, as described in the following paragraph.

I explored the relationship between multiple dimensions of neighborhood socioeconomic status on allostatic load among an urban multiracial cohort in Baltimore, MD. After adjusting for covariates at Wave IV, I found a significant relationship between the percentage of families in poverty and allostatic load, but not for the other socioeconomic status measures and allostatic load. While the finding that increases in the percentage of families in poverty is positively associated with allostatic load is supported in the literature, the null findings for the other socioeconomic status indicators on allostatic load contradicts existing literature that has supported the positive association between neighborhood socioeconomic status indicators and poor health outcomes (C.

E. Bird et al., 2010; Merkin et al., 2009; A. J. Schulz et al., 2013; Wallace et al., 2013). These associations have also been found specifically using methods similar to the neighborhood deprivation index. For example, Powell-Wiley and colleagues examined associations between neighborhood deprivation and weight gain using longitudinal data from the Dallas Heart Study. In one study, living in areas of high deprivation over time was associated with weight gain (Powell-Wiley et al., 2014), and moving to areas with more deprivation was associated with weight gain within this cohort (Powell-Wiley et al., 2015). However, the findings are inconsistent with existing literature on the relationship between neighborhood socioeconomic status and cumulative biological risk. For example, Barber and colleagues (2016) found that living in disadvantaged neighborhoods was associated with increased cumulative biological risk among African American participants in the Jackson Heart Study (Barber et al., 2016a). However, in this study, there was a positive relationship between neighborhood poverty and AL for whites and among women, further suggesting that these relationships may vary based on certain demographic characteristics. While many of these studies rely on urban populations, the null findings among participants in the Baltimore-based HANDLS study could point to unique historical and cultural differences that may shape the impact of neighborhood socioeconomic status on health.

Alternative pathways that help us understand the null findings could be attributed to people not spending all their time in their neighborhood environments. For example, people may spend considerable time outside their neighborhood environment (i.e., work, school, and social activities), which may dampen the understanding of relationships between neighborhood socioeconomic status. As mentioned by Wallace and colleagues (2013), I may not be able to detect a significant relationship between indices of neighborhood socioeconomic status and allostatic load because I do not consider measures of stress in these specific models, which may serve in the pathway linking neighborhood conditions to allostatic load. This highlights a potential limitation of the existing dataset and necessitates future research that includes a direct measure of stress associated with neighborhood socioeconomic status. The mediating role of psychosocial factors has been tested as part of Aim 1 of this chapter but did not indicate a significant mediating process for specific neighborhood stressors. Further, there may be limitations in capturing the true nature of these associations given that the distribution of participants based on certain demographic characteristics; for example, there are fewer observations in older age groups within the sample.

In sum, the findings of this paper highlight the stress process framework, which emphasizes that neighborhood poverty and other neighborhood characteristics can cause stressful life conditions, which then induce a physiological response disrupting the body's equilibrium. Repeated exposures to these neighborhood stressors accumulate over time, thus placing individuals at increased risk for increased allostatic load and other adverse health outcomes. While the findings have highlighted that different measures of socioeconomic status are differentially associated with allostatic load, the findings contribute to the existing literature linking lower socioeconomic status to increased health risk (A Diez Roux & Mair, 2010; Merkin et al., 2009; A. J. Schulz et al., 2012; Stimpson et al., 2007), but also illuminate additional pathways between neighborhood contexts and health.

3.7 Strengths and Limitations

This study makes a unique contribution to the existing literature. This examination is among the first to explore the longitudinal relationship between different indices of neighborhood socioeconomic status on allostatic load. Specifically, these findings suggest that some measures of neighborhood SES (i.e., NDI and neighborhood poverty) may be more sensitive or useful predictors of AL compared with other indices. For example, in this analysis, median household income and the percentage of adults without a BA degree were not significantly associated with AL. Using different psychosocial stressors measured by neighborhood perception domains has illuminated potential mechanisms through which neighborhood socioeconomic status influences allostatic load. While each of the three indicators of neighborhood perceptions were associated with the included neighborhood SES metrics, none of the neighborhood perception domains were associated with AL. These findings, in tandem with the literature, suggest some limitations of using neighborhood perceptions on AL. However, this could necessitate the need for further investigations to understand the ways in which neighborhood perceptions could be useful predictors of health. Further, testing interactions between neighborhood socioeconomic status indicators and demographics yield important insights onto how these relationships may vary based on individual demographics.

Despite these strengths, this study has several limitations that must be considered. For example, a major limitation is the usage of self-reported physical activity. Since physical activity is measured imprecisely, future research should consider the utility of more observed measures of physical activity (i.e., accelerometers) to help further understand these relationships. The allostatic load calculation fails to incorporate an indicator for medication used to treat hypertension which may dampen the associations between neighborhood socioeconomic status indices and allostatic load. Future research should consider whether these relationships change if allostatic load scores are adjusted for medication use. Throughout this chapter, the statistical models used linearly examine these associations. However, stepwise effects or non-linear relationships among these variables may not be captured using the linear regressions employed in this investigation. Given the exclusion criteria, those in the analytic sample have statistically significant lower allostatic load scores, and live in neighborhoods with significantly higher proportions of people without a

BA degree and lower median home values compared with the full sample (Appendix B: Table 3-17). Further, there are limited number of observations among white participants living in higher levels of neighborhood poverty, which may underestimate the true nature of these proposed associations. The statistical differences in allostatic load, median home value, and % without a BA degree between the analytic sample and excluded sample may suggest that the findings reported in this chapter are underestimating the examined associations, or associations may be otherwise influenced by the sample characteristics. Future research to examine these associations within additional populations should be conducted. A potential limitation of using observed measures of neighborhood contexts is that they are measured at a governmental unit of analysis (i.e., census tract, zip code, county). Governmental units of analysis are useful for administrative purposes, but neighborhood boundaries are subjective, and defining these boundaries vary greatly among residents (Weiss et al., 2007).

Some of these relationships could be obscured by whether participants are renters or homeowners. I hypothesize that homeowners have longer tenure in their residential neighborhoods than renters which may impact the length of time that an individual is exposed to neighborhood conditions. Additionally, I am limited in my attempt to consider the role of the length of residency in these relationships. Being able to account for the length of time someone has spent in their neighborhood may yield additional insights into the role of place in shaping health behaviors and outcomes. Future research should build upon this work to consider the role of exploring whether these relationships vary based on housing tenure and length of residency. Additionally, there are differences in some of the main exposures between those in the analytic sample and those who were excluded (Table B9) due to missing study variables. Therefore, my findings are not generalizable to either locales outside of Baltimore, Maryland, or even those in the HANDLS cohort.

Given the differences in the neighborhood perception questions, future research should reassess neighborhood perception questions to continue to parse out these relationships. Also, given that these are longitudinal relationships, future research should consider the role of gentrification and rising living costs within formerly redlined neighborhoods and those with high concentrations of poverty, which may introduce new stressors within certain demographic groups – particularly those at risk of displacement. Finally, future research should incorporate additional measures of the social environment to examine whether some of the protective effects of neighborhood socioeconomic status and health can be attributed to the social networks and social environments of people within these neighborhoods, which will be important. Specifically, future research should explore which demographic groups are less sensitive to increasing neighborhood poverty to gain a deeper understanding of how neighborhood poverty differentially impacts individuals based on their demographic characteristics.

3.8 Implications

There are several important implications that this project highlights. This work is essential because it contributes to the literature that has established a link between neighborhood socioeconomic status, allostatic load, and potential mediating pathways. Specifically, the insignificant mediating pathways of different neighborhood perception domains on associations between indices of neighborhood poverty and allostatic load suggest that, at least longitudinally, neighborhood perceptions are not significant mediators of these associations. This also suggests that other stressful neighborhood or individual-level exposures may be more proximal to the stress process among adults in Baltimore. The findings from this study may also support evidence that shows the detrimental impacts of living in concentrated areas of disadvantage on health outcomes above and beyond individual behavior and household socioeconomic status. This work builds upon existing research and explores whether changes in neighborhood poverty are related to allostatic load over time. Examining a lag time between neighborhood poverty and allostatic load may help to highlight the public health ramifications of neighborhood disinvestment due to historical redlining and other forms of institutional racism. Despite existing research that has established associations with historical redlining, neighborhood disinvestment, and allostatic load, the addition of neighborhood perceptions and physical activity as mediators advances the literature by potentially highlighting different mechanisms through which neighborhood contexts impact health outcomes. Despite these indicators not being significant mediators, it may suggest that the effects of neighborhood poverty on AL may operate through pathways above and beyond neighborhood perceptions and physical activity. Ultimately, these findings are important for understanding how neighborhood contexts induce physiological responses and can result in adverse cardiovascular functioning. The findings from this dissertation suggest that different measures of neighborhood socioeconomic status are differentially related to allostatic load and may vary by demographic characteristics, consistent with Stress Process frameworks, including the Minority Stress framework.

With this in mind, these results may suggest structural interventions to intervene on the underlying mechanisms of area disinvestment, joblessness, substandard education, and others to improve the well-being of people within formerly redlined neighborhoods. Additionally, findings presented here suggest interactions between multiple demographic characteristics (age, race, sex) and neighborhood socioeconomic characteristics: Limitations of the HANDLS dataset preclude analysis of these more complex interactions. Future research should identify other local datasets with adequate statistical power to examine whether the examined relationships in this dissertation can be analyzed with three- and four-way interactions between indicators of neighborhood socioeconomic status with individual-level age, race, and sex. Understanding how these relationships vary by some intersectional identities can be useful for creating tailored-to-place interventions that may deliver different materials based on the demographics of people within a particular neighborhood.

Further, future research should analyze these relationships among datasets with a higher proportion of adults over 65 to better understand more clearly how these relationships vary across the lifespan. Adverse socioeconomic conditions across the lifespan (from prenatal to old adulthood) can have cumulative effects on allostatic load and other cardiovascular-related outcomes. Looking at these relationships with adequate representation of adults across the lifespan may illuminate different critical periods that policy and other structural or behavior change interventions to improve health (Kumanyika, 2022).

It is important to understand the ramifications that these findings suggest. Specifically, I found no significant relationship between indices of neighborhood poverty and allostatic load until the interaction with race is added into the models--then, only the percentage of families in poverty is associated with allostatic load. The inability to detect a significant relationship between neighborhood socioeconomic status indices and allostatic load does not negate significant relationships observed in the literature. This finding suggests that additional research should consider the ways in which neighborhood deprivation impacts allostatic load may differ based on individual demographics. This study can inform subsequent attempts to examine and measure different relationships between neighborhood contexts and stress processes.

The interpretation of and implications drawn from study findings for race and allostatic load should be handled sensitively. Specifically, the finding that increased neighborhood deprivation is protective of allostatic load among African Americans should not be interpreted to suggest that African Americans should live in economically deprived neighborhoods. With this finding in mind, future research should test these associations within local and national cohorts to help contextualize my findings. Evidence that Black and other minoritized populations reside in neighborhoods with concentrated disadvantage, which this dissertation has linked to historic redlining practices. Reparations for those structurally racist policies and their long-term impacts should take the form of efforts to address and improve the stigma that minoritized and lower income neighborhoods are faced with. Briefly, spatial stigma posits that people who live within socially degraded neighborhoods may be marked in a way that limits their access to resources and their mobility beyond their communities (Keene & Padilla, 2014). With this in mind, I believe that policy makers, across all jurisdictional levels, must consider the role that their bias and stigmas play in the allocation of resources and the placement of noxious exposures within locales. The placement of these adverse exposures within low income and stigmatized neighborhoods may continue the cycle where these areas are systemically blocked from important investments that may improve the socioeconomic position of those within these areas on both the household and community levels. While a fear and a history indicate that efforts to promote neighborhood investments (e.g., urban renewal) may cause displacement, a careful and planned development focusing on equity can avoid the displacement of existing residents. For example, the Urban Displacement Project suggests several ways to prevent displacement pressures.

Additionally, neighborhoods could also implement inclusionary zoning practices. Inclusionary zoning is a strategy that increases affordable housing opportunities by requiring or encouraging developers to have a certain number of units in either new or renovated residential areas, specifically for lower and moderate-income residents (Mallach, 1984). Inclusionary zoning is an important strategy as it allows those of lower socioeconomic status group access to community resources and amenities as their more socioeconomically advantaged counterparts. Adopting their suggestions within the Baltimore context, Baltimore politicians, both community-level and city-wide, could enact rent stabilization legislation to protect existing residents from the stressors of increased rent (Cash & Zuk, 2021). Another strategy would be to ensure that all landlords are required to have just causes to evict people from their residences, ensuring that landlords are not evicting residents for unclear reasons (Cash & Zuk, 2021). Other options that could help would also be to enact rent control and rent stabilization programs. The availability of rent-regulated housing options within these newly invested neighborhoods would allow current residents to remain in their communities and enjoy the new resources that have, in the past, been systematically diverted from them. A further implication of this study would be to enact housing legislation allowing tenants access to legal counsel in case of an eviction (Cash & Zuk, 2021). Having legal counsel may help many others in their attempt to keep their current housing. Programs focused on providing legal counsel around evictions are increasing, with such programs appearing in New York City, San Francisco, Chicago, and Philadelphia (Cash & Zuk, 2021). Having such a program in Baltimore may help if Baltimore political leaders take the need to invest in historically marginalized and disinvested communities seriously.

The findings presented in this chapter are consistent with Fundamental Cause Theory in that none of the more proximal factors associated with health (i.e., neighborhood perceptions) mediated associations between neighborhood socioeconomic status and allostatic load. Consistent with Fundamental Cause Theory, interventions intended to change population health must instead focus on interrupting structural factors. Even though associations between the percentage of families in poverty and allostatic load was stronger for whites than African Americans, it is important to understand that African Americans have higher overall allostatic load scores than whites within the sample which may suggest that there are other factors above and beyond neighborhood socioeconomic status that may be associated with allostatic load that disproportionately impact African Americans. Moving beyond individual level association with allostatic load and other health outcomes to consider and intervene on the role of neighborhood and other meso-and macro level factors will be important next steps to act upon in order to make changes in racial health disparities within this country.

Chapter 4 :Do Your Neighbors Matter?: Examining Associations between Neighborhood Racial Composition and Allostatic Load

4.1 **Introduction**

Racial residential segregation has been associated with shaping racial differences in socioeconomic status and the built and social environment exposures people are exposed to, which in turn impact health (Williams & Collins, 2001). Several studies have examined the hypothesis that members of minoritized communities are healthier when they live in culturally homogeneous areas, a phenomenon often described as the "ethnic density effect" (Bécares et al., 2012; Halpern, 1993; Mueller, 1940). One proposed mechanism by which co-ethnic concentration is protective of adverse health outcomes is through increased positive social relationships that buffer the impact of discriminatory actions and the most adverse consequences of being relegated to lower socioeconomic statuses (Bécares et al., 2009, 2012; Halpern & Nazroo, 2000; Pickett & Wilkinson, 2008; Smaje, 1995). Social relationships and social support are important drivers of positive health outcomes (Lisa F. Berkman, 2000; S. Cohen, 1988; Holt-Lunstad et al., 2010; House, 1981; Pinquart & Duberstein, 2010; Uchino, 2004; Uchino et al., 2012). Social support can serve as a buffer for the adverse health effects of stressful exposure through, for example, increasing an individual's ability to cope and dampening the physiological response to a stressful stimulus (Sheldon Cohen, 2004). Briefly, social support is largely grouped into five categories: 1) informational (i.e., feedback or knowledge), 2) emotional (i.e., care and concern), 3) esteem (i.e., messages that increase intrinsic value), 4) social network support (messages that improve one's sense of belonging), and 5) tangible support (i.e., physical goods or services) (Cutrona & Suhr, 1992). These distinct types of social support can operate through different pathways to protect health. In this study, given that the HANDLS dataset does not have a direct measure of social support. I use a measure of an individual's perceived neighborhood social environment as a proxy which has been used in the literature (Andrews et al., 2020; Ceasar et al., 2020; Claudel et al., 2019; Powell-Wiley et al., 2013). More information about the HANDLS dataset is provided in the methods section.

Residential stability may play an important role in social network processes. Some research suggests that higher levels of residential turnover within neighborhoods can weaken levels of social support by disrupting long-standing social networks and interfering with the ability to build newer relationships within the neighborhood (Kasarda & Janowitz, 1974; Larson et al., 2004; Ross et al., 2000; Sampson et al., 1999; Schulz et al., 2008). Several studies have also reported findings consistent with the hypothesis that increases in the length of individual residency were related to increased social support (Kasarda & Janowitz, 1974; Sampson, 1988b; Schulz et al., 2006; Turney & Harknett, 2010).

Results from previous research have suggested that African Americans living in segregated urban neighborhoods are more likely to have poorer health outcomes due to substandard education opportunities, spatial barriers to employment opportunities, and concentrated socioeconomic disadvantage, to name a few (Chang, 2006; Corral et al., 2012; Fernandez et al., 1993; Kershaw et al., 2011; Polednak, 1991; Williams & Collins, 2001). Findings reported in the literature exploring associations between neighborhood racial composition and health appear to be mixed. Homogenous neighborhoods are considered protective for some groups in that high co-ethnic concentration could increase social and institutional support, increasing the likelihood of engaging in health-promoting behaviors (T.-C. Yang et al., 2018). These neighborhoods can also be detrimental to health if others within these neighborhoods are engaged in risky health behaviors (Christakis & Fowler, 2007), and if neighborhoods with greater proportions of minoritized racial/ethnic populations have higher observed crime rates and poverty, which are thought to be stressors (T.-C. Yang et al., 2018). While Christakis and Fowler's (2007) interpretation focuses on the behaviors of others in the neighborhood as causative for adverse health behaviors and outcomes, it does not highlight broader structural factors that may influence these behaviors. Williams and Collins (2001) suggest that residential segregation is important for health as it shapes a) socioeconomic opportunities, b) individual behaviors relevant to health, and c) access to health-promoting resources (Williams & Collins, 2001). Specifically, studies have found associations between racial residential segregation and other health-relevant neighborhood characteristics, including food environments and diet (Black & Macinko, 2008; Larson et al., 2009; Millstein et al., 2009), and access to greenspace (Kephart, 2022; Saporito & Casey, 2015). In sum, the built and social environments of neighborhoods are essential to consider in relation to health behaviors and outcomes.

Findings for the relationship between racial composition, health behaviors, and health outcomes are mixed, particularly those examining the relationship between racial composition and cardiometabolic outcomes among U.S. Blacks. In contrast, findings for the association between racial composition and mortality are more consistent, indicating that higher proportions of African Americans per unit of measurement (i.e., measures of racial segregation) are associated with increased mortality (Cooper et al., 2001; Erwin et al., 2010). Nearly a quarter century ago, Cooper and colleagues examined associations between different measures of institutional racism (i.e., income inequality and racial segregation) on premature mortality using data from the National Center for Health Statistics measured between 1989 and 1991. Their population-weighted multivariate models included the median household income, income inequality, a dissimilarity index[14], and percent Black. Both the dissimilarity index and percent Black were positively and significantly associated with premature mortality among people in 267 Metropolitan Statistical Areas. Further, associations between measures of racial residential segregation and premature mortality were stronger for Blacks than whites. These authors note that the strength of these associations is largely driven by the geographical distribution of Blacks within the sample (Cooper et al., 2001). Using a more regional sample, Erwin and colleagues (2010) examined ecological associations between population density, racial residential segregation, and standardized mortality ratios within Tennessee. Their multivariate regressions adjusting for population density, unemployment, and high school graduation rate suggest that the increase in the percentage of African American residents in an area is positively and significantly associated with standardized mortality ratios for counties in Tennessee that have more than 20 African American deaths per year. This positive association remains even in counties with less than 20 African American deaths per year, controlling for population density, poverty rates, unemployment, high school graduation, physician to population ratio, and violent crimes (Erwin et al., 2010). Taken together, these studies suggest that racial residential segregation is associated with increased mortality both nationally and regionally.

Some studies have reported stronger associations with mortality for specific age groups (Jackson et al., 2000), and some have differed by location (Blanchard et al., 2004). Nearly a quarter century ago, Jackson and colleagues (2000) examined associations between racial residential segregation and racial differences in mortality using data from the National Longitudinal Mortality

[14] The dissimilarity index measures the proportion of a population that would have to move in order for a neighborhood to have the same representation within the neighborhood that they have within the metropolitan area (Massey & Denton, 1988).

Study between 1979 and 1989. Racial residential segregation was measured as the percentage of Blacks in a census tract (i.e., categorically measured by less than 10%, 10-30%, 30-70%, and 70%+) where higher percentages correspond to more racial residential segregation. Controlling for individual-level income, their results found that racial residential segregation was significantly and positively associated with mortality among all racial groups, with the highest mortality rates per 10,000 person years being found among Black men 65 and older living in neighborhoods that are over 70% Black and non-Black men living in neighborhoods that are between 10 and 30% Black (Jackson et al., 2000). The findings of this study may be limited in the contemporary context due to the age of the data and its focus on national outcomes, thus suggesting the need to examine these associations using more current data within a specific metropolitan area.

However, other existing evidence suggests that living in a racially concordant neighborhood is protective for all-cause mortality. For example, Hutchinson and colleagues (2009) examined associations between neighborhood racial composition, social capital, and all-cause mortality among Blacks in Philadelphia, Pennsylvania using data from the U.S. Census, community health surveys, and city vital statistics between 1997 and 2000. Their univariate analyses suggest that the percentage of neighborhoods with people who were black was negatively associated with age-adjusted black mortality, with the strongest protective effect being found among neighborhoods with more than 50% Black residents. Models adjusting for neighborhood-level educational attainment, employment status, renter occupancy, and gender continued to find a protective association between neighborhood Black concentration and all-cause mortality, with higher Black mortality being higher in neighborhoods with less than 10% Black residents compared to neighborhoods with greater than 90% Black residents (Hutchinson et al., 2009). While this study illustrates these associations within a more localized context, study findings may not reflect current associations given the age of the data and the lack of measures of neighborhood socioeconomic status in their analyses.

Similarly, in a New York City-based cohort, living in a racially concordant neighborhood, measured by zip code level, was protective against all-cause mortality rates for Blacks and whites (Inagami et al., 2006). Age groups were broadly categorized as 25-64 and 65 and older. These associations vary by demographic characteristics. For example, higher mortality rates were found among women of all ages and Black men over 65 who lived in areas that were not predominantly Black. For whites of all ages, higher mortality was found in areas that were not predominantly white. However, Latino women over 65 experienced lower mortality rates in white neighborhoods but higher mortality rates in predominately Black areas when compared to Latinos living in areas with high co-ethnic concentration. In models adjusting for neighborhood-level high school graduation, unemployment, and poverty levels, there were racial differences in the effect of neighborhood racial composition on all-cause mortality rates. For example, for whites of all ages and genders, living in a predominately white neighborhood and increasing foreign-born populations protected all-cause mortality. Higher proportions of Black residents within a neighborhood were protective of all-cause mortality only among Blacks 65 and older but increases in foreign-born residents were protective of mortality only among Black men between 25 and 64. For Latinos, increases in Latino populations were protective of all-cause mortality among men between 25 and 64, while increases in foreign-born populations were associated with reduced mortality among all ages and genders except for men older than 65. These authors note that these findings may be attributed to New York City being among the most segregated cities within the U.S. and suggest that these associations may vary based on regional context. Some of these findings could be explained by the fact that studies have found a protective benefit of living in a more racially homogenous neighborhood since these neighborhoods may shield marginalized people from racial/ethnic prejudice and may improve access to social support networks and other resources (Henderson et al., 2005; Inagami et al., 2006; Neeleman et al., 2001). Taken together, these findings suggest that racial composition may matter for specific groups.

Given the mixed results reported in the literature linking racial composition to mortality, future research must take a more nuanced approach to explore associations between racial composition on health outcomes. Existing literature exploring associations between neighborhood racial composition and mortality rates has primarily relied upon national datasets over a quarter century old, while a few of the studies have adjusted for metrics of neighborhood socioeconomic status in their models. The age of the datasets used to examine these associations and the lack of consistent consideration of neighborhood socioeconomic status suggest the need to examine these associations using more recent data and robust measures of neighborhood socioeconomic status. Because mortality may be multi-causal, from a public health perspective, it is useful to understand the pathways through which effects may be operating to inform interventions. As a potential precursor to excess mortality, allostatic load is an indicator of the Stress Process Model. In situating allostatic load as a result of the built and social characteristics of segregated neighborhoods, as a result of institutional racism, allostatic load may be an important precursor to adverse health outcomes. Potentially intervening in neighborhood characteristics associated with elevated allostatic load may be an important mechanism to prevent premature aging and the development of chronic conditions related to excess mortality in structurally disinvested neighborhoods.

Similar trends have been found when examining the relationship between racial composition and cardio-metabolic indicators. Using mostly national datasets, increasing proportions of Blacks in neighborhoods have been reported to be associated with increases in BMI (Bleich et al., 2010; Boardman et al., 2005; Bower et al., 2015b; V. Chang, 2006; V. W. Chang et al., 2009). Other studies did not find a significant relationship between Black concentration and BMI (Do et al., 2007; Mobley et al., 2006; Robert & Reither, 2004) or that these associations vary by demographic characteristics. For example, using cross-sectional data from NHANES, Bower and colleagues (2015) found that a Black isolation index on the metropolitan area was positively associated with BMI among Black women, but there was a negative association for white women. Similarly, Li and colleagues (2014) examined associations between the percentage of a census tract that was Black and obesity using data from the Southeastern Pennsylvania Household Health Survey and found a null association for white women, Black women, and Black men, but increases in Black populations was protective of obesity among white men (K. Li et al., 2014). These demographic specific relationships have also been found in longitudinal studies. Cozier and colleagues (2014) examined associations between census block group Black concentrations and incident obesity using data from the Black Women's Health Study. Black concentration is positively associated with incidence obesity only among people who lived in segregated neighborhoods throughout the study period (Cozier et al., 2014). While beyond the scope of this dissertation, there is evidence of a positive association between segregation and adverse cardio-metabolic outcomes among youth within the United States using longitudinal datasets (D'Agostino et al., 2018; Wang et al., 2022). Despite these mixed findings, there are also limitations for studies that have examined associations between neighborhood racial composition and weight status, with some studies not adjusting for physical activity (Chang et al., 2009; Do et al., 2007; Li et al., 2014), measure segregation at the metropolitan area (Bower et al., 2015; Chang, 2006), or do not adjust for neighborhood socioeconomic status in their models (Robert & Reither, 2004). With the exception of a few studies, most of the previously referenced studies measure racial residential segregation using the percentage of an area that is Black/African American.

Further, institutional racism, in the form of housing discrimination, can be hypothesized as an important factor in shaping neighborhood racial composition (Rothstein, 2018; Trounstine, 2018). Specifically, as a result of the New Deal of the 1930s, the Home Owner's Loan Corporation created residential security maps that were largely shaped by the racial/ethnic composition, available infrastructure, housing quality, and the proximity to different hazards within a neighborhood (Winling & Michney, 2021). There is also evidence that has linked these historic decisions to contemporary characteristics of neighborhoods. For example, associations between neighborhoods that were historically "hazardous" or "undesirable" still remain lower-income communities of color, while historically "desirable" neighborhoods remain predominately white and higher-income (Aaronson et al., 2020; Mitchell & Franco, 2018; A. Nardone, Chiang, et al., 2020).

Given these mixed results, it is possible that the range of Black density across studies may explain why some investigations found significant, paradoxical, or demographic-specific results while others did not. There may be regional differences in the impact of racial composition as different regions may have differences in discrimination of tolerances for interpersonally mediated racism. Existing research has not examined the impact of racial composition on allostatic load, a widely accepted measure of the body's response to stress (Duong et al., 2017; Juster et al., 2010; B S McEwen & Seeman, 1999). Since cross-sectional models do not allow for time ordering of exposures between variables in a mediation model, examining these associations longitudinally may allow us to capture these concepts more accurately (Fairchild & McDaniel, 2017). A gap in the literature is that more neighborhood indicators and social relationships should be added to models with a more comprehensive multi-system dependent variable as theoretical frameworks such as the Social Ecological Model, Fundamental Cause Theory, and the Stress Process Models emphasize the role of factors outside of the individual that may help to explain the associations between neighborhood racial composition and allostatic load. These external and structural factors may also include the conditions, if any, under which neighborhood racial composition may be protective of health. This research investigation utilizes the existing literature that has examined a series of neighborhood and individual level covariates to examine associations between neighborhood racial composition and allostatic load over time and whether these associations vary by individual demographic characteristics. This examination also explores whether neighborhood racial composition mediates associations between HOLC score and both allostatic load and measures of neighborhood socioeconomic status.

The Case for Baltimore

Among the top 30th largest cities in the United States, Baltimore, Maryland, has some of the lowest average incomes when compared to other northeastern cities with poverty levels disproportionality affecting non-white neighborhoods (Theodos et al., 2019). Baltimore's spatial segregation is apparent in what is referred to as "the Black butterfly," where Black residents are primarily concentrated on the eastern and western sides, where whites are clusters in the "white L" in the central and southern regions of the city (Lawrence Brown, 2016; Theodos et al., 2019). Considering some of the limitations of using nationally representative samples, local cohort studies are important as they can shed light onto potential associations between variables considering more contextual factors (Geronimus et al., 2020).

4.2 **Specific Aims and Hypothesis**

In this chapter, I examine whether neighborhood racial composition is associated with allostatic load over time among current residents of Baltimore, Maryland. I will examine six linked research questions described below to address this overarching research question. The initial question is exploratory, and the results from this question will inform the subsequent questions, which will be reflected in the subsequent aims.

Q1. Do associations between neighborhood racial composition and allostatic load over time vary by race, gender, and age group controlling for neighborhood-level socioeconomic status?

H1*: There are racial differences in the relationship between neighborhood racial composition and allostatic load over time, controlling for neighborhood socioeconomic status.*

H2*: There are gender differences in the relationship between neighborhood racial composition and allostatic load over time, controlling for neighborhood socioeconomic status.*

H3*: There are age differences in the relationship between neighborhood racial composition and allostatic load over time, controlling for neighborhood socioeconomic status.*

Q2. Does ethnic discrimination mediate associations between neighborhood racial composition and allostatic load over time?

H1: *Higher neighborhood-level homogeneity is associated with reduced levels of ethnic discrimination and therefore reduced allostatic load over time.*

Q3. Does perceived neighborhood social environment mediate associations between neighborhood racial composition and allostatic load?

H1: *Living in a more racially homogenous neighborhood is associated with heightened social support and reduced allostatic load over time.*

Q4. Does perceived neighborhood social environment modify the mediating role of discrimination on associations between neighborhood racial composition and allostatic load?

H1: *Social environment modifies the mediation effect of discrimination on the associations between neighborhood racial composition and allostatic load over time.*

Q5. Does the percentage of a neighborhood that is Black/African American mediate associations between HOLC score and allostatic load?

H1: *Living in a neighborhood with a higher HOLC score is associated with increases in % Black and increased allostatic load.*

Q6. Do the percentage of a neighborhood that is Black/African American mediate associations between HOLC score and neighborhood socioeconomic status?

H1: *Living in a neighborhood with a higher HOLC score is associated with increases in % Black and lower neighborhood socioeconomic status.*

4.3 **Methods**

The data for this study are taken from the Health Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study. HANDLS involves 3,720 white and African American adults between 30- and 64-years old living in 13 Baltimore City, Maryland neighborhoods. While data collection began in August 2004, I used Wave 4 collected between September 2013 and September 2017. More information on the study design and methods has been published in detail (Evans et al., 2010).

Neighborhood Racial Composition

Neighborhood racial composition was measured at the census tract level by downloading data files from the American Community Survey 5-year estimates using a racial isolation index. Racial isolation was measured at the census tract using data on the number of Black and white in each census tract, the number of Black in the city, and the total population within each census tract from the American Community Survey. Specifically, the following formula will be used to calculate a racial isolation index on the census tract level:

Figure 4-1. Racial Isolation Index Formula

$$B_{bw} = \sum \left({n_{ib}}/{N_b} \right) \left({n_{iw}}/{n_i} \right)$$

Where:

n_{ib} = number of Blacks in the tract
n_{iw} = number of Whites in the tract
N_b = number of Blacks in the city
n_i = total population of the tract

Higher scores on this census tract-based racial isolation index indicates a lower likelihood that Blacks would interact with only other Blacks within their respective census tracts. I will also test the percentage of census tract residents of Black origin as an additional marker of neighborhood racial composition.

Allostatic Load

Allostatic load (A.L.) was computed using methods outlined by existing articles using the HANDLS dataset (Beydoun et al., 2019), using clinical cut points to define high and low-risk biomarkers. In keeping with the allostatic load literature, I include cardiovascular (systolic and diastolic blood pressure, pulse rate), metabolic (total cholesterol, HDL-C, HbA1c, waist-to-hip ratio), and inflammatory (albumin CRP) indicators (Beydoun et al., 2019) that function as components of A.L. taken from Wave IV data. Risk scores were assigned as follows:

Table 4-1. Allostatic Load Indicator Criteria

	High Risk Clinical
Albumin (g/dL)	<3.8
C-reactive protein (mg/dL)	≥ 0.3
Waist: Hip	>0.9 for men; > 0.85 for women
Total Cholesterol (mg/dL)	≥240
HDL (mg/dL)	<40
Glycated hemoglobin (%)	≥6.4
Resting heart rate (beat/min)	≥90
Systolic Blood Pressure	≥140
Diastolic B.P.	≥90

Psychosocial Indicators

Ethnic Discrimination

Ethnic Discrimination is measured in this survey using items from Brief Perceived Ethnic Discrimination Questionnaire (Brondolo et al., 2005). Seventeen questions were asked where a respondent was to respond to each item based on their race/ethnicity (i.e. *How often have you others thought you couldn't do things or handle a job because of your ethnicity or race?; How often have policemen or security officers been unfair to you because of your ethnicity or race?; How often have others ignored you or not paid attention to you because of your ethnicity or race?)*. Higher scores on this scale are associated with fewer experiences of discrimination.

Perceived Neighborhood Social Environment

A series of questions will be drawn from the neighborhood questionnaire that participants completed. Consistent with existing research, questions about the neighborhood social environment will be used as a proxy for the perceived neighborhood social environment (Claudel et al., 2019). Items were scored whereby higher scores represent more favorable perceptions of neighborhood social environments. The specific questions used to calculate this scale are presented in Table 2.

Table 4-2. Survey Items that are used to measure Perceived Neighborhood Social Environment

Factor	Item	Likert scale response mean
Social Environment		
	People in my neighborhood are willing to help their neighbors	2.40 (1.08) 1-5
	Live in a close-knit neighborhood	2.75 (1.19) 1-5
	People in my neighborhood can be trusted	2.97 (1.16) 1-5
	People in my neighborhood generally do not get along with each other	3.44 (1.09) 1-5
	People take action if children spray-paint	3.56 (1.27) 1-5
	People take action if children disrespect adult	3.46 (1.22) 1-5

	People take action if fight in front of house	3.47 (1.20) 1-5

Neighborhood Level Indicators

Historic HOLC score data was downloaded from the Inter-University Consortium for Political and Social Research website housed at the University of Michigan (Meier & Mitchell, 2021). Historic HOLC score maps were overlaid with 2010 and 2020 census tracts for cities across the U.S. HOLC scores were multiplied by a weighting factor based on the area of the census tracts, whereby higher scores indicate Redlined areas while lower scores correspond to Greenlined areas. Scores range from 1 (Greenlined) to 4 (Redlined). HOLC score data from 2010 census tract boundaries were used (Meier & Mitchell, 2021). A higher score corresponds with a greater proportion of the census tract being Redlined. Similar to existing research, census tract level data will be used as a proxy for neighborhoods (R. Mehdipanah et al., 2021).

Covariates

Covariates include age (35-44, 45-54, 55-64, 65+), race (white vs. African American), sex (male vs. female), current tobacco smoking status (never tried, tried, never used regularly, former user, current user), allostatic load (measured during Wave III), household poverty status (PIR<125%:below poverty; PIR ≥125%: above poverty), and neighborhood deprivation index. Neighborhood socioeconomic status will be conceptualized by a neighborhood deprivation index (NDI) and the percent of families living in poverty, both measured on the census tract level. Neighborhood deprivation was measured using neighborhood socioeconomic deprivation calculated using previously published methods on the census tract level (Powell-Wiley et al., 2020; Neally et al., 2022) drawn from the 2017 (5-Year Estimates) American Community Survey to align with Waves 4 data collection Specifically, estimates from the American Community Survey include median household income, median housing value, the percentage of individuals over 25 with a high-school diploma, the percentage of individuals over 25 with a bachelor's degree, the percentage of employed people (age 16 and older) working in management, business, science, and arts, the percentage of households below the federal poverty limit, the percentage of families receiving public assistance, the percentage of female-headed households with children under 18, and the percentage that receive interest, dividends, or rental income was downloaded from the American Community Survey. Variables were z-standardized, and reverse coded as necessary so that the sum of these variables would result in a continuous score with higher scores representing more deprivation or a lower socioeconomic status census tract.[15] In addition to the composite NDI score, the percentage of families with incomes falling below the federal poverty will also be tested as an additional indicator of neighborhood socioeconomic status.

4.4 Statistical Analysis

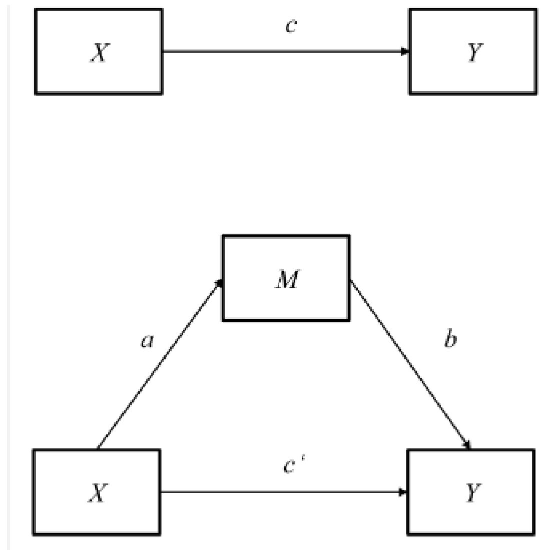
Descriptive statistics were calculated for all variables included in the analyses. Regressions for each aim of this paper were conducted using ordinary least squares models with clustered standard errors and multilevel models. The illustration and interpretation of the multilevel models are presented in the main dissertation text (Ordinary Least Squares [OLS] models with clustered standard error models can be found in Appendix C: Tables C1 – C3). Since each participant is one observation clustered in a census tract, some of the characteristics of the individual may be

[15] The percent of people over 25 with a high school diploma, the individuals over 25 with a bachelor's degree, the percentage of employed people (age 16 and older) working in the management, business, science, and arts, and the percentage of houses that receive interest, dividends, or rental income were reverse coded in the dataset to reflect a deprivation approach.

concordant with others within the cluster (R. A. Rose, 2018). Given this, multilevel models are a unique method to examine the independent effects of individual and neighborhood-level relationships. Specifically, a multilevel approach was selected using an independent variable and random intercept variation. Structural equation models were also used to examine mediating relationships and provide data on the strength of the indirect pathways using Sobel's test between the variables under study using STATA/SE 17.0 (StataCorp, College Station, TX, USA, 2021) was used to conduct all analyses. Sensitivity models were also used to check for multicollinearity among the models.

Figure 2 provides a visual schematic regarding how mediation will be examined within this chapter. "X" corresponds to the predictor variable (either the racial isolation index or the percentage of people within a census tract who identify as Black/African American), "M" corresponds to the mediator, "Y" corresponds to allostatic load. Path A examines the effect of X on M, Path B explores the effect of the mediator on Y, Path C examines the direct effect of X on Y, and Path C' examines the direct effect of X on Y after including the mediator. All mediation models were adjusted for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, baseline allostatic load, and household poverty status.

Figure 4-2. Diagram expressing the potential Mediation Pathways of Neighborhood Perceptions on the Relationship between Neighborhood SES indices and allostatic load.



4.5 **Results**

Six hundred eighty-eight participants had measures for this study's main exposure, outcome, and covariates and did not move between waves. Table 4-3 presents the descriptive statistics for each variable included in the study. The mean allostatic load score for study participants during Wave IV was 1.94 (min=0, max=6), the mean allostatic load score for study participants during Wave III was 1.94 (min=0, max=6), 7.79% of the sample was between 35 and 44 years old, 28.53% were between 45 and 54 years old, 38.24% between 55 and 64 years old, and 25.44% were 65 and older. Roughly 57% of the sample was African American, and nearly 60% of the sample was female. For physical activity, less than a third of the sample (31.62%) reported engaging in physical activity for less than 5 minutes, 22.94% reported between 5 and 15 minutes, 23.97% reported between 15 and 30 minutes, 9.41% reported between 30 and 45 minutes, and 12.06% reported over 45 minutes of daily physical activity. Smoking status varied, with 37.06%

of study participants being current users, 28.38% former users, 22.65% never tried, and 11.91% tried but never used regularly. Over two-thirds (70.15%) of participants were above the poverty threshold, while 29.85% were below. On the neighborhood level, the mean Racial Isolation Index during Wave III was 9.66 – meaning that increases on this scale are associated with a decreased likelihood that Blacks would interact with one another within a census tract, the mean percentage of residents in a census tract who were Black/African American during Wave III was 63.74%, and the mean Neighborhood Deprivation Index score during Wave IV was 11.37. Descriptive statistics and t-tests between those who were excluded from the sample due to missing study variables compared to the analytic sample are show in Appendix C: Table 4-22.

Table 4-3. Demographic Characteristics of Participants in Wave IV of HANDLS

N=688	Mean(SD) Range
Individual Level	
Allostatic Load (Wave IV)	1.94 (1.19) 0-6
Allostatic Load (Wave III)	1.94 (1.24) 0-6
Age	N (%)
35-44	53 (7.79)
44-54	194 (28.53)
55-64	260 (38.24)
65+	173 (25.44)
	N(%)
Race	
White	294 (43.24)
African American	386 (56.76)
Sex	
Female	406 (59.71)
Male	274 (40.29)
Physical Activity	
<5 min	215 (31.62)
5-15 min	156 (22.94)
15-30 min	163 (23.97)
30-45 min	64 (9.41)

>45 min	82 (12.06)
Smoking Status	
Never Tried	154 (22.65)
Tried, never used regularly	81 (11.91)
Former User	193 (28.38)
Current User	252 (37.06)
Poverty Status	
Above Poverty Threshold	477 (70.15)
Below Poverty Threshold	203 (29.85)
Neighborhood Level	
Racial Isolation Index (Wave III)	9.66 (7.74) 0-26.65
Percent Black/African American (Wave III)	63.74 (30.71) 1.60- 99.40
Neighborhood Deprivation (Wave IV)	11.37 (3.31) 0.42-20.81

First, I present the results exploring whether the relationship between measures of neighborhood racial composition (Wave III) and allostatic load (Wave IV) varies by demographic characteristics.

Race Specific Associations

Table 4-4 shows results from multilevel models asking whether associations between measures of neighborhood racial composition (Wave III) and allostatic load (Wave IV) vary by race. Table 4-4 shows that the direct relationship between the racial isolation index and the percentage of a neighborhood that was Black/African American at Wave III on allostatic load at Wave IV were insignificant *(β= 0.00, p=0.71) and (β= 0.00, p=0.24)*, respectively. Table 4-4 also shows an insignificant interaction between the racial isolation index *(β= -0.01, p=0.46)* and the percentage of a neighborhood that was Black/African American *(β= -0.00, p=0.99)* and allostatic load. Further, I tested whether the model, including the interaction term between race and neighborhood racial composition, was a better fit than models without the interaction term. Based on a p-value of 0.46 (Table 4-4), models including the interaction between the Racial Isolation

Index and race were not a better fit in modeling these associations than models without the interaction term. Based on a p-value of 0.46 and a p-value of 0.99 (Table 4-4), models 1 and 2 were not a better fit in modeling these associations than models without the interaction term, respectively.

Table 4-4. Results from Multilevel Models Regressing Allostatic Load on indicators of neighborhood racial composition vary by Race, Controlling for Categorical Age, Sex, Physical Activity, Smoking Status, Neighborhood Deprivation Index, Baseline Allostatic Load, and Poverty Status.

MLM	Model 1 (Racial Isolation Index)		Model 2 (Percent Black/African American)	
	B(SE)	P	B(SE)	P
Level 2- Neighborhood				
Racial Isolation Index	0.00 (0.01)	0.71	--	--
Percent Black/African American	--	--	0.00 (0.00)	0.24
Neighborhood Deprivation	-0.00 (0.01)	0.76	-0.01 (0.01)	0.53
Cross-Level Interaction				
RaceXNeighborhood Composition				
African American	-0.01 (0.01)	0.46	-0.00 (0.00)	0.99
Level 1- Individual				
Race				
White (ref)				
African American	0.10 (0.17)	0.57	-0.12 (0.29)	0.68
Goodness of fit*		0.46		0.99

*Tests whether models with the interaction term between race and neighborhood composition indicator are a better fit than models without these interaction terms.

Sex-Specific Associations

To test whether the relationship between each measure of neighborhood composition and allostatic load varied by sex, I tested whether there was an interaction between each index of neighborhood racial composition and sex. Table 4-5 shows that the direct association between the racial isolation index and allostatic load was insignificant (β= -0.01, p= 0.33), while associations between the percentage of a census tract that was Black or African American (β= 0.01, p= 0.01) was significant. Table 4-5 also indicates that the interaction term between the racial isolation index and sex was insignificant (β= 0.01, p= 0.20), but the interaction between the percentage of a census tract that was Blacks or African American in the neighborhood and sex was significant (β= -0.01, p= 0.00) was significant. In other words, associations between the percentage of a neighborhood that was Black or African American and allostatic lead differ for women and men. Further, I tested whether the model, including the interaction term between sex and neighborhood racial composition, was a better fit than models without the interaction term. Based on a p-value of 0.20 and a p-value of 0.00 (Table 4-5), model 1 was not a better fir in modeling these associations including the interaction term, but model 2 was, respectively.

Table 4-5. Results from Multilevel Models Regressing Allostatic Load on indicators of neighborhood racial composition and variation by Sex, Controlling for Categorical Age, Race, Physical Activity, Smoking Status, Neighborhood Deprivation Index, Baseline Allostatic Load, and Poverty Status.

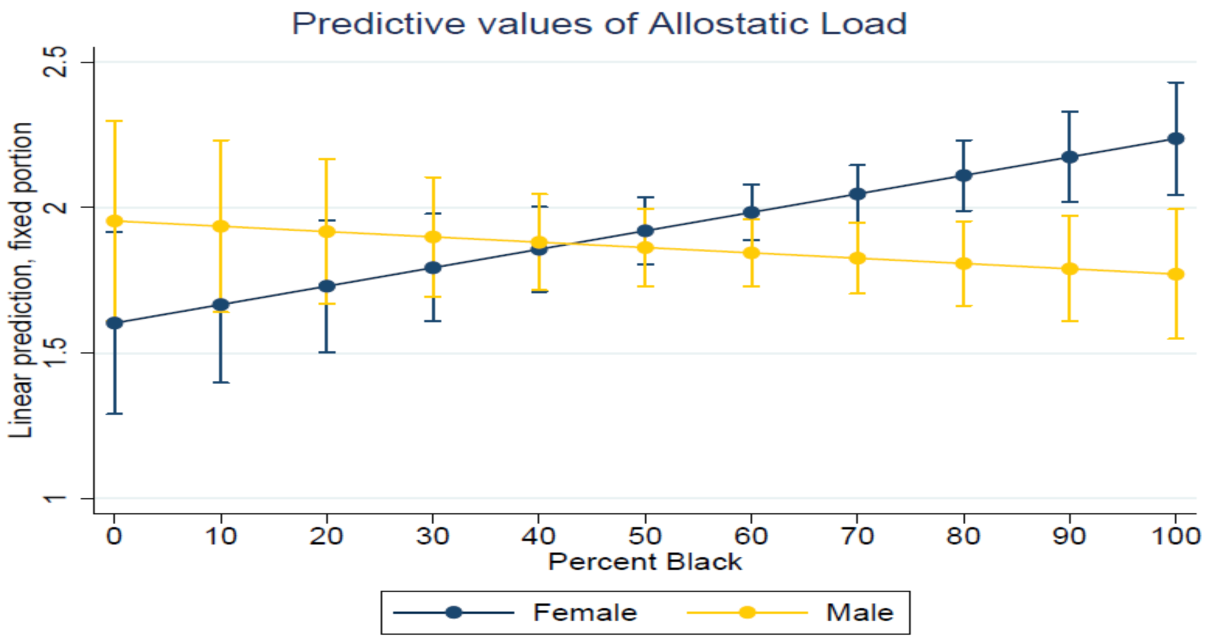
MLM	Model 1 (Racial Isolation Index)		Model 2 (Percent Black/African American)	
	B(SE)	P	B(SE)	P
Level 2- Neighborhood				
Racial Isolation Index	-0.01 (0.01)	0.33	--	--
Percent Black/African American	--	--	0.01 (0.00)	0.01
Neighborhood Deprivation	0.00 (0.01)	1.00	-0.01 (0.01)	0.26
Level 1- Individual				
Sex				
Female (ref)				

Male	-0.29 (0.13)	0.02	0.35 (0.18)	0.045
Cross-Level Interactions				
SexXSegregation Indicator				
Men	0.01 (0.01)	0.20	**-0.01 (0.00)**	**0.00**
Goodness of fit*		0.20		**0.00**

*Tests whether models with the interaction term between sex and neighborhood composition indicator are a better fit than models without these interaction terms.

As shown in Figure 4-3, men in neighborhoods with lower proportions of Black/African Americans had higher allostatic load scores than men living in areas with higher proportions of Black/African Americans. However, women in areas with low proportions of Black/African Americans had lower allostatic load scores compared to women living in areas with higher proportions of Black/African Americans (Figure 4-3). Specifically, there are no apparent sex differences in the associations between Percent Black/African American and allostatic load at levels below 70% Black. Given the differences in slopes by sex, it is only at the highest levels of Percent Black/African American that I see significant differences by sex. Given adequate sample sizes of men and women across the spectrum of the Racial Isolation index and Percent Black/African American, there is enough statistical power to estimate these associations (Table C4).

Figure 4-3. Interactions between Sex and the percent of a neighborhood that is Black/African American to see if associations between the percentage of a census tract that is Black or African American and Allostatic Load vary by Sex.



<u>Age Specific Associations</u>

Table 4-6 shows results from multilevel models asking whether associations between indices of neighborhood racial composition and allostatic load varied by age group. Table 4-6 shows the direct effect between the racial isolation index (β= -0.00, p= 0.84) and the proportion of a neighborhood that is Black/African American (β= 0.01, p= 0.12), and allostatic load is insignificant. Table 4-6 also shows no significant interaction between any age category and the association between either of the measures of neighborhood racial composition and allostatic load. Further, I tested whether the model including the interaction term between age category and neighborhood racial composition was a better fit than models without the interaction term. Based on a p-value of 0.98 (Table 4-6), models including the interaction between the Racial Isolation Index and age category were not a better fit in modeling these associations than models without the interaction term. Based on a p-value of 0.98 and 0.12 (Table 4-6), models 1 and 2 were not a better fit in modeling these associations than models without the interaction term, respectively.

Table 4-6. Results from Multilevel Models Regressing Allostatic Load on indicators of neighborhood racial composition vary by Age Category, Controlling for Race, Sex, Physical Activity, Smoking Status, Baseline Allostatic Load, and Poverty Status.

MLM	Model 1 (Racial Isolation Index)		Model 2 (Percent Black/African American)	
	B(SE)	P	B(SE)	P
Level 2- Neighborhood				
Racial Isolation Index	-0.00 (0.02)	0.84	--	--
Percent Black/African American	--	--	0.01 (0.00)	0.12
Neighborhood Deprivation	0.00 (0.01)	0.95	-0.01 (0.01)	0.50
Cross-Level Interactions				
AgeXSegregation Indicator				
35-44 (ref)				
45-54	-0.00 (0.02)	1.00	-0.01 (0.00)	0.08
55-64	0.01 (0.02)	0.80	-0.00 (0.00)	0.48
64+	0.00 (0.02)	0.91	-0.00 (0.00)	0.78
Level 1-Individual				
Age				
35-44 (ref)				
45-54	0.04 (0.25)	0.88	0.54 (0.32)	0.10
55-64	0.08 (0.24)	0.73	0.32 (0.32)	0.32
64+	0.24 (0.25)	0.33	0.31 (0.34)	0.37
Goodness of fit*		0.98		0.12

*Tests whether models with the interaction term between categorical age and neighborhood composition indicator are a better fit than models without these interaction terms.

Results from tests of the hypotheses that discrimination mediates associations between neighborhood racial composition and allostatic load are presented in Table 7.

Ethnic Discrimination as a Mediator

To begin, I examined the role of *Ethnic Discrimination* as a mediator of the relationship between census-tract level racial composition and allostatic load. Based on the results presented in Tables 4-6, the correct model specifications would include an interaction only between the percentage of a census tract that is Black/African American and sex (Table 4-5). I examine the pathways between each indicator of neighborhood racial composition and allostatic load and the potential mediation pathways. Results from models testing whether *Ethnic Discrimination* (Wave IV) mediates the relationship between neighborhood racial composition (Wave III) and allostatic load (Wave IV) over time are shown in Table 4-7.

Table 4-7. Tests of direct effects of Neighborhood Racial Composition Indicators and tests of Ethnic Discrimination as a mediating pathway among HANDLS participants

	Racial Isolation			**Percent Black/African American**		
	M: Ethnic Discrimination			**M: Ethnic Discrimination**		
	beta	S.E.	p-value	beta	S.E.	p-value
Path c: Association between Neighborhood Racial Composition Indicator and AL	-0.00	0.01	0.79	0.01	0.00	0.00
Path a: Association between Neighborhood Racial Composition Indicators and Ethnic Discrimination	-0.07	0.05	0.19	0.00	0.02	0.82
Path b: Association between Ethnic Discrimination and AL	0.00	0.00	0.41	0.00	0.00	0.41
Path c': Association between Neighborhood Racial Composition Indicator and A.L. accounting for Ethnic Discrimination	-0.00	0.01	0.80	0.02	0.00	0.00

Note: M: Mediators. All models were adjusted for age category, race, sex, poverty status, physical activity, neighborhood deprivation index, baseline allostatic load, and smoking. The interaction between neighborhood racial composition and sex was accounted for in paths c and c' only in models examining Percent Black/African American.

Associations between racial isolation and allostatic load is not significantly mediated by *Ethnic Discrimination* adjusting for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, the interaction between sex and Racial Isolation Index, baseline allostatic load, and household poverty status (paths ab = -0.00, p= 0.49) (Table 4-8). Higher scores on the neighborhood level racial isolation index were negatively associated with allostatic load, albeit not significant (β= -0.00, p=0.79) (Table 4-7). While not statistically significant, perceived ethnic discrimination was positively associated with allostatic load (β= 0.00, p=0.41) (Table 4-7). Racial isolation was not significantly associated with allostatic load (path c' [direct effect] and path c [total effect]) (Table 4-7).

Table 4-8. Tests of indirect effects of Ethnic Discrimination on the direct relationship between measures of neighborhood racial composition among HANDLS participants

	Indirect Effect		
	Ethnic Discrimination		
	beta	S.E.	p-value
Racial Isolation	-0.00	0.00	0.49
Percent Black/African American	0.00	0.00	0.83

The previous paragraph examined whether *Ethnic Discrimination* mediated associations between a Racial Isolation Index and allostatic load over time. Next, I present the results to examine whether *Ethnic Discrimination* mediated the relationship between the proportion of a census tract that are Black/African American and allostatic load (Table 4-7). Associations between racial isolation and allostatic load was not mediated via Ethnic Discrimination adjusting for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, the interaction between sex and percent Black/African American, baseline allostatic load, and household poverty status (paths ab = 0.00, p= 0.83) (Table 4-8). Higher scores on the neighborhood level racial isolation index were positively associated with allostatic load, albeit not significant (β= 0.00, p=0.82) (Table 7). Higher perceived ethnic discrimination was positively associated with allostatic load despite not being significant (β= 0.00, p=0.41) (Table 4-7). Percent Black/African

American was significantly associated with allostatic load (path c' [direct effect] and path c [total effect]) (Table 4-7).

Neighborhood Social Environment as a Mediator

Results from tests of the hypotheses that neighborhood social environment mediates associations between neighborhood racial composition and allostatic load over time are presented in Table 4-9. I examined the role of perceived neighborhood social environment as a mediator of the relationship between census-tract level racial composition and allostatic load. Based on the results presented in Table 4-5, the correct specifications of models would include an interaction only between the percentage of a census tract that is Black/African American and sex in paths c and c'.

Associations between racial isolation and allostatic load were not significantly mediated by neighborhood social environment adjusting for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, baseline allostatic load, and household poverty status (paths ab = -0.00, p= 0.83) (Table 4-9). Higher scores on the neighborhood level racial isolation index were negatively associated with allostatic load, albeit insignificant (β= -0.02, p=0.52) (Table 4-9). Higher perceived neighborhood environment was positively associated with allostatic load despite not being significant (β= 0.00, p=0.82) (Table 4-9). Racial Isolation was not significantly associated with allostatic load (path c' [direct effect] and path c [total effect]) (Table 4-9).

Associations between percent Black/African American and allostatic load was not mediated by neighborhood social environment adjusting for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, the interaction between sex and percent Black/African American, baseline allostatic load, and household poverty status (paths ab = 0.00, p= 0.91) (Table 4-20). Higher scores on the percent Black/African American were positively associated with allostatic load, albeit insignificant (β= 0.03, p=0.07) (Table 4-9). Higher perceived neighborhood environment was positively associated with allostatic load despite not being significant (β= 0.00, p=0.91) (Table 4-9). Percent Black/African American was significantly associated with allostatic load (path c' [direct effect] and path c [total effect]) (Table 4-9).

Table 4-9. Tests of direct effects of Neighborhood Racial Composition Indicators and tests of Neighborhood Social Environment as a mediating pathway among HANDLS participants

	Racial Isolation			**Percent Black/African American**		
	M: Neighborhood Social Environment			**M: Neighborhood Social Environment**		
	beta	S.E.	p-value	beta	S.E.	p-value
Path c: Association between Neighborhood Racial Composition Indicator and AL	-0.00	0.01	0.79	0.01	0.00	0.00
Path a: Association between Neighborhood Racial Composition Indicator and Neighborhood Social Environment	-0.02	0.03	0.52	0.02	0.01	0.07
Path b: Association between Neighborhood Social Environment and AL	0.00	0.01	0.82	0.00	0.01	0.91
Path c': Association between Neighborhood Racial Composition Indicator and A.L. accounting for Neighborhood Social Environment	-0.00	0.01	0.99	0.01	0.00	0.00

Note: M: Mediators. All models were adjusted for age category, race, sex, poverty status, physical activity, neighborhood deprivation index, and smoking. The interaction between neighborhood racial composition indicator and sex was accounted for in paths c and c'.

Table 4-10. Tests of indirect effects of Social Environment on the direct relationship between measures of neighborhood racial composition among HANDLS participants

	Indirect Effect		
	Neighborhood Social Environment		
	beta	S.E.	p-value
Racial Isolation	-0.00	0.00	0.83
Percent Black/African American	0.00	0.00	0.91

<u>*Social Institutions as Mediators*</u>

Results from models testing whether the density of social institutions mediates the relationship between neighborhood racial composition and allostatic load over time are shown in Table 4-11. Racial isolation index was not significantly indirectly associated with allostatic load via neighborhood religious organization, civic organization, and both religious and civic organization density adjusting for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, baseline allostatic load, and household poverty status (paths ab = -0.00, p= 0.29, -0.00, p= 0.93, -0.00, p= 0.36, respectively) (Table 4-12). Higher scores on the neighborhood level racial isolation index were negatively associated with the density of religious organization (β= -0.12, p=0.00) and the total density of both religious and civic organization (β= -0.12, p=0.00), but positively associated with the density of civic organizations (β= 0.02, p=0.72) (Table 4-11). Neither the density of religious organizations, civic organizations, or the combined religious and civic organizations were associated with allostatic load (β= 0.01, p=0.29, β= -0.00, p=0.93, and β= 0.01, p=0.20, respectively) (Table 4-11). Racial Isolation was not significantly associated with allostatic load (path c' [direct effect] and path c [total effect]) (Table 4-11).

Table 4-11. Tests of direct effects of neighborhood racial isolation index on allostatic load and test of neighborhood social and civic organization density as a mediating pathway among HANDLS participants

	M: Religious Orgs/1,000 people			M: Civic Orgs/1,000 people			M: Religious and Civic Orgs/1,000 people		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
Path c: Association between Racial Isolation and A.L.	-0.00	0.01	0.79	-0.00	0.01	0.79	-0.00	0.01	0.79
Path a: Association between Racial Isolation and Mediator	-0.12	0.02	0.00	0.00	0.01	0.72	-0.12	0.02	0.00
Path b: Association between Mediator and A.L.	0.01	0.01	0.29	-0.00	0.03	0.93	0.01	0.01	0.20
Path c': Association between Racial Isolation and A.L. accounting for Mediator	-0.00	0.01	1.00	-0.00	0.01	0.79	-0.00	0.01	0.95

Note: M: Mediators. All models were adjusted for age category, race, sex, poverty status, physical activity, neighborhood deprivation index, baseline allostatic load, and smoking.

Table 4-12. Tests of indirect effects of neighborhood social and civic organization density on the direct relationship between racial isolation on allostatic load by race among HANDLS participants

	Indirect Effect								
	M: Religious Orgs/1,000 people			M: Civic Orgs/1,000 people			M: Religious and Civic Orgs/1,000 people		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
Indirect Effect	-0.00	0.00	0.29	-0.00	0.00	0.93	-0.00	0.00	0.36

Associations between percent Black/African American and allostatic load were not mediated by the density of neighborhood institutions adjusting for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, the interaction between sex and percent Black/African American, baseline allostatic load, and household poverty status (paths ab = 0.00, p= 0.40; -0.00, p= 0.91; 0.00, p= 0.44, respectively) (Table 4-14). Higher percent Black/African American was positively associated with the density of religious organization (β= 0.01, p=0.00), the density of civic institutions (β= 0.00, p=0.90), and the density of both religious and civic organizations (β= 0.01, p=0.42) (Table 4-13). Higher percent Black/African American was positively associated with the density of religious organizations (β= 0.03, p=0.00) and the total density of both religious and civic organizations (β= -0.01, p=0.00), but positively associated with the density of civic organizations (β= 0.02, p=0.01) (Table 13). Neither the density of religious organizations, civic organizations, or the combined religious and civic organizations were associated with allostatic load (β= 0.01, p=0.39; β= 0.00, p=0.90, and β= 0.01, p=0.42, respectively) (Table 4-13). Percent Black/African American was significantly associated with allostatic load (path c' [direct effect] and path c [total effect]) (Table 4-13).

Table 4-13. Tests of direct effects of percent Black/African American on allostatic load and test of neighborhood perception scores as a mediating pathway among HANDLS participants

	M: Religious Orgs/1,000 people			**M: Civic Orgs/1,000 people**			**M: Religious and Civic Orgs/1,000 people**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
Path c: Association between percent Black/African American and A.L.	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00
Path a: Association between percent Black/African American and Mediator	0.03	0.01	0.00	-0.01	0.00	0.00	0.02	0.01	0.01
Path b: Association between Mediator and A.L.	0.01	0.01	0.39	0.00	0.03	0.90	0.01	0.01	0.42
Path c': Association between percent Black/African American and A.L. accounting for Mediator	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00

Note: M: Mediators. All models were adjusted for age category, race, sex, poverty status, physical activity, neighborhood deprivation index, baseline allostatic load, and smoking. The interaction between sex and neighborhood racial composition indicator was accounted for.

Table 4-14. Tests of indirect effects of social institutions on the direct relationship between percent Black/African American on allostatic load among HANDLS participants

	Indirect Effect								
	M: Religious Orgs/1,000 people			**M: Civic Orgs/1,000 people**			**M: Religious and Civic Orgs/1,000 people**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
Indirect Effect	0.00	0.00	0.40	-0.00	0.00	0.91	0.00	0.00	0.44

<u>*Moderated Mediation Results*</u>

The following section examines whether perceived neighborhood social environment modifies the mediating role of discrimination on associations between neighborhood racial composition and allostatic load. These models build upon existing models in Table 4-6 in that Paths a and b include an interaction between each measure of neighborhood racial composition and neighborhood social environment. Finally, I test whether neighborhood social environment modifies the potential mediating role of ethnic discrimination on associations between neighborhood racial composition and allostatic load over time, including an interaction between study variables and neighborhood social environment. The results from these analyses are presented in Tables 4-15 and 4-16.

Associations between racial isolation and allostatic load were not mediated by ethnic discrimination adjusting for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, baseline allostatic load, the interaction effect of neighborhood social environment, and household poverty status (Table 4-16). Higher scores on the neighborhood level racial isolation index were negatively associated with ethnic discrimination, albeit insignificant (β= -0.24, p=0.51) (Table 4-15). Higher perceived social environment was positively associated with allostatic load despite not being significant (β= 0.00, p=0.87) (Table 4-

15). Racial Isolation was not significantly associated with allostatic load (path c' [direct effect] and path c [total effect]) (Table 4-15).

Associations between percent Black/African American and allostatic load were mediated by ethnic discrimination adjusting for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, the interaction effect of neighborhood social environment, the interaction between sex and percent Black/African American, baseline allostatic load, and household poverty status (Table 4-15). Higher scores on the percent Black/African American were negatively associated with ethnic discrimination, albeit insignificant (β= -0.00, p=0.96) (Table 4-15). Higher ethnic discrimination was positively associated with allostatic load despite not being significant (β= 0.01, p=0.83) (Table 4-15). Percent Black/African American was significantly associated with allostatic load (path c' [direct effect] and path c [total effect]) (Table 4-15).

Table 4-15. Tests of direct effects of Neighborhood Racial Composition Indicators and tests of interactions between Ethnic Discrimination and perceived neighborhood environments as a moderated mediator among HANDLS participants

	Racial Isolation			**Percent Black/African American**		
	M: Ethnic Discrimination			**M: Ethnic Discrimination**		
	beta	S.E.	p-value	beta	S.E.	p-value
Path c: Association between Neighborhood Racial Composition Indicator and AL	-0.00	0.01	0.78	0.01	0.00	<0.01
Path a: Association between Neighborhood Racial Composition Indicators and Ethnic Discrimination	-0.24	0.36	0.51	-0.00	0.08	0.96

Path b: Association between Ethnic Discrimination and AL	0.00	0.03	0.87	0.01	0.03	0.83
Path c': Association between Neighborhood Racial Composition Indicator and A.L. accounting for Ethnic Discrimination	-0.00	0.01	0.81	0.02	0.00	<0.01

Note: M: Mediators. All models were adjusted for age category, race, sex, poverty status, physical activity, neighborhood deprivation index, baseline allostatic load, and smoking. The interaction between neighborhood composition indicator and sex was accounted for in paths c and c' for percent Black/African American.

Table 4-16. Tests of indirect effects of neighborhood Ethnic Discrimination, including an interaction with neighborhood social environment on the direct relationship between neighborhood racial composition and allostatic load among HANDLS participants

		Racial Isolation			**Percent Black/African American**		
		Beta	S.E.	p-value	Beta	S.E.	p-value
Path a:	**Path b:**						
Low Social Environment	Low Social Environment	-0.00	0.00	0.62	0.00	0.00	0.92
Mean Social Environment	Low Social Environment	-0.00	0.00	0.57	0.00	0.00	0.87
High Social Environment	Low Social Environment	-0.00	0.00	0.73	0.00	0.00	0.88
Low Social Environment	Mean Social Environment	-0.00	0.00	0.51	0.00	0.00	0.89
Mean Social Environment	Mean Social Environment	-0.00	0.00	0.50	0.00	0.00	0.84
High Social Environment	Mean Social Environment	-0.00	0.00	0.69	0.00	0.00	0.85
Low Social Environment	High Social Environment	-0.00	0.00	0.66	0.00	0.00	0.92
Mean Social Environment	High Social Environment	-0.00	0.00	0.63	0.00	0.00	0.88
High Social Environment	High Social Environment	-0.00	0.00	0.75	0.00	0.00	0.88

Percent Black/African American as a Mediator

The following ecological models test whether the proportion of a neighborhood that is Black or African American mediates the relationship between HOLC Score and allostatic load over time (Table 4-17). Percent Black/African American was significantly indirectly associated with allostatic load via neighborhood racial composition for females, but not males (β= -0.11, p=0.02; β= -0.05, p=0.08, respectively) (e.g., percentage Black/African American) adjusting for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, the interaction between sex and percent Black/African American, baseline allostatic load, and household poverty status (Table 4-18). Higher HOLC score was significantly associated with decreases in percent Black/African American (β= -9.84, p=0.00) (Table 4-17). Higher percent Black/African American was positively and significantly associated with allostatic load (β= 0.01, p=0.02) (Table 4-17). Percent Black/African American was not significantly associated with allostatic load (path c' [direct effect] and path c [total effect]) (Table 4-17).

Table 4-17. Tests of direct effects of HOLC Score on allostatic load and test of neighborhood percent Black/African American as a mediating pathway among HANDLS participants.

	M: % Black		
	beta	S.E.	p-value
Path c: Association between HOLC Score and AL	-0.07	0.08	0.39
Path a: Association between HOLC Score and percent Black/African American	-9.84	1.29	0.00
Path b: Association between % Black and AL	0.01	0.00	0.02
Path c': Association between HOLC Score and A.L. accounting for percent Black/African American	-0.04	0.08	0.59

Note: M: Mediators. All models were adjusted for age category, race, sex, poverty status, physical activity, neighborhood deprivation index, baseline allostatic load, and smoking. Path b included an interaction between percent Black/African American and Sex.

Table 4-18. Tests of indirect effects of percent Black/African American on the direct relationship between HOLC Score on allostatic load by sex among HANDLS participants.

	Indirect Effect		
	beta	S.E.	p-value
Female	-0.11	0.05	0.02
Male	-0.05	0.03	0.08

Results from models testing whether the proportion of a neighborhood that is Black or African American mediates the relationship between HOLC Score and indicators of neighborhood socioeconomic status are shown in Table 4-19. HOLC score was significantly indirectly associated with indicators of neighborhood socioeconomic status (e.g., neighborhood deprivation, the percent of families in poverty, and median home value) via neighborhood racial composition (e.g., percent Black/African American) adjusting for age category, race, sex, physical activity, smoking status, neighborhood deprivation index, the interaction between sex and percent Black/African American, baseline allostatic load, and household poverty status (paths ab = -0.74, p= <0.01; -1.72, p= <0.01; -7,548, p= <0.01, respectively) (Table 4-20). Higher HOLC score was negatively associated percent Black/African American (β= -9.90, p=<0.01) (Table 4-19). Higher percent Black/African American was positively associated with neighborhood deprivation (β= 0.07, p=<0.01) and the percent of families in poverty (β= 0.18, p=<0.01), but negatively associated with median home value (β= -763.13, p=<0.00) (Table 4-19). Percent Black/African American was significantly associated with allostatic load, except for path c' for median home value (path c' [direct effect] and path c [total effect]) (Table 4-19).

Table 4-19. Tests of direct effects of HOLC Score on indicators of neighborhood socioeconomic status and test of percent Black as a mediating pathway among HANDLS participants.

	Path c: Association between HOLC and SES Indicator			**Path a: Association between HOLC and % Black**			**Path b: Association between % Black and Neighborhood SES**			**Path c': Association between HOLC and SES Indicator accounting for Mediator**		
Outcome	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
Neighborhood Deprivation	0.78	0.14	<0.01	-9.90	1.27	<0.01	0.07	0.00	<0.01	1.52	0.10	<0.01
% of Families in Poverty	5.97	0.41	<0.01	-9.90	1.27	<0.01	0.18	0.01	<0.01	7.68	0.36	<0.01
Median Home Value (in $)	8,378 .00	3,064	0.01	-9.90	1.27	<0.01	-762.13	61.88	<0.01	829.96	2,971.08	0.78

Note: M: Mediators. All models were adjusted for age category, race, sex, poverty status, physical activity, neighborhood deprivation index, baseline allostatic load, and smoking. The interaction between sex and neighborhood racial composition indicator was accounted for.

Table 4-20. Tests of indirect effects of percent Black on the direct relationship between HOLC score on neighborhood socioeconomic status among HANDLS participants.

	Indirect Effect								
	Neighborhood Deprivation			**% of Families in Poverty**			**Median Home Value**		
	beta	S.E.	p-value	beta	S.E.	p-value	beta	S.E.	p-value
Indirect Effect	-0.74	0.10	<0.01	-1.72	0.23	<0.01	7,548	1,146.32	<0.01

4.6 **Discussion**

This chapter engaged six research questions about potential pathways linking neighborhood racial composition to allostatic load over time. These included: 1) Whether longitudinal associations between neighborhood racial composition and allostatic load vary by individual-level demographic characteristics, including race, age, and sex; 2) Whether longitudinal associations between neighborhood racial composition and allostatic load are mediated by perceived ethnic discrimination; 3) The extent to which individual self-reports of neighborhood social environment mediates associations between indicators of neighborhood racial composition and allostatic load; 4) the extent to which self-reports of neighborhood social environment moderates the mediating effect of perceived ethnic discrimination on associations between neighborhood racial composition and allostatic load over time; 5) Whether neighborhood racial composition (percent Black) mediates associations between HOLC Score and allostatic load; and 6) Whether neighborhood racial composition (percent Black) mediates associations between HOLC Score and neighborhood socioeconomic status indicators. Below I discuss the findings from these analyses and consider their implications for future research and public health practice.

First, after adjusting for relevant socio-demographics, neighborhood racial composition is not associated with allostatic load, and this association does not differ by race or age but by sex, with increasing Black/African American concentrations being associated with increased allostatic load for women but not men. Second, neither index of racial composition predicted ethnic discrimination, and ethnic discrimination did not significantly predict allostatic load. Third, neighborhood racial composition predicts the density of religious and civic organizations within a census tract, but these organizations do not mediate associations with allostatic load. Fourth, perceived social environment did not modify the lack of a mediating effect of ethnic discrimination on associations between indicators of neighborhood racial composition and allostatic load. Fifth, percent Black/African American mediated associations between HOLC score and allostatic load for women, but not men. Lastly, percent Black/African American significantly mediated associations between HOLC score and indicators of neighborhood socioeconomic status.

Neighborhood Racial Composition and Allostatic Load

This dissertation builds upon existing work by explicitly examining whether associations between neighborhood racial composition and allostatic load vary by race, sex, and age. Prior studies examining the effect of racial segregation (measured by dissimilarity and normalized exposure indices) on allostatic load found that female gender was associated with higher allostatic load using data from NHANES (Bellatorre et al., 2011). Our work extends the findings by Bellatorre and colleagues by highlighting an additional measure of neighborhood racial composition – the proportion of the census tract that identifies as Black/African American - that is significantly associated with allostatic load among women in a regional-based biracial, urban cohort.

While there appears to be limited research explicitly examining the relationship between neighborhood racial composition and allostatic load over time, existing studies examine other cardiometabolic indicators that are components of allostatic load scores. However, Ballatorre and colleagues (2011) examined whether racial residential segregation, measured by a dissimilarity index and normalized exposure index, is related to allostatic load using National Health and Nutrition Examination Survey data. Their result indicated a significant positive association between each of these indicators and allostatic load only after adjusting for sociodemographics, medication usage, and physical activity (Bellatorre et al., 2011).

The links between neighborhood racial segregation with other cardiometabolic indicators appear to be mixed. For example, using data from the National Health and Nutrition Examination Survey (NHANES), Kershaw and colleagues examined associations between racial residential segregation and obesity (Kershaw et al., 2013). In both unadjusted and adjusted models, Kershaw et al., 2013 did not find a significant relationship between racial segregation and obesity among Black men but found a positive association between racial segregation and obesity for women. The findings from this article are congruent with other national studies that suggest that racial segregation is positively associated with weight status; however, these studies did not stratify their results by sex (Chang, 2006; Corral et al., 2012). However, Li et al. examined the relationship between the percentage of Black/African Americans in a census tract and obesity using data from participants in southeastern Pennsylvania. Their race-stratified models suggest no associations between neighborhood racial composition and obesity for black men, black women, and white men, but there was a positive association for white women (K. Li et al., 2014). My finding that associations between the percentage of a census tract that is Black/African American and allostatic load differed by gender are consistent with results presented by Li et al., although I did not find a significant difference by race or age. Future studies with larger sample sizes should consider examining three-way interactions between measures of racial composition, sex, and race to more clearly understand the relationships between these variables.

My investigation suggested that the relationship between two measures of racial composition and allostatic load over time did not vary by race. This finding is supported to a certain extent by existing literature. For example, Kirby and colleagues (2012) examined associations between the percentage of a census tract that is Black/African American and BMI and obesity using data from the Medical Expenditure Panel Survey. After adjusting for individual and neighborhood-level covariates, these authors did not find associations between any racial/ethnic group and BMI (Kirby et al., 2012). While this article did not assess whether associations between neighborhood-level racial composition and allostatic load vary by race, these results shed insight into potential associations between these variables. These findings are also supported by White and colleagues (2011) who found a null association between a spatial isolation index and self-reported hypertension for U.S.-born Blacks and younger foreign-born Blacks but found a negative association for older foreign-born Blacks (White et al., 2011). Gebreab and Diez Roux, using county-level age-adjusted coronary heart disease mortality rates for Blacks and whites in the United States between 1996 and 2006, reported inverse associations between a Black isolation index and age-adjusted coronary heart disease mortality within the U.S. for Blacks but found no association for whites (Gebreab & Diez Roux, 2012). Kershaw and colleagues also examined associations between a Black isolation index and hypertension using data from NHANES. After adjusting for individual and neighborhood level covariates, they found racial differences in these relationships—specifically, increases in the Black isolation index -- were positively associated with hypertension for Blacks. Similar to the Gebreab and Diez Roux study above, no association was found for whites (Kershaw et al., 2011). The differences in findings could be due to various reasons, including the fact that some of these studies use national cohorts and include various cardiometabolic indicators. These findings suggest that different measures of neighborhood racial segregation, different outcome variables, and different samples may influence the findings reported.

Further, my analyses did not find that associations between neighborhood racial composition and allostatic load vary by age category. These findings differ from existing literature that considers the role of age in these relationships. For example, using data from the National Longitudinal Mortality Study, Jackson and colleagues (2000) examined associations between racial residential segregation and racial differences in mortality. Their findings suggest that increases in the proportion of Black residents were positively associated with mortality among Black men between 25 and 44, non-Black men and women between 45 and 64, and Black women older than 65. Further, Inagami and colleagues (2006) examined associations between neighborhood racial composition and mortality rates among people in New York City. Living in predominately Black neighborhoods was positively associated with mortality among women of all ages and Black men over 65 years old. However, after controlling for neighborhood-level high school graduation rate, unemployment rate, and poverty levels, neighborhoods with higher concentrations of Black residents were associated with lower all-cause mortality among Blacks 65 and older. Using national data, Greer and colleagues (2014) examined the ecological relationship between a Black isolation index and age-adjusted heart disease and stroke mortality (2014). After adjusting for county-level covariates, there was a positive association between black isolation and heart disease for older whites and for Blacks, regardless of age. No association was found for younger whites (S. Greer et al., 2014). For stroke mortality, there was a positive association between racial isolation and stroke among younger adults, but no relationship was found among older adults or younger whites (S. Greer et al., 2014). On a more granular level, Greer and colleagues (2011) examined relationships between spatial black isolation and age-adjusted stroke mortality rates among residents of Atlanta , GA. Adjusting for neighborhood-level covariates, there was a positive association between these relationships only for adults 35-64 years old but not for those 65 and older (S. Greer et al., 2011). It is plausible that the absence of an interaction between age and neighborhood racial composition in this analysis could be attributed to regional differences in the effect of neighborhood segregation and allostatic load despite regional differences in these associations have not been tested in the literature to my knowledge. These findings suggest the need for more granular examinations of these relationships. Specifically, studies employing city or metropolitan area level datasets would allow comparisons of region-specific variations and contextual factors underlying these relationships.

Ethnic Discrimination as a Mediator

Mediation analyses indicated no significant indirect effect of ethnic discrimination on the associations between either of the measures of neighborhood racial composition and allostatic load. Thus, the findings reported here are inconsistent with the hypotheses that associations between measures of neighborhood racial composition and allostatic load are mediated or explained by differential exposure to ethnic discrimination.

The finding that neither the Racial Isolation index nor the percentage of residents of a census tract that identified as Black/African American were associated with perceived ethnic discrimination is at odds with existing theoretical frameworks explicitly proposing linkages between these factors among African American populations (Clark et al., 1999; Harrell, 2000). For example, scholars have suggested that community contexts (i.e., racial/ethnic characteristics) shape interpersonal relationships, with implications for the mental health and well-being of the residents within (Burton & Jarrett, 2000; Gee & Payne-Sturges, 2004; Leventhal & Brooks-Gunn, 2003). Using data from the HANDLS study, English and colleagues (2014) examined associations between neighborhood racial composition and depression and whether these were mediated through perceived racial discrimination. Their findings suggested that racial discrimination was highest among men and older adults and that the percentage of whites in a neighborhood was positively associated with experiences of discrimination for African American participants (English et al., 2014). In contrast, Dailey and colleagues (2007) reported that among African American women, increases in the percentage of African Americans in a census tract were associated with decreased racial discrimination experiences (Dailey et al., 2010; Hunt et al., 2007). The mechanisms between neighborhood racial composition and discrimination are different for men. Further, Bellmore and colleagues (2012) found that among adolescents, those in moderately diverse settings experienced the highest levels of ethnic discrimination. Future research is needed to parse out these complex associations further. Specifically, future research could tailor questions around Ethnic Discrimination to focus on discrimination experiences at the neighborhood level. While existing literature has established a mediating pathway among these variables, there could be some reasons as to why these associations were not significant within this sample. For example, it could be that discrimination could operate differently based on race. Also using the HANDLS dataset, English and colleagues found that increases in the white population within a neighborhood was positively associated with racial discrimination for African Americans. In this dissertation chapter, these pathways were not examined by race, did consider the role of physical activity and neighborhood socioeconomic status, which could have obscured the potential concordance of results with the English and colleagues (2014) examination.

The findings reported in this analysis were inconsistent with the hypothesis that associations between neighborhood racial composition and allostatic load are mediated through perceived ethnic discrimination. These findings may suggest that the effects of racial isolation or concentration of Black/African Americans in a census tract on allostatic load operate through different mediating pathways. The potential variety of locations where discrimination could occur (e.g., workplace) could be an important factor in the absence of significant associations between neighborhood racial composition and perceived ethnic discrimination.

Evidence for associations between discrimination indices and allostatic load is mixed . Using data from the Midlife in the United States II Biomarker Project, researchers examined associations between discrimination and allostatic load among middle-aged adults. After adjusting for socioeconomic status, health behaviors, medication usage, and additional psychosocial factors, African Americans and whites in the highest tertile of pervasive discrimination had higher allostatic load scores. While not explicitly related to my research questions, this finding is consistent with the results presented in this dissertation that ethnic discrimination was independently associated with allostatic load. This finding is also consistent with the theoretical model of fundamental cause in that it suggests that the effect of racism on allostatic load operates through multiple pathways, including structural-level, neighborhood-level, and interpersonal level. However, the effects of these relationships were stronger among African Americans than whites

(Van Dyke et al., 2020). These authors note that initial stressors associated with discrimination could lead to secondary stressors where African Americans may not have as many resources as whites to manage these additional stressors, which results in increased allostatic load (Pearlin et al., 2005; Van Dyke et al., 2020; Williams & Mohammed, 2009). Also, it could be that African Americans who are subjected to higher discrimination are also likely to develop increased levels of vigilance and anticipatory stress, which could also be linked to health (Lewis et al., 2015, 2019). Cuevas and colleagues (2019) examined associations between two discrimination scales and allostatic load using Boston Puerto Rican Health Study data. After adjusting for sociodemographic and health behaviors, lifetime discrimination was positively associated with allostatic load, while everyday discrimination was not associated with allostatic load adjusting for covariates (Cuevas et al., 2019). Other research also support these positive findings between indices of discrimination (Currie et al., 2019; Ong et al., 2017; Upchurch et al., 2015a; Zilioli et al., 2017). While I did not find a significant association between Ethnic Discrimination and allostatic load, Ethnic Discrimination was also not a significant mediator of associations between neighborhood racial composition and allostatic load. The finding that Ethnic Discrimination may not be a mediator within this sample suggests that additional characteristics (e.g., social support, loneliness) may not be accounted for in our models. However, future research is needed to continue to parse out these relationships and how they may vary on a more granular scale by region within the United States.

Perceived Neighborhood Social Environment as a Mediator

My mediation analyses contribute to existing research by explicitly examining the mediating effects of perceived neighborhood social environment on associations between neighborhood racial composition and allostatic load. My analysis tested the extent to which neighborhood social environments mediated associations between neighborhood racial composition and allostatic load over time. I found that associations between the Racial Isolation index and perceptions of the neighborhood's social environment were insignificant. I also found an insignificant association between neighborhood social environment and allostatic load controlling for covariates. Direct associations between the Racial Isolation index and allostatic load remained insignificant when the mediator was included in the model. In models exploring percentage Black, I found that this was negatively associated with the neighborhood social environment, but this association was insignificant. The association between neighborhood social environment and allostatic load was positive but not significantly associated with allostatic load. Direct associations between percentage Black and allostatic load were significant and remained significant when the mediator was included in the model.

Neighborhood social environment did not significantly mediate associations between allostatic load and either indicator of neighborhood racial composition. Existing literature on relationships between neighborhood racial composition and health outcomes appears to be mixed. For example, some studies have suggested that increases in the proportion of African Americans within a neighborhood are associated with a variety of outcomes, including higher mortality and poorer self-reported health (S. T. Bird, 1995; Cooper et al., 2001; Deaton & Lubotsky, 2003; McLaughlin & Stokes, 2002; White & Borrell, 2006). Additional research is needed to continue to parse out the mechanisms through which neighborhood racial composition is associated with perceived neighborhood social environments. Using data from a cohort of African American adolescents in an urban area, researchers examined the associations between neighborhood racial composition and social support, among other variables. Their analyses suggest that higher proportions of African Americans within a neighborhood were positively associated with cumulative social support and neighborhood cohesion (Hurd et al., 2013). Hurd and colleagues reported that increasing proportions of Blacks at the census tract level and those with residential stability were associated with higher social support and more favorable perceptions of neighborhood social cohesion. In turn, levels of social support were negatively associated with depression and anxiety symptomology (Hurd et al., 2013), suggesting that pathways between neighborhood racial composition and depression and anxiety symptomology are indirectly associated with perceptions of social support and neighborhood cohesion. While the Hurd analysis examined depression and anxiety symptomology rather than allostatic load, their findings are relevant for allostatic load as an indicator of physiologic response to chronically stressful life conditions. Specifically, these findings are relevant because social support and neighborhood cohesion help buffer or reduce adverse effects of other exposures (i.e., built environment) that are associated with racial residential segregation. These studies highlight that increasing proportions of Black/African American residents at the census tract level may operate in two potentially opposing ways, 1) increasing stressors (e.g., associated with systemic disinvestment from Black communities), and 2) increasing social support and potentially neighborhood social cohesion. With this in mind, I may not be able to detect a significant association between neighborhood racial composition indicators and allostatic load if social support or neighborhood social cohesion are not considered in the models. However, since I am using a measure of the neighborhood social environment as a proxy for social support, the results presented in this dissertation may differ from those reported by Hurd and colleagues.

This highlights some of the neighborhood-level factors that may be operating, that inform and shape an individual's interaction with the environment, and directly impact health and wellbeing. Social support is a concept thought to benefit individuals through collective action, promoting health behaviors through social control and normative behaviors, increasing feelings of well-being, improving access to resources, and increasing race-based solidarity. Accordingly, I would anticipate a protective effect of social support on allostatic load (Cattell, 2001). This finding could also be attributed to the fact that people who live in neighborhoods with higher levels of social disorder have poorer perceptions of their neighborhood social environment.

Given this hypothesis, living in a neighborhood with large proportions of African Americans in the HANDLS context would be associated with more favorable neighborhood perceptions about social support. Having more favorable perceptions of neighborhood social environments was associated with increased allostatic load although the association was not significant. My results differ from results reported by others on the topic. For example, associations between African American concentration within neighborhoods and social support have been previously established (Boswell & Stack, 1975; Boykin et al., 1997; Klaw et al., 2003; P. Stewart, 2007) and generally interpreted as resulting from higher levels of communalism and intergeneration relationships in predominantly Black neighborhoods. While depression and anxiety are not measures of allostatic load, there is evidence to suggest that depression is an independent risk factor for cardiovascular diseases (Alesci et al., 2005; Andrews et al., 2020; Danesh et al., 1997; Dawood et al., 2007; Leo et al., 2006; Maes et al., 1995; Miller et al., 2002; Saran et al., 2012; Sims et al., 2015). I did not find evidence of a mediation effect, although direct associations between percentage Black and allostatic load were significantly associated. Despite theoretical associations and some empirical literature suggesting that social support mediates associations between neighborhood racial composition and some mental health indicators by social support, the models examined here did not find a significant mediating effect of neighborhood social environments on associations between neighborhood racial composition and allostatic load. The lack of finding a significant effect could be attributed to the fact that this dissertation uses perceived neighborhood support as a measure of social support. It could be the case that neighborhood perceptions of social support may operate differently as a mediator than reports of individual-level perceived social support.

Social Institutions as Mediators

My mediation analyses did not find a statistically significant indirect effect of neighborhood social organizations on associations between neighborhood racial composition and allostatic load. For the purposes of this dissertation, religious and civic organizational density are used as additional indicators of potentially supportive social environments. Associations between perceptions of racism and health outcomes have been moderated by a series of factors, including participating in social activities (Whitbeck et al., 2002) and engaging in religious support (Bowen-Reid & Harrell, 2002; Finch & Vega, 2003). The insignificant indirect effect, regardless of neighborhood social institution type, may suggest that despite the presence of social institutions within the neighborhood, people may not be actively using these resources. It could also be that people are utilizing social institutions outside of their neighborhood. However, any positive health effects experienced are insufficient to protect against the adverse health impacts of racial isolation (such as economic disinvestment). Each of the outlined potential causes could dampen the relationships I measure in this chapter. It is also interesting to highlight that increases in the Racial Isolation Index were negatively associated with religious organization density while positively, but only marginally insignificantly, associated with the density of civic organizations.

Conversely, increases in percentage Black were associated with increased religious organization density while negatively associated with civic organizations. This finding is supported by existing research noting that Black communities have higher densities of churches than white neighborhoods (Pegram et al., 2016) and that this high density can be attributed to churches being local social institutions that could address community problems (Pegram et al., 2016). Since percentage Black is scored where increases on this index are associated with increases in the proportion of Blacks within a census tract, our data supports the work of Pegram et al. It could also be the case that increases in percentage Black could also suggest the clustering of Black/African Americans within a community, potentially providing more social support and engagement within these religious organizations. Further, the analysis suggests that Racial Isolation Index score was positively associated with civic organizations. In contrast, increases in percentage Black were associated with decreases in civic organizations could highlight the differential experiences and access to civic engagement that Blacks and whites have historically had within the United States, whereby whites have had a linear engagement (Rich, 2015). At the same time, Blacks/African Americans have faced institutional barriers to the linear engagement that whites have had (Rich, 2015). Given these findings, it could suggest that due to a more truncated history of civic organizations, communities with higher proportions of Black/African Americans have fewer opportunities to engage with civic organizations within their communities (Rich, 2015). The differences in how the neighborhood racial composition indicators are conceptualized may also be important for understanding the direction of these associations with neighborhood social institutions. For example, the Racial Isolation Index captures how isolated Blacks are from other Blacks within a census tract highlighting the distribution of Blacks within a census tract. On the other hand, percentage Black captures the proportion of a census tract that is Black/African American with no emphasis on the distribution of individuals within the census tract. These findings could also suggest that other pathways, above and beyond these social institutions, are essential in explaining the association between neighborhood racial composition and allostatic load. With this in mind, future research should inquire directly about the resources and locations of social institutions that individuals use, which would expand the network for social institutions beyond just the lived neighborhood to include a participants' activity space. Further, additional research is needed to explore whether there are other psychosocial (i.e., loneliness, depression), economic, political, and structural factors that may also be important mediators of these relationships.

Moderated Mediation of Social Support and Ethnic Discrimination

These analyses found that a) neighborhood racial composition indices were differentially associated with perceived ethnic discrimination, b) the relationship between ethnic discrimination and allostatic load was positively associated with allostatic load, and c) perceptions of neighborhood social environment did not modify either of these pathways. Even with the inclusion of neighborhood social environments as a modifier of these relationships, indirect pathways between neighborhood racial segregation indicators and allostatic load through Ethnic Discrimination were insignificant. To my knowledge, there is limited evidence that examines the moderating role of perceived neighborhood social environment on the mediating role of Ethnic Discrimination on associations between neighborhood racial composition and allostatic load. However, there is existing literature that may help to understand the tested pathways. For example, using data from the Multi-Ethnic Study of Atherosclerosis, Hailu and colleagues (2022) examined whether neighborhood social cohesion moderated longitudinal associations between discrimination and changes in leukocyte telomere length. Their analyses found that neighborhood social cohesion modified associations between discrimination and telomere length controlling for sociodemographics, health behaviors, and health conditions (Hailu et al., 2022). While telomere length is not my outcome of interest, telomere length is a comparable variable to allostatic load, as having shorter telomere length – like allostatic load -- is associated with chronological aging, increased mortality, and morbidity (Sanders & Newman, 2013). While this prior study found a significant interaction, the present study did not find a statically significant interaction between Ethnic Discrimination and neighborhood social environments. However, it can be hypothesized that neighborhoods with high social support/cohesion have resources that reinforce healthy behaviors, facilitate healthy community environments, and increase individuals' sense of connectedness and esteem (Brondolo et al., 2009; Echeverría et al., 2008; Kawachi & Berkman, 2015), which, in turn, may buffer the adverse effects of Ethnic Discrimination on health. Further, living in a neighborhood with higher social cohesion allows individuals to understand and cope with their experiences of discrimination, reducing the toll of these stressful situations on health (Brondolo et al., 2009; Rodney Clark, 2003; N Krieger & Sidney, 1996; Saleem et al., 2018). Living in neighborhoods with lower social support/cohesion is also important to consider, as these stressful neighborhood conditions may magnify experiences of discrimination and exacerbate the physiological response (Hailu et al., 2022; S. M. Lynch et al., 2017; Needham et al., 2014; Thierry, 2020; Yen & Kaplan, 1999). Although I did not find that neighborhood social environments moderated the mediating effect of Ethnic Discrimination on associations between neighborhood racial composition and allostatic load, this may suggest that other psychosocial factors (i.e., direct measures of social support) not considered in this investigation may be more salient mediators of this relationship.

Percentage Black as a Mediator

Mediation analyses found a marginally significant indirect effect of percentage Black on associations between HOLC Score and allostatic load for women but an insignificant effect of these associations for men. The analyses suggested that increased HOLC Score, meaning more redlined, was significantly associated with decreases in contemporary percent Black and that increases in percent Black were associated with a significant increase in allostatic load when the interaction between % Black and sex were included. However, direct associations between historical HOLC scores and allostatic load were not significant and remained insignificant when the mediator was added to the models.

These pathways can be contextualized by findings from the existing literature. Aaronson, Hartley, and Mazumder (2021) examined the effects of HOLC scores on shaping neighborhoods from their enactment until the 2010s. Their analyses found that in 1930, African Americans comprised 14.6% of D graded (least desirable) neighborhoods nationally, but by 1980 the proportion of African Americans in D graded neighborhoods grew to 46.2%. In 2010, thirty years late, this proportion had decreased to 35.7% in 2010 (Aaronson et al., 2021b). Although the results from these analyses show that increases in HOLC score are associated with decreases in the Black/African American population, positive associations between HOLC Score and African American concentration is also supported by other national investigations (J. Richardson et al., 2020). However, between 1930 and 2010, the share of African Americans in A-graded (most desirable) neighborhoods grew from less than 5% in 1930 to roughly 15% in 1980 to roughly 20% in 2010 (Aaronson et al., 2021a). These authors note several potential pathways that could explain these national trends. For example, the low ratings in D-graded neighborhoods could suggest that these neighborhoods are less desirable for all racial/ethnic groups. However, the deleterious conditions within these neighborhoods mixed with limited housing options due to discriminatory practices could have led to the increasing concentrations of racial/ethnic minoritized groups in D-graded neighborhoods.

Another possible explanation is that these associations could be caused by the lack of wealth accumulation and credit opportunities for African Americans. Aaronson and colleagues

(2021) hypothesize that Blacks could have faced additional barriers to obtaining mortgage loans which also limited their housing choices, thus concentrating them into D-graded neighborhoods (Aaronson et al., 2021a). While the finding historically redlined neighborhoods may have increased proportions of Black/African Americans using national samples, the data presented in this dissertation suggest that these associations are paradoxical, whereby increases in HOLC Scores are associated with a decrease in the proportion of Black/African Americans within neighborhoods. These national findings suggest the need to parse these associations to examine regional or even city differences in these proposed associations. Also, there is a need to examine historical trends and perhaps what is happening on a granular level (e.g., census tract or census block group) as examining associations between racial residential segregation and health on the city level may not be able to capture. In a 2019 report, Perry and Harshbarger examined these associations within some of the largest cities within the United States. Relevant to this discussion a) according to 2017 American Community Survey block group data, residents living in formerly redlined areas are more likely to be Latino or Hispanic or White, while Black or African Americans rank as the third highest demographic in these areas, and b) out of the 10 cities with the largest populations in redlined areas, Baltimore ranks tenth with roughly equal shares of African American residents living in redlined and non-redlined areas. Taken together, these findings support the dissertation finding that increases in HOLC Scores are inversely associated with Black population concentrations in Baltimore.

As mentioned earlier in this discussion section, percent Black is positively associated with allostatic load when the interaction between sex and percent Black is included in the models. Testing this mediation pathway, the findings suggest a differential indirect effect of percent Black on associations between HOLC Score and allostatic load by sex, with a marginally significant mediation effect found only for females. It has been noted that sex is relevant to our discussion about neighborhood effects on health as sex shapes how individuals perceive their neighborhoods (E. Bassett & Moore, 2013; Ellaway & Macintyre, 2001), the exposures and intensity of stressors within a neighborhood (E. Bassett & Moore, 2013; Ellaway & Macintyre, 2001), and the social stressors associated with being a female (E. Bassett & Moore, 2013),

The subsequent models examined whether percent Black mediated associations between HOLC Score and three indicators of neighborhood socioeconomic status. In each of the mediation models, percent Black significantly mediated these associations and was significantly associated with an increase in neighborhood deprivation and the prevalence of families in poverty but significantly associated with a decrease in median home value. There is evidence that draws links between these variables. In line with a fundamental cause perspective, Williams and colleagues have suggested that neighborhood racial composition is relevant to health since Black neighborhoods in segregated metropolitan areas are more likely to have poorer access to educational resources and employment opportunities, which have been linked to both concentrated poverty and unemployment (Popescu et al., 2018a; D. Williams & Collins, 2001b; D. R. Williams et al., 2003; D. R. Williams & Sternthal, 2010). Since the neighborhood deprivation index is comprised of indicators around employment, income/wealth, and education, following the fundamental cause perspective, it stands to reason that neighborhoods with increased shares of African Americans would be more likely to have higher deprivation as higher deprivation is a marker of lower socioeconomic status.

The mediation analysis also found associations between percent Black and home value, suggesting that a unit increase in percent Black is associated with an over $750 decrease in median home value. Researchers from the Brookings Institute examined the devaluation of Black homeownership and made four key findings relevant to this discussion: a) in neighborhoods where Blacks comprise 50% or more of the population, values of homes are roughly half of those in neighborhoods without Black residents; and b) homes in neighborhoods with high concentrations of Black/African Americans are valued at much less than neighborhoods with low to moderate concentrations of Blacks even with similar amenities (Perry et al., 2018).

The devaluation of assets based on neighborhood racial composition can be explained by the concept of racial capitalism. Briefly, capitalism is a mode of production based on labor exploitation and the accumulation of value (Heinrich, 2012; Marx, 1909) and was expanded to include a racial lens in the 20th century to suggest that capitalism works through the differential valuation of people, places and things which manifests in either the investment or divestment from these same things (O. C. Cox, 2015; W. E. B. Du Bois, 1935; Hall, 2021; Robinson, 1985). Laura Pulido builds upon the concept of racial capitalism to suggest the importance of relational analysis, as this form of analysis highlights how whiteness and capitalism are intertwined in a manner that relies on the domination and exploitation of nonwhite groups (Pulido, 2017). Ultimately, the differences in the value assigned to things show both who (i.e., whites and whiteness) and what (i.e., home values, neighborhood characteristics) are valuable and this worthy of investment (Hatch, 2016; Mayorga et al., 2022; Reese, 2019).

For the purposes of this examination, I am positing that the government, in tandem with local agents (i.e., urban planners, real estate agents, financial lending institutions), are those responsible for deciding where resources are allocated. Using the racial capitalism framework, investing in a particular neighborhood means that another neighborhood will not be invested in, which emphasizes relational racist logic, further exacerbating socioeconomic inequalities (Mayorga et al., 2022). The association between relational racist logic and neighborhood socioeconomic inequalities and disinvestment also then become cues for what constitutes a “good” or “bad” neighborhood. This process obscures the impact of sustained disinvestment via racial capitalism in creating the contexts appraised as “bad” while more resources are funneled into these “good” neighborhoods (Mayorga et al., 2022). Based on this description, it can be understood that disinvestment in certain neighborhoods, in favor of others, is a mechanism and manifestation of racial capitalism. Taken together, racial capitalism could be one plausible explanation of the negative association between increases in Black residents within a census tract and increased neighborhood deprivation and decreased median home value.

Ultimately, percent Black was the only significant mediator of associations between structural racism on individual health outcomes. Thus, intervening on more proximal factors may be unlikely to change health outcomes, consistent with a fundamental cause approach. Building upon the work of Williams and Collins (2001), in order to eliminate racial health disparities, there needs to be an emphasis on confronting segregation through acknowledging how the discriminatory housing practices within United States history have changed form to operate under new mechanisms contemporarily.

4.7 **Strengths and Limitations**

This study contributes to the literature on associations between neighborhood racial composition and allostatic load over time by explicitly testing different interactions based on demographic factors (i.e., race, age, gender) to explore differential relationships based on these identities. Building upon existing literature, this exploration also explores a variety of potential psychosocial mediators of these relationships. This study is also important as it longitudinally examines associations between neighborhood racial composition and allostatic load over time while exploring different mediating pathways. Further, this chapter has found that percent Black is a significant mediator of associations between HOLC Score and allostatic load as well as neighborhood deprivation, the percentage of families in poverty, and median home value. There are several limitations of this study. For example, I use two specific measures of neighborhood segregation to measure neighborhood racial composition, while other measures may capture the true nature of racial interactions within neighborhoods. There may be other metrics of neighborhood racial composition that may be able to assess these relationships. Due to limitations within the HANDLS dataset, I cannot explicitly measure social support among participants and instead use perceived neighborhood social environments to capture this concept. Future research should examine these relationships using explicit measures of social support or participant information about their use and the location of their preferred religious or civic institutions to determine if these relationships change over time. A considerable number of observations were dropped from the analytical sample due to moves outside of Baltimore City, Maryland, or missing covariates. Consequently, some of the main exposure and mediating variables differ between the included and excluded samples. Specifically, those in the analytic sample have statistically higher scores on the racial isolation index and density of religious organizations while having lower scores on the social environment and the density of civic organizations (Appendix C: Table C5). These sample differences may underestimate the true association between the study variables, and may introduce selection bias into the sample that may affect the results presented here, and also complicate the generalizability of these findings to the broader HANDLS cohort. Future research should capture these associations among those who moved out of Baltimore City to see if these associations hold. Another limitation might be the length of time between the waves of data. For example, the time period between exposure and outcome may be relevant as it may take more than five years before racial composition may be salient for allostatic load and other potential health outcomes. Future research should examine these changes using more extended longitudinal periods to examine if these associations change over time. Furthermore, while I include a variety of social environmental characteristics as mediators, there may be additional psychosocial factors, such as loneliness and isolation, or structural factors, which are not included and may enhance models of these relationships better.

4.8 Implications

Despite the limitations described above, this study makes several important contributions to the literature on neighborhood racial composition of neighborhoods and allostatic load. Findings from this study can inform community-based interventions and advocacy campaigns and inform future research on the role of neighborhood environments on health outcomes and stress processes.

There are a few relevant implications based on these results. Multiple potential mediators were assessed to examine their influence on the causal pathway between neighborhood racial composition and allostatic load. None of these factors, perceived ethnic discrimination, perceived neighborhood social environment, nor the density of religious or civic associations served as significant mediators of this relationship. Existing research emphasizes methodological limitations within the existing literature around neighborhood racial composition and allostatic load, noting that evidence exploring associations between racial residential segregation and health vary based on the geographic unit of analysis (Bailey et al., 2017; Gee & Ford, 2011; Kramer & Hogue, 2009; White & Borrell, 2011; Williams et al., 2019). Further, these challenges are heightened due to the difficulty in disentangling different mediating and moderating variables on hypothesized causal relationships. For example, there is evidence to suggest that neighborhood socioeconomic status (Kramer & Hogue, 2009; White & Borrell, 2011), food environments (Goodman et al., 2018), exposure to hazardous sites (Williams et al., 2019), and lack of medical facilities/healthcare access

(White et al., 2012) may be additional variables that will be important to examine in order to understand pathways between neighborhood racial composition and allostatic load.

The specific finding that perceived neighborhood social environment is not a significant mediator of associations between neighborhood racial composition and allostatic load suggests that intervening on perceptions of neighborhood social environments is insufficient for significantly impacting on allostatic load. It is also important to note that percent Black was a significant mediator of associations between HOLC Score and allostatic load as well as indicators of neighborhood socioeconomic status. This finding is consistent with a fundamental cause theory suggesting that the root or fundamental cause, in this case, percent Black as a proxy for racial residential segregation, needs to be addressed rather than any mediating pathways or modifiable risk factors proximal to health (Phelan et al., 2010). Existing research also suggest that interventions focused on individual health behaviors and outcomes should be comprehensive and identify the upstream, institutional factors that influence individuals (Phelan et al., 2010; Williams & Purdie-Vaughns, 2016; Williams et al., 2019). Applying this to this dissertation chapter, I have identified neighborhood racial composition as a potential upstream factor associated with health. Specifically, associations between increases in the percentage of a neighborhood that is Black/African American is associated with higher allostatic load for women, but not men. Also, percent Black is associated with increases in neighborhood deprivation and poverty and with decreases in median home value. While acknowledging the differential impacts of the adverse effects of living in an area with a high Black/African American concentration by sex is important, other contextual factors that might be important to intervene on could also be related to the neighborhood socioeconomic status conditions of the area as a result of racial capitalism and strategic disinvestment in African American communities. Given that minoritized communities have experienced systematic disinvestment throughout the history of this country, providing equitable investments within these excluded communities while protecting the existing housing stock and housing security among existing residents could be another possible solution to mitigating risk factors for adverse health above and beyond neighborhood racial composition. Evidence has suggested the positive health benefits of providing additional income to lower-income residents (Williams & Mohammed, 2013). Providing these families with extra income such as the Child Tax Credit during the COVID-19 pandemic (K. Cox et al., 2022), funded by local business investments, allowed families to increase their access to formal education while decreasing adolescent deviant behaviors (Akee et al., 2010; Costello, 2010). While these positive benefits have been found on a granular level (i.e., neighborhood), there is a need for these interventions to be tested on a larger scale (i.e., citywide or metropolitan areas) to see if these benefits can be scaled to impact larger populations of historically oppressed populations.

As mentioned earlier, associations between neighborhood racial composition and allostatic load varied by sex, where increases in the proportion of Black/African Americans within a census tract were positively associated with allostatic load for women but negatively associated with men. Similar to the need for interventions that consider the role of structural factors to intervene on, there is also the need to focus on women and why neighborhood racial composition is positively associated with allostatic load among this demographic but not others. Any structural-level intervention intended to impact individual-level health should be assessed for its effectiveness in how it operates for different demographics within a population. The insignificant associations based on race or age group do not deny the potential differential effect that neighborhood racial composition may differentially have for these groups in other contexts.

Finally, based on the findings of this chapter, it is important to understand that it is not the neighborhood racial composition that is important, per se, but rather the economic disinvestment in communities of color that are relevant for health. Racial segregation has been associated with a variety of neighborhood inequities, including restricting socioeconomic mobility (Chetty et al., 2020; Hardaway & McLoyd, 2009), limiting access to high-quality education and primary education completion (Axinn et al., 1997; Bhargava, 2017; Conley, 2001; Goldsmith, 2009; Orr, 2003), restricting employment opportunities (Ihlanfeldt, 1994; H. Li et al., 2013; Ruef & Grigoryeva, 2020; Stoll, 2005), disinvestment by both public and private institutions (Austin Turner & Greene, n.d.), and lowering housing/property values (Akbar et al., 2019; P. Christensen et al., 2020; Perry et al., 2018). These manifold stressful conditions associated with historic economic disinvestment within minoritized communities could be the actual driver of associations between neighborhood contexts and health inequalities above and beyond neighborhood racial composition.

Future research should also continue to investigate these pathways using different and more specific psychosocial factors. For example, the ethnic discrimination measure is general, whereas these questions should be tailored to reflect exposures to ethnic discrimination on the neighborhood level to capture neighborhood-level exposures better. Additional research is needed to examine interactions between age, race, and sex to understand better how neighborhoods matter differently based on intersectional identities. A more granular understanding of how and why these relationships matter for different groups can be an important and valuable tool for future activism by providing more specific data about how these relationships work within a specific community. Further, additional research should explore specific neighborhood factors that are stressors—

without considering context-specific stressors, some of the true associations between these indicators may be masked.

As the literature has mentioned, and the results of this chapter have suggested, racial residential segregation has many adverse health outcomes. In sum, this study extends our understanding of how institutional racism impacts individual-level outcomes through a series of mechanisms that shape the neighborhood's built and social environment that individuals are exposed to.

Chapter 5 : Conclusion

The analyses conducted for this dissertation investigated whether historic redlining is associated with contemporary levels of allostatic load among current residents of Baltimore, Maryland neighborhoods, and tested several potential. mechanisms through which historic redlining may have shaped subsequent neighborhood contexts and associations with allostatic load for current residents. This investigation is grounded in several explicit theories about the role of racism in shaping health, and ways those effects may differ by individual demographic characteristics. In it, I sought to confirm and test new relationships among a bi-racial urban cohort, going beyond national cohort data and building upon work done in other locales. Building upon these theoretical frameworks and gaps within the literature, three quantitative papers examined the role of historic redlining, census tract level neighborhood socioeconomic status, and neighborhood racial composition in shaping contemporary variations in allostatic load. Figure 1 highlights the specific pathways that were tested. Pathways are color-coded to indicate significant (green), or insignificant (red) relationships found in the models presented in the corresponding chapters.

In this chapter, following a brief summary of findings from each empirical chapter, I discuss how the findings from each chapter are relevant for the existing literature and how they contribute to our understanding of these phenomena.

Dissertation Summary

In Chapter 2 (Historic Redlining and Contemporary Disparities in Allostatic Load in Baltimore, Maryland), I examined associations between historic HOLC scores and contemporary allostatic load scores among participants in the HANDLS study (Wave IV) (Path 1), whether associations between race and allostatic load were mediated by HOLC scores, and whether neighborhood socioeconomic status mediated associations between HOLC scores and allostatic load (Paths 1, 2, and 3) (Figure 1). HOLC scores were assigned based on weights reflecting the proportion of a census tract represented by specific HOLC categories. Higher scores indicate that a greater proportion of the census tract was formerly redlined. For example, a census tract that had a majority of its area redlined, with some yellow and blue areas, would have a lower HOLC score compared to a census tract whose entire area was redlined with no other color assignment. I found that historic HOLC scores were positively associated with allostatic load. That is, current residents living in census tracts with larger proportions of previously redlined areas were more likely to have higher allostatic load scores compared with those living in areas with lower HOLC scores. Associations between HOLC scores and allostatic load are significantly steeper for persons in the 55-64 age group as compared to those in the 35-44 age group. These associations also varied by race (increases in HOLC scores were associated with greater allostatic load for whites but not African Americans) (Path 1). Mediation models found that individual-level race was associated with neighborhood-level HOLC scores and that HOLC scores positively predicted allostatic load with stronger mediation effects being found among whites. Additional mediation models found that the neighborhood deprivation index (a proxy for neighborhood socioeconomic status) mediated associations between HOLC score and allostatic load (Paths 2 and 3).

To my knowledge, this study is the first to examine associations between HOLC scores and allostatic load and contributes to a growing literature suggesting that historic HOLC scores are associated with contemporary health markers. Testing associations between HOLC scores and allostatic load goes beyond the existing literature by establishing relationships using a measure of stress as a precursor to the development of cardiovascular diseases. This approach may identify clinical markers as intervention points before the development of adverse cardio or cerebrovascular events. These findings are important as they highlight the lasting impact of historic home lending policies – a structural manifestation of racism - in shaping the health and well-being of contemporary community residents decades after those policies have been rescinded.

The association between HOLC scores, from the early 1900s, and allostatic load is observed for contemporary residents of Baltimore neighborhoods. However, it is important to note that the majority of current residents were not present when these neighborhoods were assigned HOLC scores over 80 years ago. Essentially, findings from this dissertation join a growing body of literature suggesting that historical policies have important implications for more recent generations of residents. HOLC scores and redlining were instrumental mechanisms associated with targeted community disinvestments (i.e., limited housing stock, poorer quality of existing housing stock, restricted access to finances to improve housing quality) that shaped neighborhood poverty conditions (Taylor, 2019). Further, HOLC scores mediated associations between race and allostatic load. This suggests that racialized groups are differentially sorted into different HOLC categories. HOLC scores then predict the allostatic load of people who live in these neighborhoods which suggests that race is not a biological construct, but that racial differences reflect the effects of structural racism on health outcomes. Given that there was a stronger relationship for whites than African Americans, it will be important to conduct additional studies examining this finding. It may reflect the clustering of white respondents in the HANDLS sample in yellowlined neighborhoods, with relatively fewer in green, blue and redlined neighborhoods: Thus, an artifact of the HANDLS sample. It may also suggest that there are other factors beyond HOLC score (i.e., neighborhood policy, interpersonally mediated discrimination, supportive social relationships etc.)

that speak to the lived realities of African Americans within the sample compared to whites. Further, it is important to emphasize that African Americans had higher HOLC scores than whites, and it is the interaction between HOLC score and race that was stronger for whites than African Americans. This chapter's findings join a growing body of literature that highlights associations and specific linkages between historic discriminatory lending practices and contemporary unequal patterning of health across geographic areas.

In Chapter 3 (From Streets to Stress: Longitudinal Pathways between Neighborhood Socioeconomic Status and Allostatic Load), I examined: a) associations between four measures of neighborhood socioeconomic status (a neighborhood deprivation index, the percentage of families in poverty, median home value, and the percentage of people without a bachelor's degree) and allostatic load over time, and whether these varied by age, race, sex, and household poverty status (Path 3); b) whether associations between neighborhood socioeconomic status and allostatic load remained significant after accounting for physical activity; and c) whether neighborhood perceptions mediate associations between measures of neighborhood socioeconomic status and allostatic load over time (Paths 4, 5, 6, 7, 8, and 9) (Figure 1). Results from analyses of differences in associations between neighborhood socioeconomic status and allostatic load by demographic characteristics included several significant interactions. Specifically, I found that both census tract level neighborhood deprivation index and neighborhood poverty and allostatic load were significantly stronger for those between 65 and 76 years old compared with those aged 35-44 (Path 3). In addition, the percentage of families in poverty was inversely associated with allostatic load for African Americans, but positively associated with allostatic load among whites. Specifically, allostatic load was on average higher for African Americans than for whites, but African Americans living in neighborhoods with low poverty have higher allostatic load scores than whites with low poverty until the neighborhood poverty concentration reaches around 25%. In neighborhoods with a poverty concentration greater than 25%, increases in neighborhood poverty is positively associated with allostatic load for whites, while negatively associated with allostatic load for African Americans. The associations between census tract level neighborhood deprivation index and the percentage of families in poverty and allostatic load were inversely associated with allostatic load for men but positively associated for women (Path 3). Specifically, men have higher allostatic load scores than women at low levels of neighborhood deprivation. In neighborhoods with a deprivation score around 10, increases in neighborhood deprivation are positively associated with allostatic load for women, while negatively associated with allostatic load scores for men where men have statistically significantly lower allostatic load in neighborhoods with a neighborhood deprivation score of 17. Similarly, men have higher allostatic load scores than women in neighborhoods with low levels of poverty. In neighborhoods with roughly 15% of families in poverty, increases in neighborhood poverty are positively associated with allostatic load scores among women, while negatively associated with allostatic load scores for men where men have statistically significantly lower allostatic load in neighborhoods with 60% of families in poverty than women in the sample. No significant interactions existed between any neighborhood socioeconomic status indicator and whether a family's income was above or below the federal poverty limit.

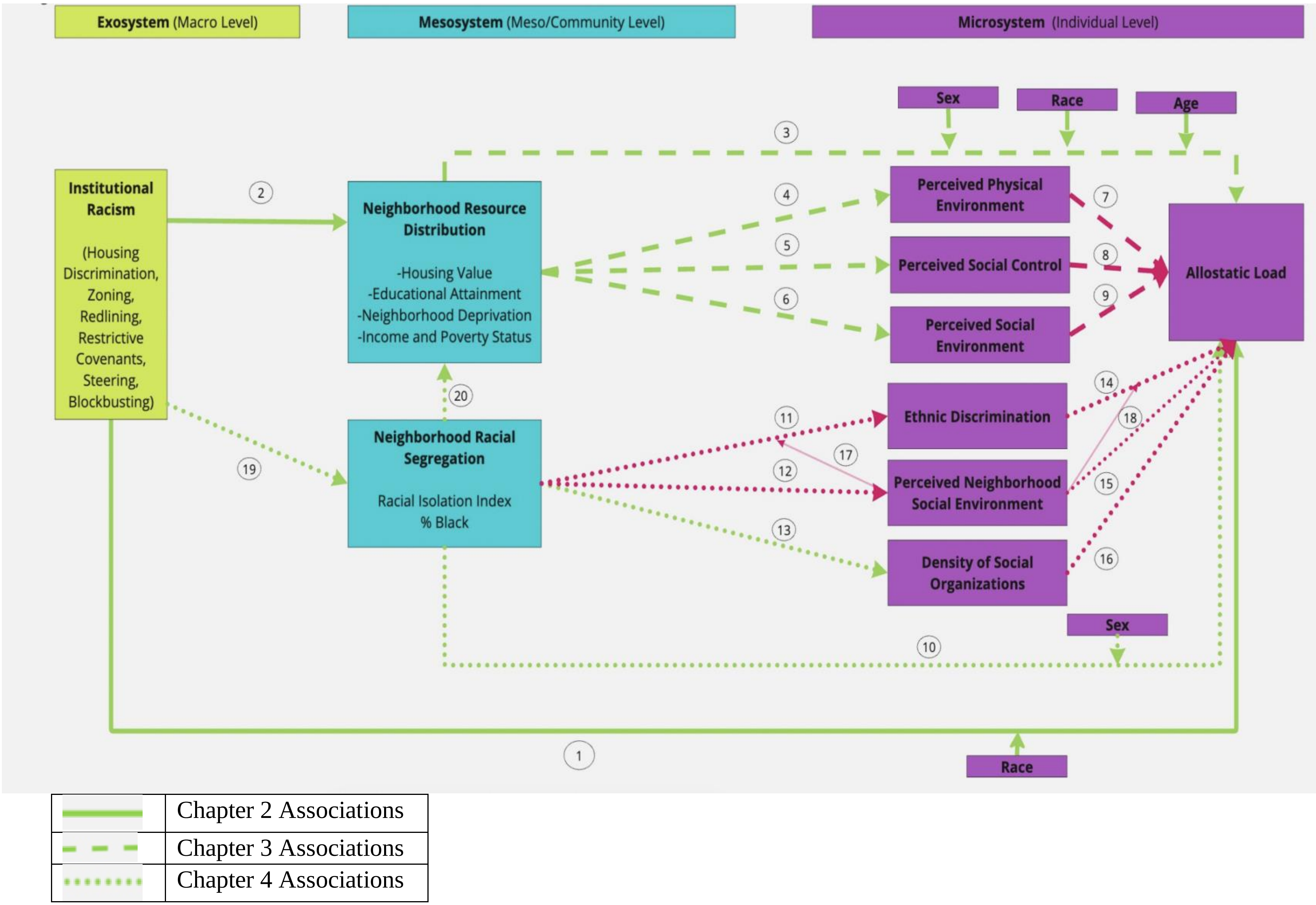
Findings from the tests of potential mediators of the association between the four indicators of neighborhood socioeconomic status and allostatic load were insignificant. Specifically, findings reported in this chapter indicated that physical activity did not significantly attenuate associations between any of the four neighborhood socioeconomic status indicators and allostatic load. Similarly, none of the three indicators of neighborhood perceptions used in Chapter 3 models mediated associations between neighborhood socioeconomic status indicators and allostatic load (Paths 4, 5, 6, 7, 8, and 9).

While the finding that older adults have a significantly different slope than those in the referent group could be supported by the weathering hypothesis (A. Geronimus et al., 2006), the findings by race and sex are somewhat counterintuitive. The specific finding in Chapter 3 that increasing proportions of families living in poverty are positively associated with allostatic load for whites than for African Americans may largely be attributed to the small number of observations of white participants living in neighborhoods with higher poverty. With this limitation in mind, this finding is inconsistent with the weathering hypothesis and the bulk of existing literature. Some may suggest potential explanations for these paradoxical findings by suggesting that African Americans may be shielded from the adverse effects of living in low socioeconomic neighborhoods (Boynton-Jarrett et al., 2008; Christie-Mizell, 2022; Thomas Tobin et al., 2022a). Specifically, Christie-Mizell (2022) explicitly suggests that African Americans are more likely to live in economically disadvantaged areas and that the stigmas associated with living in these areas may be less relevant for their health than for whites. Christie-Mizell (2022) also suggests that African Americans may be less sensitive than whites to the health impacts of neighborhood conditions that do not epitomize the white middle-class trajectory (i.e., employment prestige, educational attainment). These explanations may explain why increased neighborhood deprivation may operate differently for African Americans than whites. Other potential explanations could be that because perceptions of neighborhood environments failed to mediate these associations, there may be differences in how African Americans and whites perceive their neighborhoods. Neighborhood social networks may be a help to buffer the adverse impacts of economic deprivation but is not the sole factor. Factors on the structural level (e.g., neighborhood investment, workforce development, educational funding) may also be important mechanisms to intervene on to bolster the social support networks within these communities. Building upon Christie-Mizell's work (2022), predominantly African American neighborhoods may have social networks and other social factors that are protective for health. To assess the plausibility of the idea that neighborhood-related social support and social factors may be potential pathways that buffer adverse effects of neighborhood socioeconomic context and allostatic load, Chapter 4 tests this specific mediation pathway.

These findings build upon the work of Schulz and colleagues (2013) by examining associations between neighborhood socioeconomic status and allostatic load over time and confirming that neighborhood perceptions are not significant mediators of these associations within this sample. Further, positive associations between both neighborhood deprivation and the percentage of families in poverty and allostatic load for women, while the inverse for men, is supported by literature suggesting that living in neighborhoods with lower socioeconomic status may be more detrimental for women through mechanisms including an increased likelihood of being targeted for violence (Baker & O'Connell, 2022; E. Bassett & Moore, 2013; Stansfield & Doherty, 2019). These findings suggest that neighborhood socioeconomic status may operate differently based on individual race and sex and that they are not explained by the neighborhood perception indicators included in this analysis.

In Chapter 4 (Do your neighbors matter?: Examining associations between Neighborhood Racial Composition and Allostatic Load), I examined whether: a) associations between neighborhood racial composition and allostatic load over time vary by race, sex, and age (Path 10); b) ethnic discrimination and neighborhood social environment mediate associations between neighborhood racial composition and allostatic load (Path Paths 11 and 14); c) the density of

Figure 5-1 Conceptual Model Exploring Multilevel Associations between Institutional Racism and Allostatic load (color-coded by significance)



neighborhood social and civic institutions mediate associations between neighborhood racial composition and allostatic load (Paths 13 and 16); d) neighborhood social environment mediates associations between neighborhood racial composition and allostatic load (Paths 12 and 15); e) neighborhood social environments moderate the mediating impact of ethnic discrimination on associations between neighborhood racial composition and allostatic load (Paths 11, 17, 14, and 18); f) neighborhood racial segregation (i.e., the percentage of a census tract that is Black/African American) mediates associations between HOLC Score and allostatic load (Paths 19 and 10); and g) neighborhood racial segregation (i.e., the percentage of a census tract that is Black/African American) mediates associations between HOLC Score and indices of neighborhood socioeconomic status (i.e., neighborhood deprivation, the percentage of people in poverty, median home value) over time (Paths 19 and 20) (Figure 1).

This study also builds upon analyses conducted in Chapter 2 by examining the longitudinal associations between neighborhood racial composition and allostatic load while also explicitly exploring associations between historical policies (i.e., HOLC designations) and contemporary patterns of racial residential composition and between neighborhood racial composition and indicators of neighborhood socioeconomic status. The analyses for this chapter found that there was a significant and positive association between neighborhood percent Black and allostatic load, but not for the neighborhood racial isolation index, in unadjusted models, suggesting that increases in the proportion of Black/African Americans in a census tract are associated with increased allostatic load over time. Neither indicator of neighborhood racial composition was significantly associated with allostatic load after controlling for individual and neighborhood level characteristics (i.e., age, race, sex, household poverty status, physical activity, smoking status, baseline allostatic load, and neighborhood deprivation). When testing moderations of these associations by demographic characteristics, neither individual-level race nor age were significant moderators of associations between neighborhood racial composition and allostatic load. However, sex was a significant moderator of associations between neighborhood percent Black and allostatic load (Path 10). The proportion of a neighborhood that was Black/African American was positively associated with allostatic load for females but negatively associated for males, suggesting that increases in the proportion of Black/African Americans were associated with lower allostatic load scores among males.

In mediation models, neither perceived ethnic discrimination nor perceived neighborhood social environment significantly mediated associations between neighborhood racial composition and allostatic load (Paths 11, 12, 14, and 15). Also, there were no significant associations between either indicator of neighborhood racial composition and both perceived ethnic discrimination and perceived neighborhood social environment (Paths 11 and 12). Further, neither perceived ethnic discrimination nor perceived neighborhood social environment were associated with allostatic load (Paths 14 and 15). Similarly, the density of neighborhood religious and civic associations did not significantly mediate associations between neighborhood racial composition indicators and allostatic load (Paths 13 and 16). However, neighborhood percent Black significantly predicted the density of social organizations (Path 13), but associations between the density of social organizations and allostatic load were not significant (Path 16). Perceived neighborhood social environments did not moderate the mediating impact of ethnic discrimination on associations between neighborhood racial composition and allostatic load (Paths 11, 17, 14, and 18). Specifically, neither measure of neighborhood racial composition was associated with ethnic discrimination, and ethnic discrimination was not significantly associated with allostatic load (Paths 11, 17, 14, and 18).

Additional models tested mediators of associations between HOLC score and both allostatic load and neighborhood socioeconomic status. Specifically, neighborhood percent Black was a significant mediator of associations between HOLC score and allostatic load for females but not males (Paths 19 and 10). In these models, HOLC score was negatively associated with neighborhood percent Black (Path 19), while neighborhood percent Black was positively associated with allostatic load (Path 10). Ecological mediation models examined whether neighborhood percent Black mediated associations between HOLC score and indicators of neighborhood socioeconomic status (e.g., neighborhood deprivation, the percentage of families in poverty, and median home value) (Paths 19 and 20). Indirect effects found that neighborhood percent Black was a significant mediator of associations between HOLC score and indicators of neighborhood socioeconomic status. Specifically, HOLC score was significantly associated with decreases in neighborhood percent Black (Path 19) but increases in neighborhood percent Black were associated with increases in neighborhood deprivation and the percentage of families in poverty. In contrast, increases in neighborhood percent Black were associated with decreased home value over time (Path 20). Throughout this dissertation, a series of mediators were tested and consistently found that individual-level factors (e.g., ethnic discrimination, perceived neighborhood social environment) were not significant mediators of associations between both neighborhood socioeconomic status and neighborhood racial composition on allostatic load over time, while neighborhood-level factors (e.g., neighborhood socioeconomic status, neighborhood racial composition) were. The differential mediating impact of perceptions of neighborhood contexts in contrast to structural level characteristics is consistent with a Fundamental Cause perspective suggesting that intervening on more proximal factors (i.e., individual psychosocial factors) alone is not enough to change population health outcomes if structural factors (i.e., neighborhood disinvestment and neighborhood racial composition) remain unchecked.

As the other analyses have illuminated, Chapter 4 also suggests that neighborhood characteristics may matter differently based on individual characteristics (i.e., age, race, sex), emphasizing the need for more tailored place interventions that are informed by a nuanced understanding of how place characteristics may be experienced differently by different subgroups, and that are tailored with these differences in mind. It also suggests that there are potentially other forces at play that should be considered. This may include: discrimination that affects the health of African Americans and whose impacts extend beyond neighborhood socioeconomic status; sex-based discrimination/violence that affects the health of women; and workplace policies that differentially affect incomes for African American women and men. Each of these potential pathways warrant further consideration.

This chapter aligns with others in this dissertation in informing our understanding of the long-term impacts of racial residential segregation and redlining on health over time. Residential and housing practices enacted throughout United States history (i.e., mortgage lending discrimination/denial) and discriminatory processes that produced neighborhood disinvestment remain relevant for health decades after they are enacted or even overturned. These relationships highlight the need for considering how the past shapes contemporary issues within neighborhoods.

There is evidence that residents living in formerly redlined areas are more likely to be Latino or Hispanic, or white. However, Black or African Americans rank as the third highest demographic in formerly redlined neighborhoods behind Latinx and white populations (Perry et al., 2018). The racial/ethnic composition of these areas complicates efforts to understand how historic redlining is associated with contemporary patterning of neighborhood racial composition.

The concept of racial capitalism could explain associations between neighborhood racial composition and neighborhood socioeconomic status. Briefly, capitalism is a mode of production that is based on labor exploitation and the differential valuation of people, places, and things. Racial capitalism builds upon this definition by suggesting that this differential valuation highlights the preference assigned to whites compared to non-white groups (O. C. Cox, 2015; W. E. B. Du Bois, 1935; Hall, 2021; Heinrich, 2012; Marx, 1909; Pulido, 2017; Robinson, 1985). The choice to invest in particular neighborhoods (i.e., white) emphasizes the notion that *other* neighborhoods will not be invested in. Choosing not to invest in specific neighborhoods then encodes and signals to others what a "bad" neighborhood is and, accordingly, shapes attitudes regarding subsequent (dis)investment in these spaces (Mayorga et al., 2022).

Discussion

Taken together, the findings presented across the three analytic chapters of this dissertation are reasonably consistent with the theoretical frameworks that guided the analysis. In each dissertation chapter, I examined and tested the nested nature of these relationships. Since people are nested within neighborhoods that are nested within cities, structural level influences such as HOLC Scores are relevant for neighborhood socioeconomic status and neighborhood racial composition. Together, they offer examples of structural forces that have shaped the mesosystems and microsystems (i.e., neighborhood perceptions and perceived ethnic discrimination) in which individuals live and seek to thrive (U Bronfenbrenner et al., 1984). In addition to these systems, the chronosystem is also relevant to this examination. The chronosystem changes both with the individual and the environments that a person is exposed to. Given this, examining the associations between neighborhood contexts over time and allostatic load highlights the impacts of neighborhood level and individual changes over time in relation to health.

Fundamental Cause Theory

My results are also largely consistent with theoretical frameworks that posit racism or race-based residential segregation as a fundamental cause of health. Williams and Collins (2001) building on the work of Link and Phelan (1995) argue that racial residential segregation is a fundamental cause of racial health disparities. In essence, racial residential segregation shapes the socioeconomic conditions for both Blacks and whites within the United States, shaping inequitable access to resources that an individual may leverage to support health, avoid illness, and/or diminish the impact of disease. These authors also emphasize distinguishing fundamental causes from surface or proximate causes (Link & Phelan, 1995; Williams, 1990, 1997). Surface or proximate causes (in this case factors such as diet and physical activity) are related to outcomes, but changes to these causes are, they argue, unlikely to lead to changes in said outcomes (Williams & Collins, 2001). Interventions focused on changing the surface-level causes are limited in their effectiveness in impacting health (Williams & Collins, 2001). In contrast, fundamental causes (in this case neighborhood racial composition or neighborhood socioeconomic status) are responsible for changing an outcome, and thus, changes in these fundamental causes are related to changes in the specific outcomes (Williams & Collins, 2001).With this in mind, it is important to note that segregation withdraws and diverts resources from predominantly African American communities while allowing these resources to be hoarded within predominately white neighborhoods aligning with the concept of racial capitalism.

This dissertation tested several micro-level associations with allostatic load. For example, mediation pathways in Chapter 3 found that neighborhood perceptions (i.e., perceived physical environment, perceived social control, perceived social environment) were not significantly associated with allostatic load. Similar patterns were found in Chapter 4, where perceived ethnic discrimination, perceived neighborhood environment, and the density of neighborhood social organizations (as an observed proxy for social support) were significantly associated with allostatic load. In Chapters 3 and 4, elements of the mesosystem, which includes identified fundamental causes, were examined. Together these chapters highlight significant associations between both neighborhood socioeconomic status (i.e., deprivation index and percentage of families in poverty) indicators (Chapter 3) and neighborhood racial composition (i.e., percentage Black/African American) indicators (Chapter 4), with allostatic load over time. Neighborhood socioeconomic status, as an indicator of the mesosystem and a fundamental driver of health disparities was positively associated with allostatic load as predicted by Fundamental Cause Theory and Segregation as a Fundamental Cause.

Ecological Model and the Stress Process Model of Neighborhoods

In Chapter 3, significant interactions between allostatic load and neighborhood deprivation and the percentage of families in poverty were found for sex, race, and age. This is consistent with the Stress Process Model of Neighborhoods that posits that different people experience neighborhood exposures differently. In Chapter 4, neighborhood percent Black was significantly associated with allostatic load in unadjusted models. Consistent with Fundamental Cause Theories and the Stress Process Model of Neighborhoods this association was significant in adjusted models when the interaction between neighborhood percentage Black and sex were included in the models. Finally, analyses in Chapters 2 and 4 explored how the exosystem (i.e., HOLC Scores) is associated with allostatic load and several mediating pathways to allostatic load. In Chapter 2, I explicitly test whether HOLC Scores (as a potential proxy for historic racial segregation) are associated with indicators of neighborhood socioeconomic status and whether these socioeconomic status indicators are associated with allostatic load. These analyses found that the HOLC score was positively associated with neighborhood deprivation and the percentage of families in poverty. In turn, neighborhood deprivation and the percentage of families in poverty were positively associated with allostatic load.

Chapter 4 also highlights that HOLC Scores are associated with contemporary neighborhood racial composition and that contemporary racial composition is a significant predictor of both allostatic load and neighborhood socioeconomic status (i.e., neighborhood deprivation, percentage of families in poverty, and median home value). In line with the work of Williams and Collins (2001), HOLC Scores shape socioeconomic conditions, which are, in turn, associated with differences in social and physical environmental risk as a pathway to adverse health outcomes. Consistent with Fundamental Cause Theories, both neighborhood racial segregation and neighborhood socioeconomic status serve as key causes through which structural factors influence disparities in individual health outcomes. This investigation found that associations varied by age, race, and sex, suggesting that an intersectional approach may be beneficial in moving forward to acknowledge the intersectional identities that individuals possess. These theoretical frameworks have guided the analytical models used for this dissertation and support several of the proposed pathways illuminated by said theoretical models.

Implications for Research and Policy

This dissertation has several implications for future research as well as policy. Throughout each chapter, interactions between the main exposure (e.g., HOLC score, neighborhood socioeconomic status indicators, neighborhood racial composition indicators) and demographic characteristics (i.e., age, race, sex) were found. With this in mind, future research should adopt an intersectional approach to better understand how the intersections of social identities or positions (e.g., older Black women) shape vulnerabilities, protective factors, and health risks. Due to the scope of this investigation and the limitations of the dataset used, three-way interactions that were suggested by results were not explicitly tested. Findings reported in this dissertation and elsewhere, suggest that the impacts of structural racism likely differ across demographic groups. An intersectional approach that examines the combined influences of different social identities and forms of systematic oppression across multiple ecological levels (Dhamoon & Hankivsky, 2012; Hankivsky & Cormier, 2009), is needed to enhance understanding these mechanisms.

Building upon the Stress Process Model and other guiding theories for this dissertation, a young black male compared to an older white woman who lives in the same neighborhood or even an urban area may experience and interact with their neighborhood environments in ways that have different implications for health and behaviors. Adequately examining these relationships concerning a person's intersectional identity is important for policy recommendations. Specifically, policies enacted to alter neighborhood built and social contexts must understand that policies are not neutral and differentially impact people based on their identities (Hankivsky & Cormier, 2011). Policies should not focus on single markers of identity (i.e., race, gender, sexual orientation) as the several identities a person possesses are differentially situated within their social location and context (Hankivsky & Cormier, 2011). Further, it is important that all policy decisions employ interdisciplinary collaboration to consider the impact of health in these proposed policies. Specifically, designing policies with health in mind uses interdisciplinary relationships to facilitate capacity building, governance and accountability, and shared resourcing to examine the ways in which public policy has ramifications for health in addition to holding policymakers accountable for the well-being of their constituents (Baum et al., 2014; Green et al., 2021; Hastings & Snowden, 2019; McDaid, 2012; World Health Organization, 2010).

A fundamental cause model suggests that the effect of fundamental causes on health is unlikely to be explained by proximal or intermediate pathways and that these pathways are likely to be replaced by other mechanisms over time. Accordingly, research methods should move away from identifying the pathways to developing interventions that address these fundamental drivers of health. Several potential strategies are discussed in the following paragraphs.

Dissertation findings reported here are consistent with a robust literature suggesting that adverse neighborhood conditions may be associated with adverse health outcomes. This information can be used to create policies and interventions that directly target community and local level factors to reduce some of these adverse effects. Specifically, the findings reported in this dissertation suggest that neighborhood level socioeconomic status is associated with allostatic load. One such pathway to reduce the adverse effects of neighborhood socioeconomic status on health could be through intentional investment in the city's educational system and workforce development. Especially focusing on neighborhoods that have been systemically and historically excluded for resources and funding in these particular areas. Improving the local environment through providing resources (i.e. financial capacity) to local organizations in their attempts to build and improve their relationships with the community could be a step toward equitable communities (Robert Wood Johnson Foundation, 2022). Other steps can be taken to create grassroots solutions to neighborhood issues and address how these issues are rooted in structural racism (Robert Wood Johnson Foundation, 2022). Additionally, local governments can promote job training, apprenticeship programs, and provide incentives to hire local long-term residents to engage those living in the neighborhood in participating in neighborhood change (Butler & Grabinsky, 2020). Further, local investment in transportation networks may play a vital role in increasing employment opportunities for those residing in low income areas and may be an important step in addressing spatial mismatch which limits suitable employment opportunities (Criden, 2008).

On the research aspect, the paradoxical findings reported in this dissertation related to neighborhood socioeconomic status and allostatic load highlight the need to consider other structural level factors (i.e., spatial mismatch, transportation networks) that may be a part of the causal pathway between neighborhood contexts and health outcomes. It might also highlight the need to examine factors beyond the immediate neighborhood that differentially affect the health of African American and white residents.

In chapters 2 and 4, neighborhood socioeconomic status was positively associated with allostatic load. Building upon this association, growing discussions within the literature focus on reparations as a potential solution to the lasting impacts of slavery and institutional racism on African descendants within the United States. In line with a fundamental cause theory application, providing this oppressed group with power, money, and access to resources may be a potential method of improving health outcomes within this group and reducing the racialized health disparities within the country (B. G. Link & Phelan, 1995). Bassett and Galea (2020) outline three pathways through which reparations could aid in reducing health disparities. These include a) expanding limited resources to Black Americans to access health-producing resources (i.e., better neighborhoods, cleaner air), b) reducing psychological strain associated with being Black within the United States, and c) improving access to wealth and assets with implications for health through cash transfers and investments, to name a few (M. T. Bassett & Galea, 2020). While these authors emphasize that reparations will not end racism, they will serve as a major milestone in addressing historical injustices and their ramifications on contemporary health.

Throughout each chapter of the dissertation, a series of moderators and mediators were tested to examine whether associations are modified by the presence of a particular variable or are mediated through specific variables with health implications. Two indicators of neighborhood socioeconomic status, percent of families in poverty and neighborhood deprivation index, significantly mediated associations between HOLC score and allostatic load (Chapter 2). The effects of percent poverty and neighborhood deprivation index on allostatic load were not explained by perceptions of the environment (Chapter 3). Although neighborhood perceptions were not significant mediators of these associations, there may be other mediators (e.g., neighborhood racial composition) that may be on the causal pathway relevant to health. It may also be that no single pathway serves as a mediator in and of itself. Examining the cumulative impacts of multiple potential mediating pathways when considered together will be important.

The percentage of a neighborhood that is Black/African American was a significant mediator of associations between HOLC Score and both allostatic load and neighborhood socioeconomic status indicators. Building upon the results and discussions in Chapter 4, other evidence suggests additional mediators such as food environments (Goodman et al., 2018), exposure to hazardous waste sites (D. R. Williams et al., 2019), and lack of access to quality healthcare (White et al., 2012) at the neighborhood level could serve as mediators of this causal pathway. Phelan and colleagues (2010) and Williams and colleagues (2016, 2019), argue that interventions that focus on the individual level should be comprehensive and identify the upstream and institutional factors that largely impact individual health (Phelan, Link, & Tehranifar, 2010; Williams & Purdie-Vaughns, 2016; Williams et al., 2019). Since the percentage of a neighborhood that is Black/African American was a significant mediator of these relationships, this data suggests that intervening on the structures that produce racial residential segregation may be beneficial for health. Although Williams and Collins suggest that segregation, in and of itself, may not be harmful, it may indicate the need for a critical examination of the social policies that restrict the availability of economic and other resources in racially segregated communities.

The final implication of this dissertation is to continue what Dr. Camara Jones phrases as "name racism" (Camara Phyllis Jones, 2002) that acknowledges the importance of addressing racial health disparities and associated social determinants of health and emphasizes the need for both national and local leaders to keep racism at the forefront of policy (Jones, 2002). As other scholars have also noted, while there is a need to name racism and to include it as a descriptor in research, there is also a need to name and understand the processes that have led to racialized health disparities within the United States (Hardeman et al., 2018b). A systematic review of public health articles published between 2002 and 2015 found that only 16 articles named institutional racism as a core concept of the research investigation, with only four being empirical (Hardeman et al., 2018a). While there has not been another systematic review that examines this topic since

Hardeman and colleagues' investigation, extensive research since then has considered institutional racism as a core concept within their research investigations.

Beyond these implications for future research and policy, findings suggest the importance of investigating neighborhood effects on health. *Space-Focused Racial Stereotyping*, a concept put forth by Bonam and colleagues (2017, 2020), informs my synthesis of the relationship between different metrics of institutional racism (i.e., historic redlining, neighborhood socioeconomic status, racial residential segregation) on allostatic load. The historical mechanisms that have been enacted within the United States have led to both a racialized hierarchy as well as the physical separation of people by race. These mechanisms have engendered racialized spaces where physical spaces, or for this dissertation, the neighborhood, have been and continue to be associated with certain racial and ethnic groups (C. Bonam et al., 2020; C. M. Bonam et al., 2017; Rothstein, 2018). These places are then stigmatized in what is known as *spatial stigma* which then constrains the opportunities and wellbeing of those residents living within these stigmatized places.

Policies and actions such as the Moving to Opportunity and Hope VI programs have focused on removing lower income residents from their "stigmatized" neighborhoods in favor of more affluent neighborhoods. There is evidence indicating physical and mental health benefits associated with the Moving to Opportunity program (Ludwig et al., 2013). However, removing residents from their neighborhoods reinforces the concept of spatial stigma and the belief that these lower income neighborhoods are not suitable places to live and should be demolished (Keene & Padilla, 2010; Whittaker et al., 2020) . Further, there is evidence that those from these stigmatized neighborhoods may carry this social stigma with them into their new neighborhoods, which may interfere with their integration into these new communities (Keene & Padilla, 2010; Whittaker et al., 2020). It may also be the case that removing individuals from potentially protective social environments may take away these protective networks that may buffer against the adverse impacts of their stigmatized identities.

In contrast to poverty interventions that relocate residents, more research is needed to highlight neighborhoods' positive assets (e.g., presence of positive social networks) and working with a community to understand their needs and involve them in identifying, developing, and implementing desired changes to their neighborhoods. Additionally, local polices should work to address transportation as a barrier to employment since there is evidence that suggest that quality transportation systems can help with employment opportunities and upward economic mobility (Chetty et al., 2014; Stacy et al., 2020)

Direct associations between census tract neighborhood poverty and allostatic load over time were only significant when the interaction between neighborhood poverty and race was included in the model. This may suggest that findings presented in this dissertation are generally consistent with a fundamental cause interpretation, this verifying that neighborhood socioeconomic status and racial segregation operate as fundamental causes. It may also be the case that other factors may buffer some of these hypothesized outcomes. For example, those living in “poor neighborhoods” may have other forms of social, emotional, and informational support that are important resources that counteract hazardous neighborhood exposures and help neighborhood residents cope.

Continuing studies on connections between neighborhood contextual factors and allostatic load and other health outcomes can help to clarify the impact of fundamental vs. proximal causes of health. In addition, future research and practice should collaborate with residents to identify and enhance existing interactions and processes (e.g., support networks) within their neighborhoods that may buffer negative health outcomes. A Health in All Policies approach to neighborhoods that focuses on capital and infrastructure investments (e.g., transportation, housing, health resources and amenities, education) can both enhance opportunities to build health and diminish health risks. Finally, a health equity approach to neighborhood development could utilize health equity impact assessments to resist gentrification, ensure that current residents are retained, and the integrity of the neighborhood is preserved.

Strengths and Limitations

This dissertation makes several contributions to the existing literature, including the use of local data, which provides an understanding of neighborhood within local contexts and has implications for local policies and advocacy. Chapter 2 makes a unique contribution in that it is the first study, to my knowledge, to explicitly examine associations between HOLC score and contemporary allostatic load in an urban area and to explore whether demographic characteristics moderate these associations. This chapter also contributes to the literature by examining the mediation effects of measures of neighborhood socioeconomic status on allostatic load over time. Chapter 3 contributes to the literature by exploring the longitudinal relationship between different indices of neighborhood socioeconomic status on allostatic load. This chapter also highlights the potential mediating pathways that neighborhood socioeconomic status is associated with health while highlighting the need for additional research on this topic. Chapter 4 contributes to the literature by examining associations between neighborhood racial composition and allostatic load over time, testing specific interactions based on demographic characteristics, and exploring important mediating pathways. Further, this chapter has found that neighborhood percent Black is a significant mediator of associations between HOLC score and allostatic load and associations between HOLC score and indices of neighborhood socioeconomic status. This dissertation has explored associations between neighborhood-level characteristics on allostatic load, which moves away from individual-level explanations to macro-level explanations of factors associated with health.

A major limitation of this dissertation is that many observations were excluded from the analytic sample due to missing variables. Since some of the study variables differed between those included in the sample compared to those dropped due to missing variables, the findings from this dissertation cannot be generalized. The sample for this cohort comes from selected neighborhoods in Baltimore, which may also limit the generalizability of these findings to people in other areas of Baltimore. It may also be the case that those who participated in this study are healthier, potentially obscuring the associations found in this dissertation. Additionally, there some concepts may not be accurately measured due to the constructs not being specifically measured (e.g., social support) or measured via self-report (e.g., physical activity) which may limit the ability to capture the true associations between these variables. Furthermore, the time period between exposure to neighborhood characteristics and health outcomes should continue to be studied as it may take more than five years before these exposures become relevant for health.

Closing Remarks: Commentary

This dissertation was motivated by my conviction that, in order for the United States to move forward in addressing health inequities, we must acknowledge the history of institutional racism and the mechanisms through which historical policies related to housing and other areas of life have a continuing negative impact that harms the health of racial/ethnic minoritized groups. Therefore, I chose to test a series of specific hypotheses that examine the links between structural racism, as manifested by HOLC score, neighborhood socioeconomic status, and neighborhood racial composition, and health outcomes years later. Empirical evidence that explicitly recognizes the failures of existing policies focused on achieving racial equity within this county and amending these policies with these failures in mind are important as we continue to understand how historical discriminatory practices have facilitated the devaluation of primarily Black communities and the subsequent devaluation of their assets in favor of whiteness. One such method could come in the form of reparations intended to acknowledge and rectify injustices and to provide closure to the groups that have been subjected to these offenses (Darity, 2008)—engaging in this form of redress to the lasting effects of institutional racism can serve as a pathway towards addressing racial health disparities (Bassett & Galea, 2020; Williams & Collins, 2004). I leave you with the words of the late Malcolm X, “ If you stick a knife in my back nine inches and pull it out six inches, there’s no progress. If you pull it all the way out that’s not progress. Progress is healing the wound that the blow made. And they haven’t even pulled the knife out much less heal the wound. They won’t even admit the knife is there” (Malcolm, X., 1964).

Appendices

Appendix A: Chapter 2 Main text Regressions using Clustered Standard Errors

*each table corresponds to the multilevel model results presented in the main text

Table A1. Results from Clustered Standard Error Models Regressing Allostatic Load on HOLC Score Controlling for Age, Race, Sex, Physical Activity, Smoking Status, and Poverty Status

	Model 1		Model 2	
	B(SE)	P	B(SE)	P
HOLC Score	**0.11 (0.07)**	**0.11**	**0.14 (0.07)**	**0.05**
Age Category	--	--		
35-44 (ref)	--	--	--	--
45-54	--	--	0.22 (0.12)	0.07
55-64	--	--	0.33 (0.14)	0.02
65-76	--	--	0.29 (0.15)	0.05
Race	--	--		
white (ref)	--	--	--	--
African American	--	--	0.10 (0.12)	0.42
Sex				
Female (ref)	--	--	--	--
Male	--	--	-0.39 (0.10)	0.00
Physical Activity				
<5 min (ref)	--	--	--	--
5-15 min	--	--	0.14 (0.12)	0.24
15-30 min	--	--	0.09 (0.10)	0.37
30-45 min	--	--	-0.12 (0.10)	0.27
>45 min	--	--	-0.24 (0.09)	0.01
Smoking Status				
Never Tried (ref)	--	--	--	--
Tried, never used regularly	--	--	-0.04 (0.13)	0.78
Former User	--	--	-0.02 (0.11)	0.89
Current User	--	--	-0.04 (0.11)	0.73
Poverty Status				
Above Poverty Threshold (ref)	--	--	--	--
Below Poverty Threshold	--	--	0.05 (0.07)	0.54

Table A2. Results from Clustered Standard Error Models Regressing Allostatic Load on the interaction between HOLC Score and Age Category Controlling for Race, Sex, Physical Activity, Smoking Status, and Poverty Status

	B(SE)	P
HOLC Score	-0.13 (0.19)	0.50
Age Category		
35-44 (ref)		
45-54	-0.65 (0.59)	0.27
55-64	-0.77 (0.57)	0.18
65-76	-0.15 (0.65)	0.81
Age Category * HOLC Score		
35-44 * HOLC Score (ref)		
45-54 * HOLC Score	0.31 (0.21)	0.14
55-64 * HOLC Score	0.39 (0.21)	0.06
65-76 * HOLC Score	0.16 (0.23)	0.49
Race		
white (ref)		
African American	0.10 (0.12)	0.40
Sex		
Female (ref)		
Male	-0.39 (0.10)	0.00
Physical Activity		
<5 min (ref)		
5-15 min	0.15 (0.12)	0.22
15-30 min	0.07 (0.10)	0.45
30-45 min	-0.11 (0.10)	0.29
>45 min	-0.24 (0.09)	0.01
Smoking Status		
Never Tried (ref)		
Tried, never used regularly	-0.05 (0.13)	0.68
Former User	-0.01 (0.11)	0.92
Current User	-0.03 (0.11)	0.77
Poverty Status		
Above Poverty Threshold (ref)		
Below Poverty Threshold	0.04 (0.07)	0.61

Table A3. Results from Clustered Standard Error Models Regressing Allostatic Load on the interaction between HOLC Score and Race Controlling for Age, Sex, Physical Activity, Smoking Status, and Poverty Status

	B(SE)	P
HOLC Score	0.42 (0.20)	0.04
Race		
white (ref)		
African American	1.11 (0.63)	0.08

HOLC * African American	-0.36 (0.22)	0.11
Age Category		
35-44 (ref)		
45-54	0.23 (0.12)	0.06
55-64	0.33 (0.14)	0.02
65-76	0.30 (0.14)	0.04
Sex		
Female (ref)		
Male	-0.39 (0.11)	0.00
Physical Activity		
<5 min (ref)		
5-15 min	0.15 (0.12)	0.19
15-30 min	0.08 (0.10)	0.40
30-45 min	-0.10 (0.10)	0.33
>45 min	-0.24 (0.10)	0.01
Smoking Status		
Never Tried (ref)		
Tried, never used regularly	-0.08 (0.13)	0.57
Former User	-0.04 (0.10)	0.72
Current User	-0.07 (0.11)	0.53
Poverty Status		
Above Poverty Threshold (ref)		
Below Poverty Threshold	0.04 (0.07)	0.56

Appendix B: Chapter 3 Main text Regressions using Clustered Standard Errors

*each table corresponds to the multilevel model results presented in the main text

Table B1. Results from Clustered Standard Error Models Regressing Allostatic Load on the interaction between each of four indicators of neighborhood SES indicators and Categorical Age Controlling for Race, Sex, Physical Activity, Smoking Status, and household Poverty Status using clustered standard errors.

	NDI		% of Families in Poverty		Median Home Value		% without a BA	
	B(SE)	P	B(SE)	P	B(SE)	P	B(SE)	P
NDI	-0.01 (0.02)	0.49	--	--	--	--	--	--
% of Families in Poverty	--	--	-0.01 (0.01)	0.11	--	--	--	--
Median Home Value	--	--	--	--	-0.03 (0.02)	0.04	--	--
% without a BA	--	--	--	--	--	--	0.01 (0.01)	0.27
Age Category								
35-44 (ref)								
45-54	0.24 (0.32)	0.45	-0.04 (0.23)	0.87	-0.35 (0.20)	0.08	1.65 (0.92)	0.08
55-64	-0.23 (0.35)	0.52	-0.23 (0.22)	0.29	-0.13 (0.31)	0.68	0.18 (1.71)	0.92
65-76	-0.83 (0.54)	0.13	-0.52 (0.32)	0.11	-0.29 (0.35)	0.41	1.12 (1.69)	0.51
Age Category * SES indicator								
35-44 * SES indicator (ref)								
45-54 * SES indicator	-0.02 (0.02)	0.46	0.00 (0.01)	0.75	**0.03 (0.01)**	**0.04**	-0.02 (0.01)	0.09
55-64 * SES indicator	0.02 (0.03)	0.34	0.01 (0.01)	0.10	0.01 (0.03)	0.57	-0.00 (0.02)	0.94
65-76 * SES indicator	**0.09 (0.04)**	**0.03**	**0.03 (0.01)**	**0.01**	0.04 (0.02)	0.10	-0.01 (0.02)	0.60

Table B2. Results from Clustered Standard Error Models Regressing Allostatic Load on the interaction between SES Indicators and Race Controlling for Age, Sex, Physical Activity, Smoking Status, and household Poverty Status

	NDI		% of Families in Poverty		Median Home Value		% without a BA degree	
	B(SE)	P	B(SE)	P	B(SE)	P	B(SE)	P
NDI	0.02 (0.01)	0.03	--	--	--	--	--	--
% of Families in Poverty	--	--	0.01 (0.00)	0.01	--	--	--	--
Median Home Value	--	--	--	--	-0.00 (0.01)	0.96	--	--

% without a BA	--	--	--	--	--	--	0.00 (0.01)	0.55
Race								
White (ref)								
African American	0.45 (0.24)	0.06	0.51 (0.18)	0.01	0.12 (0.25)	0.62	-0.37 (1.11)	0.74
SES indicator * African American	**-0.04 (0.02)**	**0.04**	**-0.02 (0.01)**	**0.00**	-0.01 (0.02)	0.44	0.00 (0.01)	0.78

Table B3. Results from Clustered Standard Error Models Regressing Allostatic Load on the interaction between SES indicators and Sex Controlling for Age, Sex, Physical Activity, Smoking Status, and household Poverty Status

	B(SE)	P	B(SE)	P	B(SE)	P	B(SE)	P
NDI	0.02 (0.02)	0.24	--	--	--	--	--	--
% of Families in Poverty	--	--	0.01 (0.01)	0.27	--	--	--	--
Median Home Value	--	--	--	--	-0.01 (0.01)	0.21	--	--
% without a BA	--	--	--	--	--	--	0.00 (0.01)	0.48
Sex								
Female (ref)								
Male	0.37 (0.31)	0.24	0.20 (0.22)	0.35	-0.29 (0.21)	0.16	-0.40 (0.85)	0.64
SES Indicator * Male	-0.05 (0.02)	0.06	**-0.02 (0.01)**	**0.04**	0.01 (0.01)	0.56	0.00 (0.01)	0.79

Table B4. Results from Clustered Standard Error Models Regressing Allostatic Load on the interaction between each of four measures of neighborhood socioeconomic status and household Poverty Controlling for Age, Sex, Physical Activity, Smoking Status, and household Poverty Status

	Model 1: Census tract level neighborhood deprivation index		Model 2: Census tract percent poverty		Model 3: Census tract median home value		Model 4: Census tract percent without a BA	
	B(SE)	P	B(SE)	P	B(SE)	P	B(SE)	P
NDI	0.01 (0.01)	0.16	--	--	--	--	--	--
% of Families in Poverty	--	--	0.00 (0.00)	0.22	--	--	--	--
Median Home Value	--	--	--	--	-0.00 (0.01)	0.61	--	--
% without a BA	--	--	--	--	--	--	0.00 (0.00)	0.38
Household Poverty Status								

Above Poverty Threshold (ref)								
Below Poverty Threshold	0.36 (0.20)	0.08	0.29 (0.17)	0.09	0.19 (0.16)	0.23	-0.25 (0.85)	0.74
SES Indicator * Below Poverty Threshold	-0.03 (0.01)	0.08	-0.01 (0.01)	0.06	-0.01 (0.01)	0.23	0.00 (0.01)	0.74

Table B5. Allostatic load regressed on census tract level Neighborhood Deprivation Index and physical activity, Controlling for Age, Race, Sex, Household Poverty, Smoking Status, and Baseline Allostatic Load using Standard Clustered Errors

Neighborhood Deprivation Index				
	Model 1a		Model 1b	
	B(SE)	P	B(SE)	P
Level 2-Neighborhood Level				
Neighborhood Deprivation	-0.00 (0.01)	0.74	0.00 (0.01)	0.90
Level 1-Individual Level				
Physical Activity				
No (ref)				
Yes	--	--	-0.08 (0.09)	0.41

Table B6. Allostatic load regressed on census tract level percent of families in poverty and physical activity, Controlling for Categorical Age, Race, Sex, Household Poverty Status, Smoking Status, Baseline Allostatic Load, and the interaction between census tract level percent of families in poverty and race using Standard Clustered Errors

% of Families in Poverty				
	Model 1a		Model 1b	
	B(SE)	P	B(SE)	P
Level 2-Neighborhood Level				
% of Families in Poverty	**0.01 (0.01)**	**0.08**	**0.01 (0.00)**	**0.01**
Level 1-Individual Level				
Physical Activity				
No (ref)				
Yes	--	--	-0.08 (0.09)	0.38

Table B7. Allostatic load regressed on census tract level Median Home Value and physical activity, Controlling for Categorical Age, Race, Sex, Household Poverty Status, Smoking Status, and Baseline Allostatic Load using Standard Clustered Errors

Median Home Value				
	Model 1a		Model 1b	
	B(SE)	P	B(SE)	P
Level 2-Neighborhood Level				
Median Home Value	-0.01 (0.01)	0.32	-0.01 (0.01)	0.14
Level 1-Individual Level				
Physical Activity				
No (ref)				
Yes	--	--	-0.08 (0.09)	0.42

Table B8. Allostatic load regressed on census tract level percent of adults without a BA degree and physical activity, Controlling for Categorical Age, Race, Sex, Household Poverty Status, Smoking Status, and Baseline Allostatic Load using Standard Clustered Errors

% Without a Bachelor's Degree				
	Model 1a		Model 1b	
	B(SE)	P	B(SE)	P
Level 2-Neighborhood Level				
% without a BA	0.00 (0.01)	0.53	0.01 (0.00)	0.20
Level 1-Individual Level				
Physical Activity				
No (ref)				
Yes	--	--	-0.07 (0.09)	0.43

Table B9. T-test results exploring whether there are statistically significant differences in the means of the study variables between the sample and the full HANDLS cohort.

Variable	T-test Statistic	Excluded (n= 574) Mean (SD)	Included (n=618) Mean (SD)
Allostatic Load (Wave IV)	0.02	2.07 (1.21)	1.90 (1.21)
Neighborhood Deprivation Index (Wave III)	0.36	11.56 (4.12)	11.77 (3.61)
% Poverty (Wave III)	0.59	24.13 (12.86)	24.53 (12.12)
Median Home Value (Wave III)	<0.001	14.06 (7.14)	12.69 (5.76)
% without a BA	<0.01	89.17 (8.35)	90.50 (6.59)

Appendix C: Chapter 4 Main text Regressions using Clustered Standard Errors

*each table corresponds to the multilevel model results presented in the main text

Table C1. Results from Multilevel Models Regressing Allostatic Load on indicators of neighborhood racial composition vary by race Controlling for Categorical Age, Sex, Physical Activity, Smoking Status, Neighborhood Deprivation Index, and Poverty Status.

MLM	Racial Isolation Index		% Black	
	B(SE)	P	B(SE)	P
Racial Isolation Index	-0.00 (0.01)	0.99	--	--
% Black	--	--	0.00 (0.00)	0.46
Race				
White (ref)				
African American	0.03 (0.19)	0.88	0.02 (0.22)	0.93
RaceXNeighborhood Composition				
African American	-0.00 (0.01)	0.80	-0.00 (0.00)	0.67

Table C2. Results from Multilevel Models Regressing Allostatic Load on indicators of neighborhood racial composition vary by Sex, Controlling for Categorical Age, Sex, Physical Activity, Smoking Status, Neighborhood Deprivation Index, and Poverty Status.

MLM	Racial Isolation Index		% Black	
	B(SE)	P	B(SE)	P
Level 2- Neighborhood				
Racial Isolation Index	-0.01 (0.01)	0.27	--	--
% Black	--	--	0.01 (0.00)	0.02
Neighborhood Deprivation	-0.01 (0.01)	0.57	-0.01 (0.01)	0.31
Level 1- Individual				
Sex				
Female (ref)				
Male	-0.31 (0.13)	0.02	0.35 (0.16)	0.04
Cross-Level Interactions				
SexXSegregation Indicator				
Men	0.01 (0.01)	0.14	**-0.01 (0.00)**	**0.00**

Table C3. Results from Multilevel Models Regressing Allostatic Load on indicators of neighborhood racial composition vary by Age Category, Controlling for Categorical Age, Sex, Physical Activity, Smoking Status, and Poverty Status.

MLM	Racial Isolation Index		% Black	
	B(SE)	P	B(SE)	P
Level 2- Neighborhood				
Racial Isolation Index	-0.00 (0.01)	0.82	--	--
% Black	--	--	0.00 (0.00)	0.31
Neighborhood Deprivation	-0.01 (0.01)	0.60	-0.01 (0.01)	0.34
Cross-Level Interactions				
AgeXSegregation Indicator				
35-44 (ref)				
45-54	0.00 (0.01)	1.00	-0.01 (0.00)	0.23
55-64	0.01 (0.01)	0.75	-0.00 (0.01)	0.60
64+	-0.00 (0.01)	0.87	0.00 (0.00)	0.75
Level 1-Individual				
Age				
35-44 (ref)				
45-54	0.16 (0.19)	0.39	0.52 (0.36)	0.15
55-64	0.17 (0.22)	0.43	0.39 (0.43)	0.37
64+	0.34 (0.20)	0.10	0.20 (0.29)	0.50

Table C4. Descriptive Statistics estimating the distribution of participants based on quartile of neighborhood racial composition indicator and sex.

	% Black/African American	
	Women	Men
Quartile 1 (low)	133	94
Quartile 2	109	84

Quartile 3	130	77
Quartile 4 (high)	97	75
Total	469	330

Table C5. T-test results exploring whether there are statistically significant differences in the means of the study variables between the sample and the full HANDLS cohort.

Variable	T-test Statistic	Excluded (n=1,221) Mean (SD)	Included (n=799) Mean (SD)
Allostatic Load (Wave IV)	0.18	2.02 (1.24)	1.95 (1.19)
% Black (Wave III)	0.16	66.37 (31.82)	64.27 (30.66)
Racial Isolation Index	0.00	8.43 (7.93)	9.59 (7.82)
Ethnic Discrimination	0.07	24.33 (10.05)	23.46 (8.89)
Social Environment	0.048	22.31 (3.27)	22.01 (3.34)
Religious Org Density	0.00	6.90 (4.08)	7.45 (4.07)
Civic Org Density	<0.001	1.52 (1.98)	1.12 (1.35)
Religious and Civic Org Density	0.49	8.42 (4.86)	8.56 (4.42)

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