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Can Changing Your Environment Change Your Health? Examining Public Housing Relocation and Cardiovascular Disease Risk

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ABSTRACT

CAN CHANGING YOUR ENVIRONMENT CHANGE YOUR HEALTH? EXAMINING PUBLIC HOUSING RELOCATION AND CARDIOVASCULAR DISEASE RISK

By

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2016

Cardiovascular disease is the leading cause of premature death in the United States today, and vulnerable populations may be more susceptible to this disease risk. Relocating into a new neighborhood may affect one's cardiovascular disease risk. Through a socio-ecological framework, this study sought to determine whether changes in one's interior and exterior built environment had a significant effect on cardiovascular disease risk in Atlanta's relocated public housing population. Using pre- and post-relocation data from a questionnaire delivered to public housing residents, and built environment assessments from before and after demolition neighborhoods, the results showed residents were significantly more satisfied with their new neighborhoods and residences. However, while the interior built environment improved significantly after relocation, the exterior built environment declined significantly. Further, neither overall health nor cardiovascular disease risk improved significantly after relocation. These results corroborate findings in other public housing research that shows that many former public housing residents do not perceive an improvement in their health after relocation.

Keywords: Public housing, cardiovascular disease, built environment, diabetes, relocation

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Author's Statement Page

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1 INTRODUCTION

Cardiovascular disease is the leading cause of premature death in the United States today. Each year, Americans suffer 1.5 million heart attacks and strokes, and around 610,000 people die of heart disease (Million Hearts 2015). Additionally, cardiovascular disease can cause serious illness, disability, and a decreased quality of life. Vulnerable populations may be more susceptible to heart disease and its consequences (Mobley, Root, Finkelstein, Khavjou, Farris, & Will 2006). Specifically, the risks of cardiovascular disease morbidity and mortality are higher for minority women or those of lower income, lower education or no insurance (Mobley et al. 2006). Recently, there has been a growing interest in how residential environments may influence cardiovascular disease risk (Diez-Roux 2003). Where one lives may have an effect on their health. More specifically, where one lives may have an effect on their cardiovascular disease risk. In this study, I seek to determine the extent to which the built environment may affect individual cardiovascular disease risk in a vulnerable population. This research will examine cardiovascular disease risk for residents who relocated from public housing and into the private market. I will determine whether the neighborhoods to which they moved had a significant effect on their cardiovascular disease risk.

In 2008, the Atlanta Housing Authority began demolishing all public housing projects in Atlanta and relocating their residents into the private market (Oakley, Ruel, Reid, & Sims 2010). Using rental vouchers, public housing residents were able to move into qualifying units anywhere their vouchers were accepted. By late 2009, all public housing projects in Atlanta were demolished. While there has been some research into the health of public housing residents after they have relocated, none has specifically focused on cardiovascular disease risk. This could be due to the fact that cardiovascular disease is chronic, and not easily altered by external factors. It is unclear whether changes to one's environment could be an impetus to change one's cardiovascular disease risk. Some research has shown that the social and physical characteristics of neighborhoods can affect health through behaviors such as smoking, drinking alcohol, and a sedentary lifestyle (Haney 2007; Robert 1998). Whether these characteristics are powerful enough to affect cardiovascular disease risk is one of the main goals of this thesis. Using data from Georgia State University's Urban Health Initiative public housing study, I will determine the extent to which changes in the environment influence overall health and cardiovascular disease risk through corresponding risk factors, including high blood pressure, diabetes, obesity, and other factors.

1.1 Research Problem

Relocating into a new neighborhood may affect residents' cardiovascular disease risk. Improvements in the physical environment, such as a reduction in graffiti, abandoned houses, or unkempt lawns, could positively affect cardiovascular disease risk. Overall, it is possible that the built environment has an effect on cardiovascular disease risk in a vulnerable population. Using a socio-ecological framework to frame my research, I hypothesize that factors that contribute to cardiovascular disease risk, such as diabetes, high blood pressure, and obesity will decline after relocation into the private market. Secondly, I hypothesize that the decline in these cardiovascular disease risk factors will be partially explained by improvements in the built environment. Third, I hypothesize that subjective overall health will improve after relocation, and fourth, that the improvement in subjective overall health will be partially explained by improvements in the interior and exterior built environment. As stated before, I will use data from the Urban Health Initiative, which includes former public housing residents living in

Atlanta, Georgia. This research fills a gap in the literature concerning the built environment and its effect on cardiovascular disease risk in a vulnerable population. Chapter two will cover the review of the literature. This will detail the built environment, cardiovascular disease risk, and research that informs this study as to the effects of the built environment on health. It will also cover the socio-ecological model and how it applies to this research. Chapter three will cover the methods and plan of analysis. From detailing the sample, data, and constructs, to explaining the ordinal logistic models used in this study, it will cover all aspects of the methods used in this work. Chapter four will present the research findings. Finally, chapter five will include the summary, conclusions, discussion, and suggestions for future research.

2 BACKGROUND AND THEORETICAL FRAMEWORK

In the early 1900s, most urban areas were compact and many places were walkable (Dearry 2004). Public health initiatives that began in the late 1800s tended to focus on infectious disease due to poor sanitation and dilapidated housing conditions. In the modern era, public health focuses on a number of different geographical densities (including rural and suburban areas as well as urban) along with increasingly diverse communities of people. The importance of place in health was revived in earnest in the early 1990s (Diez-Roux 2001). This resurgence in interest in the role of place in health is due to a couple of factors. First, there has been increased interest in the social determinants of health. These include issues such as socioeconomic status, race, and poverty and how these factors interact with both an individual and their environment. Second, there has been an increasing amount of research on the methods used to study place, and determining how social influences affect health at a micro- and macro-level (Diez-Roux 2001). Overall, the built environment has become a more popular topic in the public health literature, yet we know more about the association between ambient environmental factors and health than we do about how the built environment affects health (Dearry 2004).

A methodological issue concerning the built environment is defining it. There are nearly as many definitions for the built environment as there are articles that examine it. Northridge et al. (2003) defines the built environment as the part of the physical environment made by people for people, including buildings, transportations systems and open spaces. Other researchers define the built environment as including “all of the physical structures engineered and built by people—the places where we live, work, and play” (Dearry 2004, p. 47). Srinivasan et al. (2003) states “The built environment includes our homes, schools, workplaces, parks/recreation areas, business areas and roads. It extends overhead in the form of electric transmission lines, underground in the form of waste disposal sites and subway trains, and across the country in the form of highways. The built environment encompasses all buildings, spaces, and products that are created or modified by people. It impacts indoor and outdoor physical environments (e.g. climatic conditions and indoor/outdoor air quality), as well as social environments (e.g. civic participation, community capacity and investment) and subsequently our health and quality of life" (p. 1446). Sallis & Glanz (2006) define the built environment as "the totality of places built or designed by humans, including buildings, grounds around buildings, layout of communities, transportation infrastructure, and parks and trails" (p. 729). Finally, Healthy People 2010 include the built environment in their definition of environmental health:

> *In its broadest sense, environmental health comprises those aspects of human health, disease, and injury that are determined or influenced by factors in the environment. This includes not only the study of the direct pathological effects of various chemical, physical, and biological agents, but also the effects on health of the broad physical and social environment, which includes housing, urban development, land-use and transportation, industry, and agriculture*
>
> (Srinivasan, O'Fallon, & Dearry 2003).

Overall, these definitions agree that the built environment includes any and all physical structures that are developed by people. This includes both the interior built environment (which includes plumbing, paint, heating, and other factors) and the exterior environment (such as the presence of sidewalks, graffiti, abandoned houses, and others). I detail both the interior and exterior built environment below.

2.1 Interior Built Environment

Housing conditions and health problems research in the public health literature date as far back as 1872 (Dunn 2000). Back then, as today, communities of a lower socioeconomic status usually had limited access to quality housing (Srinivasan et al. 2003). Issues such as crowding, poor housing conditions, and pests are endemic in higher poverty areas. Because we spend more than 90% of our lives indoors, the interior built environment is of utmost importance to our health (Dearry 2004; Srinivasan et al. 2003). Housing stressors are significantly associated with both physical and psychological distress, which could eventually lead to immunity issues (Dunn 2000). Housing disrepair among the poor exposes them disproportionately to lead, pests, air pollutants, contaminants, and is associated with greater social risks, such as gang violence and crime (Dunn 2000; Srinivasan et al. 2003). Public housing residents are among the poorest populations in the United States. Due to various restrictions on public housing funding, public housing units are frequently rundown and do not meet safety standards (Boston 2005). Overall, they are considered unsafe, unsanitary, and are poorly managed (Boston 2005; Schill 1993). Common complaints of public housing units include lack of heating, lack of insulation, poor plumbing, poor water quality, peeling paint, existence of lead, presence of radon, pests (including roaches, ants, rats and mold), overcrowding, fire and burn hazards, deterioration, vandalism, and poor maintenance (Bennett, Smith, & Wright 2006; Eiseman, Cove, & Popkin 2005; Oakley, Ruel, & Wilson 2008; Popkin, Levy, Harris, Comey, Cunningham, & Buron 2004; Schill 1993; Shaw 2004). Overall, the interior built environment can create a number of health issues, such as asthma, obesity, and mental health conditions such as depression (Goetz 2010; Sousa-Briggs et al. 2010).

2.2 Exterior Built Environment

While there is fairly little literature on the effects of the interior built environment on chronic disease, there is a wealth of literature on the exterior built environment on health. The exterior built environment can also be considered a part of "neighborhood effects".

Neighborhood effects are experiences of deprivation that may be more prevalent in poor areas due to perceived negative impacts of the area on health, and are “the independent, separable effects on life chances that arise from living in a particular neighborhood” (Atkinson & Kintrea 2004, p. 438). Neighborhood qualities associated with socioeconomic status, such as those described below, have an effect on individual social, economic, and health outcomes (Anderson, St. Charles, Fullilove, Scrimshaw, Fielding, & Normand 2003).

Characteristics of the exterior built environment in neighborhoods include any human-made feature, including houses, streets, sidewalks, lights, automobiles, and any number of other items. Common features of a distressed neighborhood built environment include deterioration of lawns, graffiti, abandoned cars, broken windows, abandoned buildings, and garbage in the street. (Sampson & Raudenbush 1999; Sampson 2012). These physical factors, along with social factors such as limited outdoor options for physical activity due to high crime rates, fear of safety, lack of neighborhood parks, a lack of sidewalks, or fast traffic can influence the health of the residents (Northridge, Sclar, & Biswas 2003). In many poor urban areas, the physical and social constructions of the urban environment promotes isolation, through higher rates of television watching, geographic isolation, and a lack of social networks (Srinivasan et al. 2003). All of these factors can contribute to a multitude of chronic illnesses, such as obesity, diabetes, mental health problems, cardiovascular disease, and mortality (Srinivasan et al. 2003). On the positive side, many public housing projects are actually highly walkable in that they are in high density areas with sidewalks that could potentially influence physical activity, but the environments associated with public housing units are generally associated with poorer health outcomes, such as a higher body mass index (Houston, Basolo, & Yang 2013).

2.3 The History of Public Housing and the Built Environment

Public housing in the United States began with the Public Works Administration in 1933. This administration was the first to create government-funded housing (where the costs of building and maintaining housing would be under the government's purview) and the first public housing project was built in Atlanta in 1937 (Fraser, Oakley, & Bazuin 2011). A few years later, the Housing Act of 1937 was signed into law, and public housing projects began to be built in earnest. There were a number of issues with the first public housing projects. First, they were purposefully built to be less desirable than private sector homes (Fraser et al. 2011; Schill 1993). This was done to keep private housing contractors happy and to discourage public housing as a "nice" place to live. Second, public housing projects were racially segregated from the beginning, in line with Jim Crow laws of the era (Quadagno 1994). Third, there were no provisions in the Housing Act to allow for maintenance or modernization of facilities. Further, housing authorities were not allowed to stockpile monetary reserves to support large-scale renovation projects (Schill 1993). Thus, the way they were built originally was, in general, as modern as public housing projects were destined to be. A decade later, the 1949 Housing Act appeared to be attempting to rectify the built-in disparities that developed from the Housing Act of 1937. The 1949 Housing Act stated that Americans had the right to a decent home and a suitable living environment (Fraser et al. 2011; Oakley & Burchfield 2009). Decent housing consisted of the quality of the home itself, while the suitable living environment encompassed the surrounding neighborhood (Oakley et al. 2009). However, public housing continued to deteriorate and become more and more dangerous for the residents living there.

By 1966, living in public housing had become so dangerous, poverty-ridden, and segregated that a group in Chicago sued the Chicago Housing Authority in a case titled

Gautreaux vs. Chicago Housing Authority (Sousa-Briggs, Popkin, & Goering 2010). The court ruled that the Chicago Housing Authority could no longer construct new public housing in areas that were predominately African-American and they could no longer construct high-rises for families. This decision was upheld in the Supreme Court in 1976's *Hills vs. Gautreaux*, which determined that the Department of Housing and Urban Development was liable for Chicago Housing Authority's actions and was required to provide remedies for the public housing problem throughout the Chicago area. This was the beginning of rental-assistance vouchers, which enabled families to move into the private market. Although the *Gautreaux* decision was a turning point for public housing residents in Chicago, public housing in the United States continued to deteriorate for decades afterward.

By the 1990s, public housing was deemed a failure (Brooks, Zugazaga, & Wolk, & Adams 2005). For many decades, it had been associated with concentrated poverty and little opportunity for upward mobility (Oakley et al. 2009). As stated above, the original developments were located in high-poverty, racially segregated high-crime neighborhoods (Cohen, Inagami, & Finch 2008; Goetz 2003; Oakley et al. 2009). They were characterized as having more than 30% of their residents living in poverty, and more than 90% of residents being a racial minority (Cohen et al. 2008). The public housing projects anchored poor and minority residents to these neighborhoods, and they had little opportunity to improve their ways of life (Goetz 2003). Public housing units were often in great disrepair, and the surrounding communities were plagued with a number of social problems, including high crime, low employment, and low education (Bennett et al. 2006; Boston 2005). There comes a point of resource deprivation at which social institutions collapse and simply cannot be damaged further (Hannon 2003). This was the case with public housing facilities in the 1990s.

In 1989, the National Commission on Severely Distressed Public Housing was created to develop a plan to eradicate distressed public housing (Schill 1993). There were two major programs designed to reconceptualize public housing. The first program was Moving to Opportunity. Implemented in 1994, it was the largest social experiment ever conducted by the United States government (Katz, Kling, & Leibman 2001; Leventhal & Brooks-Gunn 2003). Volunteers into the program were randomly grouped into one of three categories. The first group was the experimental group, who received a rental voucher that required them to move into an area with less than 10% of its residents living in poverty. The second group was the comparison group, who also received a rental voucher, but were not limited to where they could move. The third group was the control group, and they did not move from public housing (Leventhal et al. 2003; Sousa-Briggs et al. 2010). The early results were positive. The experimental group had the highest levels of satisfaction with their new neighborhoods and lived in areas of higher quality, with safer and less stressful communities (Bennett et al. 2006; Leventhal et al. 2003). The comparison group did better as well, but not as well as the experimental group.

The second program instituted by the government was the Housing Opportunities for People Everywhere (HOPE VI) program. This program began in 1992 with demolition and revitalization grants (Brooks et al. 2005). It was a government shift from project-based to tenant-based subsidies and also included vouchers (Goetz 2003). The goals of HOPE VI were to improve the living environment for residents, the revitalization of public housing sites, a deconcentration of poverty, and building sustainable communities (Brooks et al. 2005; Oakley et al. 2009). The severely distressed public housing projects were demolished and were to be replaced with mixed income housing (Bennett et al. 2006; Oakley et al. 2009). This was in an attempt to reduce isolation, build community, and reduce crime and violence (Brooks et al.

2005). This program was by far the most strenuous government effort to transform public housing (Bennett et al. 2006). The initial findings showed that people experienced real benefits and were living in better housing. However, the new neighborhoods were still extremely poor and racially segregated. Atlanta's public housing demolition was based on the HOPE VI program, although not funded through it. The public housing communities affected by this demolition were built between 1941 and 1973 and most were demolished between 2009 and 2011, although most residents moved in 2009. It is the first major city to eliminate all of its traditional public housing, and to relocate all public housing residents to the private market with rental-assistance vouchers (Oakley et al. 2010).

Researchers have conducted a number of studies regarding public housing relocation in cities throughout the United States, including Atlanta. In general, after relocation into the private market, former public housing residents were living in better areas. However, they still faced a number of issues. First, housing choice was highly constrained for these residents for factors outside of rent, such as transportation, social networks, and amenities (Goetz 2003). Thus, most residents did not move very far from their original public housing residences (Goetz 2010; Oakley et al. 2010). In Atlanta, former public housing residents moved only about four miles away (average distance) from their former public housing project. In these new neighborhoods, residents stated that they lived in better housing with less poverty and crime (Bennett et al. 2006; Cohen et al. 2008; Goetz 2003; Goetz 2010; Oakley et al. 2009; Oakley et al. 2010). However, the neighborhoods were still of higher poverty relative to the city and region (Goetz 2010; Oakley et al. 2009; Sampson, Morenoff, & Gannon-Rowley 2002). The new neighborhoods had higher employment rates, better schools for children, and healthier store options (Goetz 2003; Oakley et al. 2010; Rosenbaum 2008). There were perceptions of lower crime and fewer neighborhood problems, such as graffiti, drugs, abandoned buildings, and crime (Bennett et al. 2006; Cohen et al. 2008; Goetz 2003). Residents reported living in significantly safer neighborhoods, enabling children to play outside (Cohen et al. 2008; Goetz 2003; Goetz 2010). Many of the neighborhoods had a greater racial diversity, but were still highly segregated and higher poverty by state and national standards (Bennett et al. 2006; Cohen et al. 2008). Some research shows that people who moved to less segregated areas benefitted more than those who moved but stayed in the area (Boston 2005). Further, those who moved to the private market did better than those who moved to other public housing projects (Brooks et al. 2005; Cohen et al. 2008). Physical health problems persisted after relocation as well. Goetz (2010) states in his study that one third of the residents he followed reported having a chronic illness, such as diabetes or cardiovascular disease. Follow-up surveys with former public housing residents showed that 75% of residents indicated no change or a decline in their health after relocation (Goetz 2010). Thus, it is uncertain whether changes in the built environment (through relocation) can have a positive impact on chronic disease, such as cardiovascular disease.

2.4 The Built Environment and Health

There is a general consensus among sociological and public health researchers that the physical and social environments of neighborhood may be important in understanding the distribution of health outcomes (Diez-Roux 2001; Diez-Roux, Merkin, Arnett, Chambless, Massing et al. 2001; Dunn 2000; Yen, Michael, & Perdue 2009). Where one lives exerts a profound effect both on one's health and their life chances (Massey & Denton 1993). Additionally, neighborhood qualities associated with socioeconomic status have an effect on individual social, economic, and health outcomes (Anderson et al. 2003).

There are two major explanations for why neighborhoods affect health. The first is the compositional explanation. This attributes the geographic clustering of health outcomes to the shared characteristics of residents (Bernard, Charafeddine, Frohlich, Daniel, Kestens, & Potvin 2007). In other words, similar people aggregate within geographical areas. There are issues with this explanation, especially concerning chronic disease. Logically, it does not make sense to assume that people with a high cardiovascular disease risk choose to live near other with a high cardiovascular disease risk, especially because for many chronic diseases, the symptoms are invisible. The second explanation is the contextual explanation. It attributes spatial variations in health outcomes in part to the characteristics of the environment itself (Bernard et al. 2007). Spatially patterned health inequalities are rooted in the unequal distribution of resources. Overall, the contextual explanation makes the most sense, as the resources available in a community do affect health, and health has been shown to improve when people move from poor areas to areas with more affluence and resources.

Physical health issues abound for residents living in high poverty neighborhoods (Bennett et al. 2006; Dunn 2000). In disadvantaged areas, residents have a higher risk of disease, both chronic and infectious, than residents living in advantaged neighborhoods, even after controlling for household income, education, and occupation (Diez-Roux et al. 2001). There has been a multitude of research on the effects of the built environment on obesity. As obesity is a prevalent chronic disease and a risk factor for cardiovascular disease, it is appropriate to add here. The built environment of a neighborhood affects both food intake and energy expenditure, while presenting opportunities or barriers for physical activity (Dearry 2004; Feng, Glass, Curriero, Stewart, & Schwartz 2010). These are in the forms of food access and access to physical activity facilities. Higher density areas are associated with higher rates of walking and biking, while those living in sprawling counties are more likely to walk less, weigh more, and have a higher prevalence of hypertension, another risk factor for cardiovascular disease (Dearry 2004). While most public housing residents moved to areas that are high density, research shows that they continue to be in poor health relative to the general population of the United States (Goetz 2010).

2.5 The Built Environment and Cardiovascular Disease

Cardiovascular disease is the leading cause of death in the United States (Mobley et al. 2006). Risks for cardiovascular disease morbidity and mortality are higher for minority women or for those of low-income, low education, or no insurance. Additionally, age is significantly positively related to both body mass index and cardiovascular disease risk (Mobley et al. 2006). In the last couple of decades, there has been a growing interest in the public health field in how residential environments may influence cardiovascular disease risk (Diez-Roux 2003; Sundquist, Malmstrom, & Johansson 1999; Sundquist, Winkleby, Ahlen, Johansson et al. 2004). Due to the growing visibility of obesity and the increasing numbers of Americans suffering from chronic diseases, many public health researchers study how neighborhoods in general effect health, as well as an increasing interest in interdisciplinary work in understanding population health (Diez-Roux 2003). Interestingly, along with obesity, one of the most frequently investigated subjects in studying neighborhood effects on health has been cardiovascular disease (Cubbin & Winkleby 2005; Diez-Roux 2003; Diez-Roux 2007; Diez-Roux, Nieto, Muntaner, Tyroler, Comstock et al. 1997; Diez-Roux et al. 2001; Sundquist et al.1999; Sundquist et al. 2004). In the past, cardiovascular disease prevention has focused predominately on individual-level risk factors, with little to no consideration to meso-level factors, such as one's place of residence. Through health education, early detection of risk factors and medical treatment at an individual level, cardiovascular disease has been managed at the individual level (Diez-Roux 2003). However, some research shows that it may be more effective to address cardiovascular disease through interventions designed to bring the blood pressure (for example) of the population down, rather than just those at the very top of the distribution (Diez-Roux 2003). Thus, there seems to be a connection between neighborhood characteristics and cardiovascular disease risk.

Coronary heart disease is strongly patterned by social class, with a higher incidence in the lower class (Diez-Roux 1997; Sundquist et al. 1999). Living in socioeconomically disadvantaged and deprived neighborhoods has been linked to a higher incidence and prevalence of coronary heart disease and higher cardiovascular disease mortality (Diez-Roux 2003; Diez-Roux 2007; Diez-Roux 1997; Diez-Roux et al. 2001). Additionally, living in disadvantaged areas is associated with increased levels of cardiovascular disease risk factors, such as obesity, high blood pressure, dietary patterns, smoking, and physical activity, which persist even after controlling for common socioeconomic factors such as individual income, education, and occupation (Diez-Roux 2003; Diez-Roux 2007; Diez-Roux 1997; Diez-Roux et al. 2001; Sundquist et al. 1999; Sundquist et al. 2004). However, some research shows that for African-American men living in poor neighborhoods, coronary heart disease prevalence decreased as neighborhood characteristics worsened (Diez-Roux 1997). Overall, living in the most disadvantaged group of neighborhoods was associated with an up to 90% higher risk of cardiovascular disease in whites and up to a 50% higher risk in African-Americans (Cubbin et al. 2005; Diez-Roux et al. 2001). Thus, the research shows that there is a significant association between the built environment and the risk for cardiovascular disease. While there is a decent amount of literature on neighborhood effects on health, there are a few challenges in studying the built environment and its effects on health.

2.6 Challenges to Studying the Built Environment

The built environment has become a hot topic in the public health literature in the last few decades. However, there are a few issues that researchers have run into to study the environment and health. The first is a lack of valid and reliable indicators of the built environment to monitor effects of urban planning and health interventions (Northridge et al. 2003). Related to that, there is little consensus on the definition of neighborhood or other relevant geographic areas (Diez-Roux 2001; Diez-Roux 2003). For example, Diez-Roux (2001) defines neighborhood as the "geographic area whose characteristics may be relevant to the specific health outcome being studied," which can mean anything from a house block to an entire city (p. 1784). Additionally, the definition of a neighborhood may change based on the outcome of interest. For example, a study involving education may examine school districts, or neighborhoods within them (Diez-Roux 2001). In general, health research often uses a resident's neighborhood and community to refer to a person's immediate residential environment (Diez-Roux 2001). A second issue in studying the built environment is the growth of the megalopolis, or a super urban region (Northridge et al. 2003). In the United States, the ten largest consolidated metropolitan areas account for one third of the population. Some built environment research focuses on large areas, and some focuses on smaller areas. Finally, there may also be differences in conducting subjective versus objective assessments. While objective assessments can control for bias, subjective assessments may not be able to. Although there are issues in studying the built environment, studying neighborhood effects on health has shed light on meso-level effects of the community on health, and can lead to improvements in population health, and perhaps reduce the prevalence of cardiovascular disease risk in the nation.

2.7 The Ecological Model and the Built Environment

The ecological model is an appropriate model in social epidemiology. Social epidemiology is a relatively new branch of epidemiology that focuses on the effects of social-structural factors on states of health (Berkman & Kawachi 2000; Honjo 2004). It examines the distribution of advantages and disadvantages in society and how it is reflected in the distribution of health and disease. While social epidemiology primarily examines the social determinants of health (such as socioeconomic status), the built environment can also be examined through social epidemiology and the ecological model because the built environment is a human-made social construct.

In order to understand human health and development, we must consider the entire ecological system in which growth occurs (Bronfenbrenner 1994). Bronfenbrenner developed the ecological model, which consists of five socially organized subsystems, which range from microsystems to macrosystems. A microsystem is a pattern of activities, social roles, and interpersonal relations experienced by an individual in a personally interactive manner. Mesosystems are the middle level, which comprises the process that take place in two or more settings that involve the individual. A mesosystem is a group of microsystems. The exosystem is a larger system that comprises the process in two or more settings, in which at least one does not contain the individual directly. A macrosystem is the overarching pattern of micro-, meso-, and exosystems characteristic of a given culture, while chronosystems consider time as a characteristic of the surrounding environment (Bronfenbrenner 1994). Please see Figure 2.1 for an example of the ecological model.

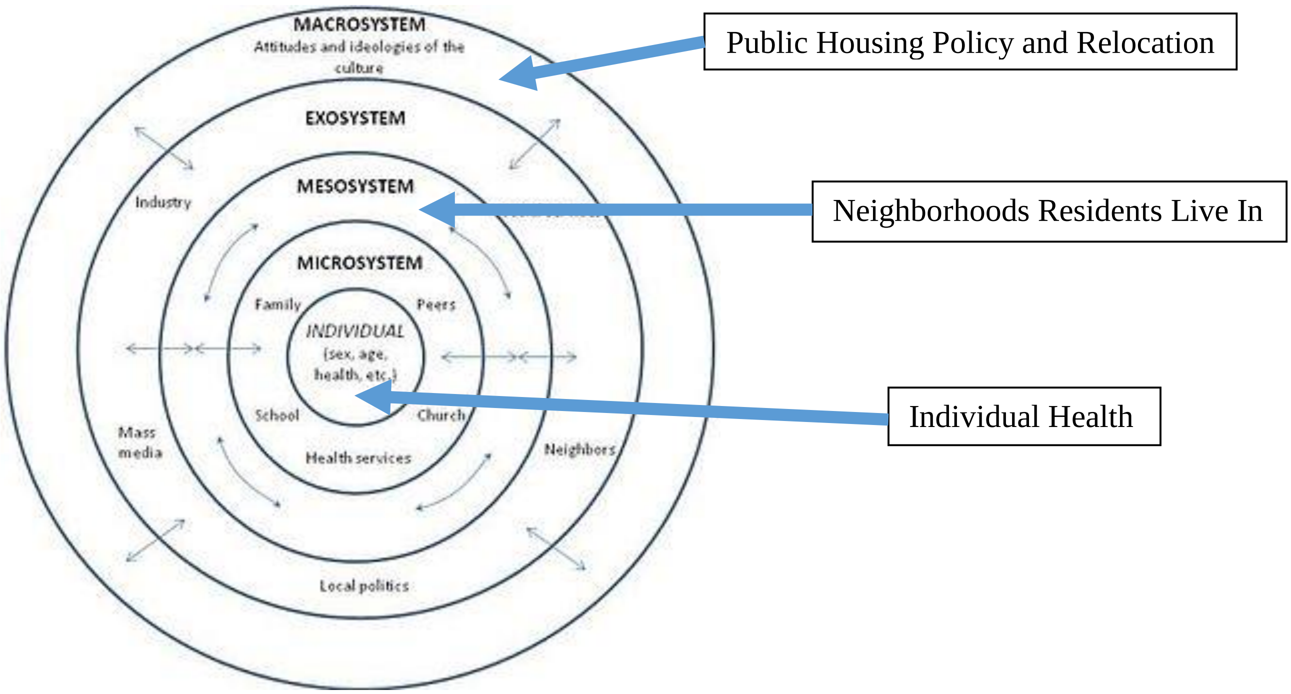

Figure 2.1 Social-ecological model (Bronfenbrenner 1999).

The ecological model is characterized by three factors. First, it shows a connection between individuals, families, and communities, as well as the biological, physical, social, and economic environments that surround them (Woolf & Aron 2013). Second, it emphasizes the existence of proximate (or downstream) health influences that are shaped by distal (or upstream) influences (Woolf et al. 2013). Third, it attempts to highlight societal processes, cultures, and values as the important upstream for conditions that affect health downstream (Woolf et al. 2013). The ecological model fits with this study because I am examining neighborhood-level factors on individual cardiovascular disease risk (Berrigan & McKinno 2008). As stated at the beginning of this chapter, I hypothesize that cardiovascular disease risk will decline (and overall health will improve) after relocation into the private market for former public housing residents. Secondly, I hypothesize that the decline in cardiovascular disease risk (and improvement in overall health) will be partially explained by improvements in the built environment. Thus, I hypothesize that the neighborhood built environment (the mesosystem) will have an effect on an individual's cardiovascular disease risk and overall health (the microsystem). The methods for conducting this study are below.

3 METHODOLOGY

The Urban Health Initiative is a longitudinal, prospective study that took place between 2009 and 2013. This study was aimed toward public housing residents living in Atlanta, GA whose communities were being demolished. The residents were moved into the private sector. The study was in the form of a predominately quantitative questionnaire. There were three waves of data collection among this population. The first was a baseline survey collected before residents left public housing. The second wave took place approximately 6 months after relocation into the private market. The third wave was collected once residents had been living out of public housing for 24 months. For the purposes of this study, I am examining data from the baseline study and the 24 month post-move study.

A partner study was conducted at the same time as the wave 3 data collection of the Urban Health Initiative study above. This was the Neighborhoods Matter study, which consisted of an objective built environment audit of the neighborhoods to which the public housing residents relocated, along with shorter interviews of five neighbors of the resident in their new neighborhoods. For this study, I use data from the built environment assessment to examine changes in the built environment and to determine whether said changes are related to a decrease in cardiovascular disease risk in this population after relocation.

3.1 Sample

There were 382 public housing residents who participated in the first wave of data collection. All respondents were aged 18 and older, and more than 90% of the residents interviewed were the leaseholders for their apartments (Oakley, Ruel, & Wilson 2008; Ruel, Oakley, Ward, Alston, & Reid 2012). The sampling strategy was originally a simple random sample of residents living in seven public housing projects, six of which were scheduled for demolition. However, after an initial response rate of 49%, the principal investigators decided to open up the pool of respondents to anyone who met eligibility criteria. Of the 382 respondents, 224 were randomly chosen and 158 were not (Oakley et al. 2008). Sensitivity analyses showed that there were no significant differences between the randomly and non-randomly selected individuals on any variable (Oakley et al. 2008). The residents were sampled from seven public housing communities. Six were scheduled for demolition within the year the survey was conducted, while one served as a ‘control,’ as their residents were not relocated, nor were there any plans to do so.

3.2 Constructs and Measures

For this study, I am interested in examining changes in cardiovascular disease risk in public housing residents after relocation. As stated above, I hypothesize that cardiovascular disease risk declines after relocation into the private market. Secondly, I hypothesize that the decline in cardiovascular disease risk will be partially explained by significant improvements in the built environment. Third, I hypothesize that subjective overall health will improve after relocation, and fourth, that the improvement in subjective overall health will be partially explained by improvements in the interior and exterior built environment. To test these hypotheses, I have created a number of constructs, some of which are aggregated into indices.

3.2.1 Urban Health Initiative

The data for this study come from a number of sources. The residents’ health information, demographic data, and subjective interior built environment assessments have been obtained through Urban Health Initiative’s wave 1 and wave 3 survey results. I am using wave 1 as a baseline measure, and wave 3 determines whether any significant change in health data and interior environment information exists. Most questions for this survey were quantitative with closed-ended questions.

From this study come all of the health-related and demographic variables. The first dependent variable in this study is overall health. The responses range from 1-5, where 1 indicates ‘excellent’ health and 5 indicates ‘poor’ health. The second dependent variable in this study is the prevalence of cardiovascular disease risk in the relocated public housing population. To assess risk, I have created an index of ‘cardiovascular disease risk’ based on residents’ answers to the following indicators: self-reported obesity, diabetes, high blood pressure, and a doctor’s diagnosis of coronary heart disease. All of the variables that comprise the index are dichotomized as dummy variables, with 0 indicating an answer of ‘no’ or an absence of the condition and 1 indicating an answer of ‘yes’ or a presence of the condition. Please see Appendix A for the questions associated with the above indicators. The index ranges from 0-4, with 1 point each for presence of any of the above and 0 points for absence of above indicators. For the purposes of this index, a score of 4 indicates presence of all indicators of cardiovascular disease risk. People with all four indicators are considered to be at higher risk of developing cardiovascular disease.

The interior built environment variables also come from this study. The interior built environment is one of two independent variables for this research. I have created an index of interior built environment features that could play a role in cardiovascular disease risk. The indicators of the interior built environment are self-reported, and thus subjective. The index consists of the following presence of the following: leaky roof, nonworking plumbing, broken windows, electrical problems, pests, working smoke detector, and water damage, and whether the stove/oven and furnace works. As all indicators but the smoke detector are negative, the question regarding the smoke detector is reverse-coded to be consistent with the other indicators. Please see Appendix A for the questions associated with the interior built environment. The index ranges from 0-10, with 0 indicating an absence of all indicators above and 10 indicating a presence of all indicators. A score of 10 indicates a highly negative interior built environment, because residents with that score are subject to every negative aspect that we asked about inside their homes. We asked residents about the overall condition of their house (or apartment) before and after relocation. There were four possible responses: excellent, good, fair, and poor. Finally, we asked residents about their satisfaction with their neighborhood. There were five possible responses: very satisfied, satisfied, in the middle, dissatisfied, and very dissatisfied.

Finally, the demographic and control variables also come from the Urban Health Initiative study. I am using a number of demographic variables as controls to ensure, to the extent it is possible, that any influence the independent variables have on the dependent variable are not confounded by alternate explanations. The demographic variables that are controlled in this study include education, marital status, income, age, and sex. Race was not a control factor, as 97% of the residents interviewed were African-American. Please see Appendix A for the control variables and measures.

3.2.2 Neighborhoods Matter Study

The second source of data is come from the Neighborhoods Matter study, described above. I examined the built environment assessment portion of this study. These data are also quantitative, as the assessments consisted of counting multiple characteristics of the built environment within a one block radius of the residents' home.

From this study, I have collected the pertinent exterior built environment variables that were consistent amongst all types of residences (apartments, single family homes, or high-rises).

These variables have also been aggregated into an index for ease of analysis. The exterior built environment consists of eleven indicators of the residents' immediate surroundings, within a block of their residence. The indicators for this index include: the presence of sidewalks, curbs, graffiti, abandoned vehicles, damaged street signs, unboarded abandoned buildings, boarded abandoned buildings, for sale or for rent signs, crime watch signs, crosswalks, and stop signs or street lights. Please see Appendix A for all index indicators. The presence of sidewalks, curbs, crosswalks, and stop signs/street lights are positive, while the others are negative aspects of the built environment. Therefore, I have reverse-coded the positive aspects to create an index consistent with the other two above, where negative aspects lead to a higher score. This index ranges from 0-11, with 0 indicating an absence of all negative indicators of the built environment, and 11 indicating a presence of all negative indicators of the built environment.

3.2.3 Retrospective Built Environment Assessment

Finally, the third source of data comes from Google Street View. In order to be able to compare the built environment of residents' neighborhoods before and after relocation, I conducted a retrospective built environment assessment of the public housing projects from which residents relocated. All but one of the public housing communities are available pre-demolition on Google Street View (GSV). Google Street View has been used in previous studies to conduct built environment assessments, and the researchers found that the results obtained from GSV have a high reliability to built environment assessments conducted in person (Rundle, Bader, Richards, Neckerman, & Teitler 2011). For the public housing community that did not have pre-demolition views on GSV, I examined a YouTube video from January 2009 to conduct its retrospective built environment assessment. This YouTube video can be considered valid in that the videographer walks around his public housing project after the residents were made aware of their pending relocation, but before the actual demolition. With slow, sweeping camera pans, the videographer captures all of the exterior built environment features that I examine in the video, and thus, can be considered a valid representation of the one public housing project for which information was not available in Google Street View.

3.3 Analysis

To analyze the data, I first conducted a univariate descriptive analysis for each variable. For the health variables of overall health, cardiovascular disease, diabetes, obesity, high blood pressure, and cardiovascular disease risk, I conducted cross-tabulations to determine whether there was significant change from baseline to wave 3 data. I also conducted cross-tabulations on the condition of the residents' house/apartment, the interior built environment index, the exterior built environment index, and the residents' satisfaction with their neighborhood.

Secondly, I conducted an ordinal logistic regression on the dependent variables. Each hypothesis was tested separately, once as a bivariate regression and again with the control variables added. To ensure the models of analysis is the best fit for the data, I used model-fit and goodness-of fit statistics. The significance threshold for these tests and for all other variable significance tests is at $\alpha = 0.05$. A significant chi-square model-fit test statistic and nonsignificant Pearson's goodness-of-fit test statistic indicate that the models are a good fit for the data. Further, I report Cox & Snell pseudo R-square statistics to give a general idea of the extent to which the variance is explained by the variables in the study.

These methods of analysis are appropriate in determining the change between health and cardiovascular disease risk, and both the overall health variable and the cardiovascular disease risk are ordinal variables. Further, the ordinal logistic analyses will help to explain the extent to which the exterior and interior built environment are associated with overall health and cardiovascular disease risk. With these two methods, I am able to reliably assess whether significant differences in health and cardiovascular disease risk exist, and if so, how much the built environment can help explain these differences.

4 RESULTS

For this analysis, I am using data from relocated residents that participated in the third wave of data collection. The original data collection consisted of 382 interviews from residents in seven public housing communities. The third wave of data consisted of 302 interviews, for a retention rate of 79%. I eliminated the senior residents who did not relocate (n=53), those who did not have data for their wave 3 exterior built environment (n=15), and those who did not complete a majority of the questions of interest (n=3). To conduct these analyses, I used a total sample of 231 residents.

4.1 Univariate Descriptive Analysis

The results of the descriptive analyses are displayed in Table 4.1. We asked residents about their overall house condition before and after relocation. At the baseline measure, the largest percentage of residents said that their house was in ‘fair’ condition (n=89, 38.5%). However, the largest percentage group response for wave 3 data was that residents found their houses to be in ‘good’ condition (n=103, 44.6%). Please see Figure 4.1 for the results of this question. When asked about their satisfaction with their neighborhood, at baseline the largest percentage of residents of residents (n=53, 22.9%) indicated that they were ‘in the middle,’ neither satisfied nor dissatisfied with their neighborhood. This measure took a big leap in the post-relocation responses. In wave 3, nearly half of residents (n=110, 47.6%) indicated that they were ‘very satisfied’ with their neighborhoods. See Figure 4.2 for a dispersion graph. In examining the responses for the interior built environment index, at baseline the majority of residents indicated that they had at least one negative built environment condition (n=182, 79%). This number dropped by quite a bit at

Table 4.1. Descriptive Statistics for Built Environment Variables

Variable	Response	Wave 1		Wave 3	
		n	%	N	%
Condition of House	Excellent	31	13.4	82	35.5
	Good	80	34.6	103	44.6
	Fair	89	38.5	38	16.5
	Poor	31	13.4	8	3.5
Satisfaction with Neighborhood	Very Satisfied	51	22.1	110	47.6
	Satisfied	48	20.8	56	24.2
	In the Middle	53	22.9	39	16.8
	Dissatisfied	40	17.3	13	5.6
	Very Dissatisfied	39	16.9	13	5.6
Interior Built Environment Index	0 Conditions	49	21.0	108	46.8
	1 Condition	66	28.6	60	26
	2 Conditions	42	18.2	29	12.6
	3 Conditions	25	10.8	17	7.4
	4 Conditions	19	8.2	11	4.0
	5 Conditions	18	7.8	2	0.9
	6 Conditions	8	3.5	2	0.9
	7 Conditions	4	1.7	2	0.9
Exterior Built Environment Index	0 Conditions	0	0	2	0.9
	1 Condition	0	0	35	15.2
	2 Conditions	78	33.8	55	23.8
	3 Conditions	76	32.9	37	16
	4 Conditions	77	33.3	39	16.9
	5 Conditions	0	0	33	14.3
	6 Conditions	0	0	16	6.9
	7 Conditions	0	0	10	4.3
	8 Conditions	0	0	3	1.3
	9 Conditions	0	0	1	0.4
Improvement in Quality of Life	Strongly Agree			71	30.7
	Agree			96	41.6
	No Opinion			31	13.4
	Disagree			27	11.7
	Strongly Disagree			6	2.6
Total n = 231					

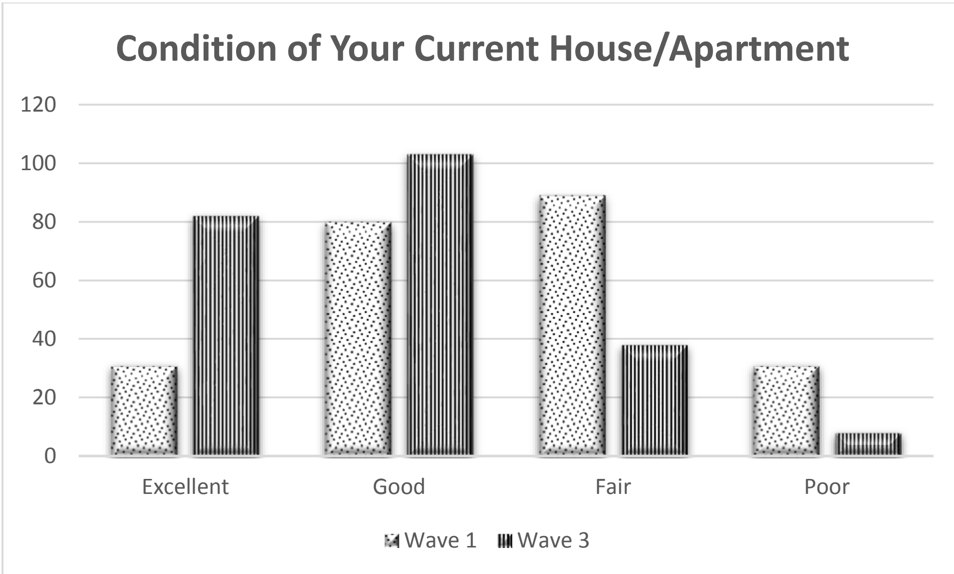

Figure 4.2. Condition of Residents' Current House.

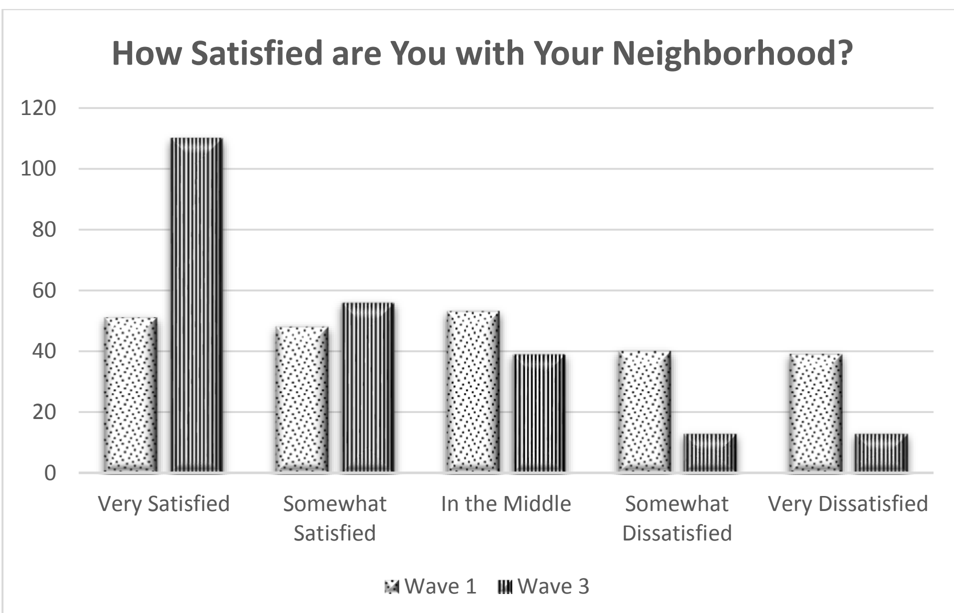

Figure 4.3. Neighborhood Satisfaction Distribution.

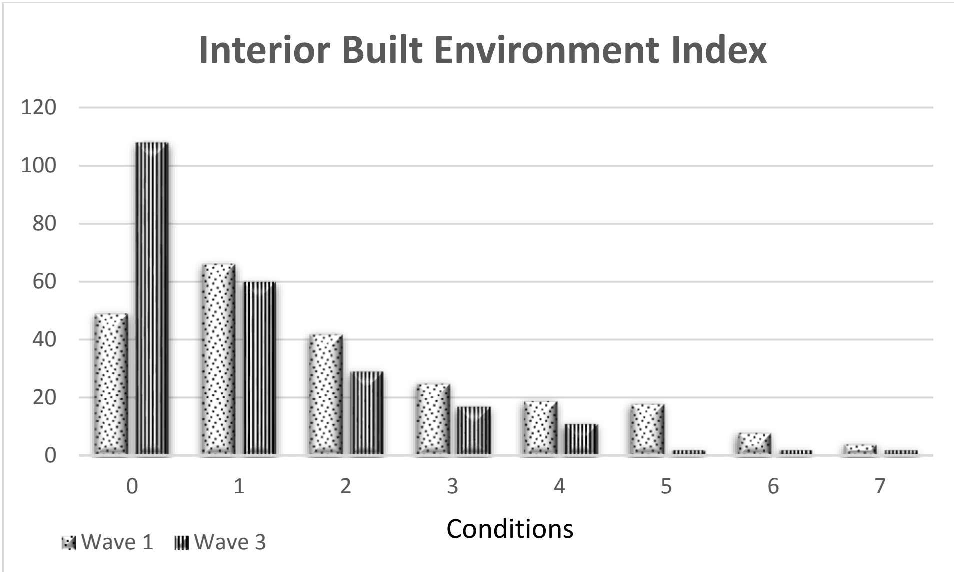

Figure 4.4. Interior Built Environment Index Distribution.

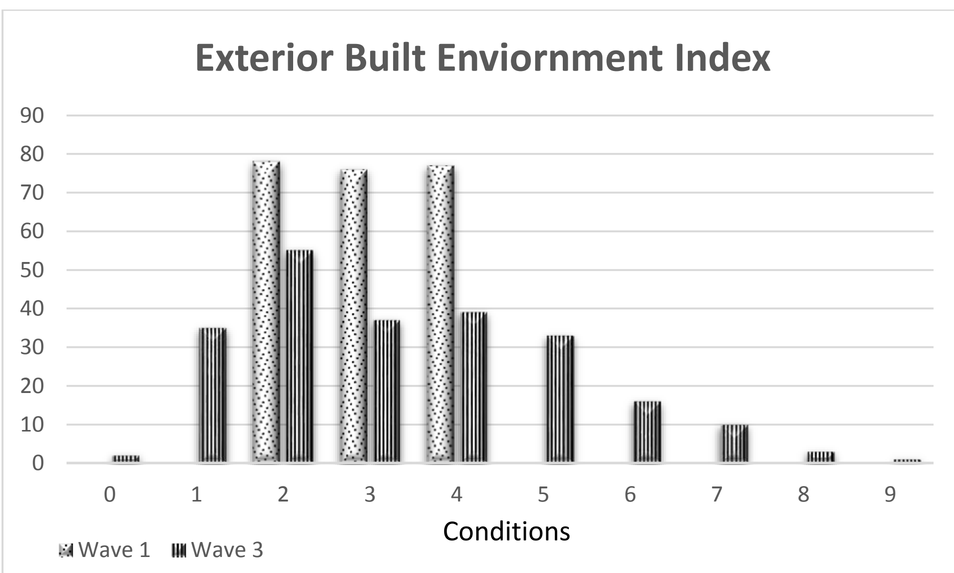

Figure 4.5. Exterior Built Environment Index Distribution.

wave 3 data collection. At 24 months post-relocation, the number of people who had at least one negative interior built environment condition dropped by a third (n=122, 53.2%). Please see Figure 4.2 for a graph of the dispersions of each variable.

The exterior built environment index variable results are interesting. The data for this variable can also be found in Table 4.1. For the first wave of data collection, the results for the exterior built environment variables were quite flat, meaning that there was not a lot of variability between the different communities. Of the possible eleven built environment negative indicators, one third of residents had two negative conditions, one third had three negative conditions, and the last third had three negative conditions. As all residents originated in one of six public housing projects, this lack of variability is not wholly surprising. In the third wave of data collection, there is much more variability in the amount of negative exterior built environment conditions that exist for residents. The largest group of residents had two negative exterior built environment conditions (n=55, 23.8%), but it ranged from 0 conditions to 9 conditions post relocation. Please see Figure 4.4 for the dispersion of exterior built environment index. Finally, we asked residents at wave 3 whether relocation had improved their quality of life. Residents overwhelmingly agreed that this was the case. Please see Figure 4.5 for the results of this question.

For the dependent variable of overall health, at baseline the largest group of residents stated that they were in good health (n=69, 29.9%). However, at wave 3 the largest group of residents stated that they were in fair health (n=73, 31.6%). For the dependent variable of cardiovascular disease risk, the largest percentage of residents at wave 1 had one of the four conditions that make up the index (n=75, 32.5%). That percentage stayed the same for the wave 3 data (n=70, 30.3%), but in general,

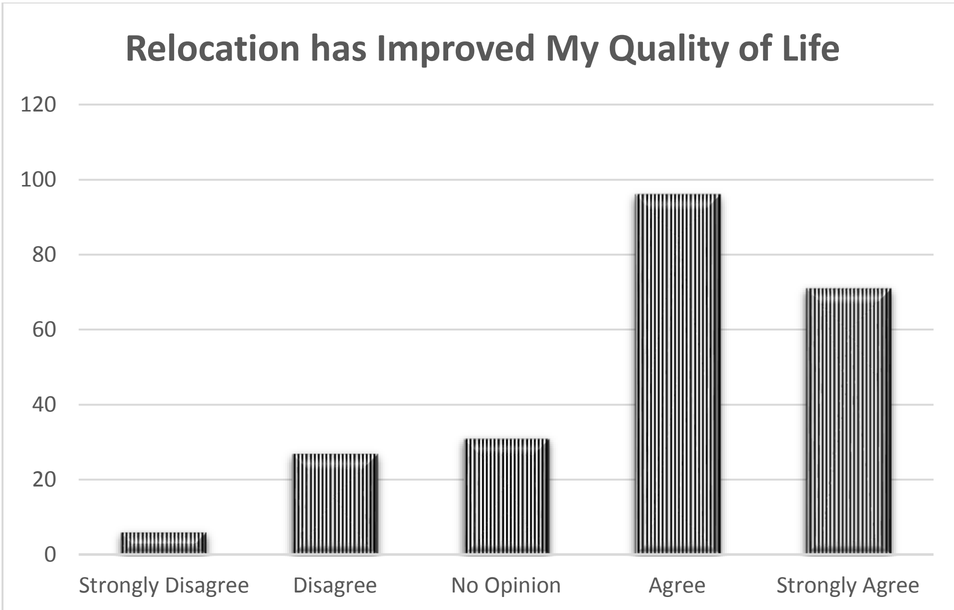

Figure 4.6. Improved Quality of Life.

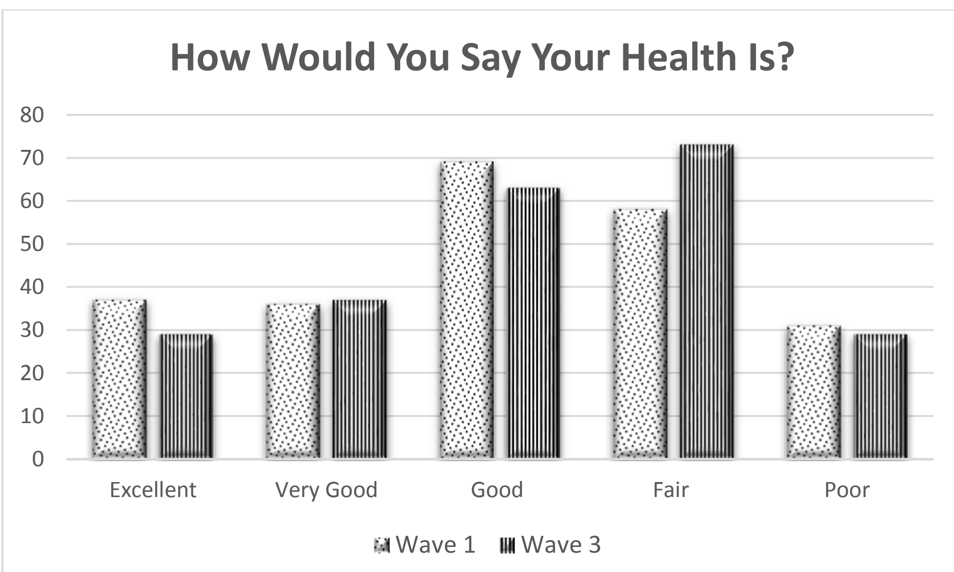

Figure 4.7. Distribution of Overall Health Variable.

Table 4.2 Descriptive Statistics for Health Variables

Variable	Response	**Wave 1**		**Wave 3**	
		n	%	n	%
Overall Health	Poor	31	13.4	29	12.6
	Fair	58	25.1	73	31.6
	Good	69	29.9	63	27.3
	Very Good	36	15.6	37	16.0
	Excellent	37	16.0	29	12.6
CVD	No	202	86.7	204	88.3
	Yes	29	12.4	27	11.7
Diabetes	No	188	81.4	177	76.6
	Yes	43	18.6	54	23.4
Obesity	No	115	49.8	114	48.9
	Yes	116	50.2	117	50.2
High Blood Pressure	No	108	46.4	107	46.3
	Yes	123	52.8	124	53.7
CVD Risk	0 Conditions	58	25.1	58	25.1
	1 Condition	75	32.5	70	30.3
	2 Conditions	61	26.4	62	26.8
	3 Conditions	34	14.7	36	15.6
	4 Conditions	3	1.3	5	2.2
Total n = 231					

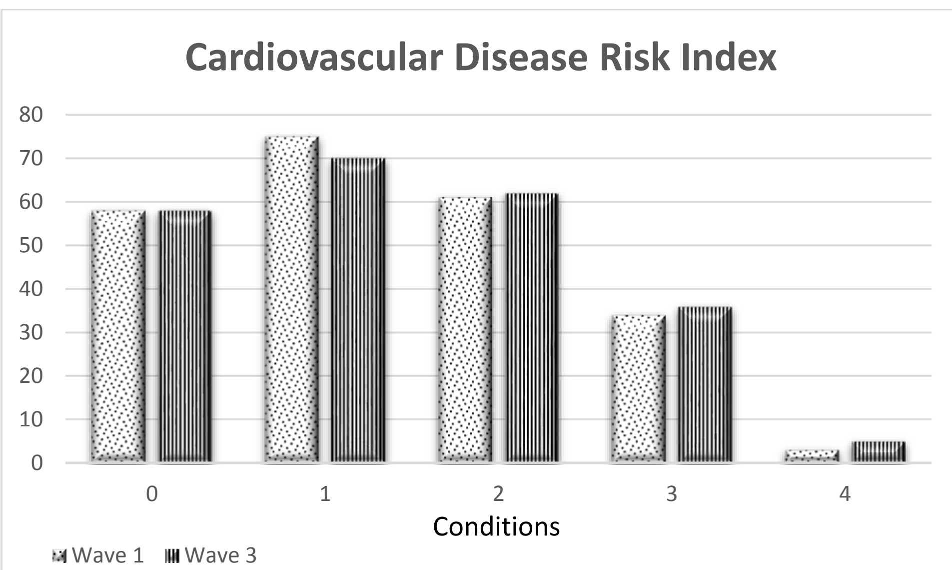

Figure 4.8. Cardiovascular Disease Risk Distribution.

the proportion of people who had more than one condition of cardiovascular disease risk rose. Please see Figures 4.6 and 4.7 for the distribution of the health variables. Overall, for both dependent variables, results indicated that residents' health was worse after relocation, but the numbers did not rise significantly.

Finally, there are six control variables for this study. Please see Table 4.3 for the descriptive statistics of these variables. The first is age. This is categorized into one of three groups: young (18-39), middle aged (40-65) and elderly (over 65). The young and middle aged residents made up the majority of residents (n=192, 82.7%). The second control variable is sex. Females make up the vast majority of the residents interviewed (193, 83.2%). Third is income.

Table 4.3. Descriptive Statistics of Control Variables

		Sample		Overall Wave 3	
Variable	Response	n	Percentage	n	Percentage
Age	Young	94	40.5%	96	31.4%
	Middle Age	98	42.2%	146	47.7%
	Elderly	40	17.2%	64	20.9%
Sex	Male	39	16.8%	78	25.3%
	Female	193	83.2%	230	74.7%
Income (center point)	< $250	15	6.4%	15	5.6%
	$375	17	7.3%	18	6.8%
	$625	82	35%	102	38.3%
	$875	58	24.8%	56	21.1%
	$1125	30	12.0%	37	13.9%
	$1375	4	1.7%	10	3.8%
	$1875	12	5.1%	12	4.5%
	$2125	5	2.1%	6	2.3%
	$2700	8	3.4%	9	3.4%
	> $3000	1	0.4%	1	0.4%
Marital Status	Single	212	91.4%	259	91.8%
	Married/Cohabiting	20	8.6%	23	8.2%
Education	No HS Diploma/GED	108	46.6%	143	46.6%
	HS Diploma/GED	124	53.4%	164	53.4%
Total n = 231					

The highest frequencies of income were at a monthly income of $625 a month (n=82, 35%) and $875 a month (n=58, 24.8%). The fourth control variable is marital status. The residents were overwhelmingly single (n=212, 91.4%). Finally, the fifth control variable is education. This variable is fairly evenly distributed, with nearly half (n=108, 46.6%) with no high school diploma or GED, and the other half (n=124, 53.4%) with at least a high school diploma or GED. The results of the sample for this study were very similar to the overall Wave 3 study population, with the exceptions of age and sex. Participants for this study were more likely to be female and younger, but were nearly identical in terms of income, marital status, and education.

4.2 Cross-tabulations

After conducting descriptive analyses, I ran a series of cross-tabulations on the health variables and on the built environment variables. P-values were obtained using Cochran's Q, which determines whether there is a statistical difference between two or more matched groups. A significant p-value of $< .05$ indicates that there is a significant difference between the groups. Please see Tables 4.4 and 4.5 for the results of the cross-tabulations for these variables.

4.2.1 Cross-tabulations of the Built Environment Variables

For the overall condition of residents' houses, residents perceived a significant improvement in the condition of their houses after relocation. Additionally, residents were significantly more satisfied with their post-relocation neighborhoods compared to their public housing apartments. Table 4.4 shows how residents perceived the conditions of their houses and their satisfaction with their neighborhood pre- and post-relocation. The numbers in bold show an improvement in residents' perceptions of their house and neighborhood, while the numbers in italics show a decline in residents' perceptions of their house and neighborhood. The interior built environment index followed the same pattern as the above variables. Residents lived in areas with a significantly improved interior built environment after relocation. What is interesting is that the exterior built environment moved in the opposite direction of the other built environment variables. After relocation, residents were significantly more likely to live in areas with a *worse* exterior built environment than before.

Table 4.4. Cross-Tabulations of the Built Environment Variables

Condition of House	Measures Wave 3	Excellent	Good	Fair	Poor	Total		p-value
Measures Wave 1	Excellent	18	*10*	*3*	*0*	31		**<.001**
	Good	**29**	40	*8*	*3*	80		
	Fair	**23**	**43**	22	*1*	89		
	Poor	**12**	**10**	**5**	4	31		
	Total	82	103	3	8	231		
Satisfaction with Neighborhood	Conditions Wave 3	Very Satisfied	Somewhat Satisfied	In the Middle	Somewhat Dis-satisfied	Very Dis-satisfied	Total	p-value
Conditions Wave 1	Very Satisfied	39	*6*	*3*	*0*	*3*	51	**<.001**
	Somewhat Satisfied	**23**	13	*6*	*3*	*3*	48	
	In the Middle	**19**	**13**	16	*3*	*2*	53	
	Somewhat Dissatisfied	**13**	**14**	**8**	3	*2*	40	
	Very Satisfied	**16**	**10**	**6**	**4**	3	39	
	Total	110	56	39	13	13	231	

Table 4.5. Changes in the Interior and Exterior Built Environment

Interior Built Environment	n	%
Negative Change (the interior built environment declined).	47	20.4
Zero Change	55	23.8
Positive Change (the interior built environment improved)	129	55.8
Total = 231		
P-value <**.001**		

Exterior Built Environment	n	%
Negative Change (the exterior built environment declined).	94	40.7
Zero Change	63	27.3
Positive Change (the exterior built environment improved)	74	32.0
Total = 231		
P-value <**.001**		

4.2.2 Cross-tabulations of the Health Variables

As Table 4.6 shows, there were not many significant differences in health between wave 1 and wave 3 of data collection. Residents did not perceive a significant difference in their overall health, nor were there significant differences in cardiovascular disease, obesity, high blood pressure, or overall cardiovascular disease risk. However, the exception was diabetes. Residents were significantly more likely to be diabetic 24 months after relocation than they were pre-relocation (Table 4.7).

Table 4.6. Cross-Tabulations of the Health Variables

Variable		Measures						p-value
Overall Health		Excellent	Very Good	Good	Fair	Poor	Total	
Measures	Excellent	14	*9*	*10*	*3*	*1*	37	.574
	Very Good	**6**	12	*10*	*8*	*0*	48	
	Good	**8**	**9**	31	*16*	*5*	53	
	Fair	**1**	**5**	**8**	36	*8*	40	
	Poor	**0**	**2**	**4**	**10**	15	31	
	Total	29	37	63	73	29	231	
		Conditions Wave 1						
Cardiovascular Disease Risk		0	1	2	3	4	Total	
Conditions Wave 3	0	40	*14*	*1*	*2*	*1*	58	.691

	1	**14**	43	*15*	*3*	*0*	75	
	2	**3**	**11**	40	*7*	*0*	61	
	3	**1**	**2**	**5**	24	*2*	34	
	4	**0**	**0**	**1**	**0**	2	3	
	Total	58	70	62	36	5	231	

Table 4.7. Cross-Tabulations of the Dichotomous Health Variables

Variable	Wave 1	Wave 3		p-value
Cardiovascular Disease		No	Yes	
	No	190	12	.845
	Yes	14	15	
Diabetes	No	174	14	**.013**
	Yes	3	40	
High Blood Pressure	No	88	20	.873
	Yes	19	104	
Obesity	No	97	18	.866
	Yes	17	99	

4.3 Ordinal Logistic Regressions of the Built Environment Indices on Health

The first two ordinal logistic models (shown in Table 4.8) examine the effects of the interior and exterior built environment on overall subjective health of residents after relocation. The second model includes the control variables described above. The first model has a model-fit statistic of .106, indicating that the model is not a good fit for the data. Therefore, I will not discuss it further. The second model is a much better fit for the data, with a model-fit statistic of .001 and a goodness-of fit of .351. The Cox & Snell pseudo-R square indicates that this model explains approximately 10.6% of the variables in the dependent variable of overall health at wave 3. The model indicates that the interior built environment have a significant impact on subjective overall health. For every one unit increase in interior built environment conditions (indicating a worsening of the interior built environment), we expect a 0.227 decrease in the log odds of overall health. Age also had a significant effect on overall health.

Table 4.8. Ordinal Logistic Regression of Built Environment Variables on Health

	Model 1				Model 2			
Variable	Estimate	95% Confidence Interval		P-value	Estimate	95% Confidence Interval		P-value
		Lower	Upper			Lower	Upper	
Interior Built Environment	0.187	0.018	0.355	**.030**	0.227	0.055	0.398	**.010**
Exterior Built Environment	0.001	-0.127	0.128	.993	0.120	-0.022	0.261	.098
Age					0.826	0.447	1.206	**<.001**
Sex					-0.160	-0.817	0.496	.632
Marital Status					-0.006	-0.861	0.849	.989
Income					0.022	-0.114	0.157	0.753
Education					-0.209	-0.688	0.270	0.393
Model-fit	.106				.001			
Goodness-of-Fit	.327				.351			
Cox & Snell	.019				.106			
n=231								

The second two ordinal logistic models examine the effects of the interior and exterior built environment on cardiovascular disease risk. Please see Table 4.9 for the ordinal logistic results. The second of the two models includes the control variables. The first model has a model-fit statistic of .479 and a goodness-of-fit of .004, indicating again that the model was not a good fit for the data. As before, because of this, I will not discuss it further. In the second model, the model-fit statistic was significant (at $p < .001$) and the goodness-of-fit was not significant, indicating that the model was a good fit for the data. The Cox & Snell pseudo R square indicates that the model explains 14.6% of the variance in cardiovascular disease risk at wave 3. What is interesting with this model is that neither the interior nor the exterior built environment has a

Table 4.9. Ordinal Logistic Regression of Built Environment Variables on Cardiovascular Disease Risk

	Model 1				Model 2			
Variable	Estimate	95% Confidence Interval		P-value	Estimate	95% Confidence Interval		P-value
		Lower	Upper			Lower	Upper	
Interior Built Environment	0.067	-0.099	0.233	0.430	0.115	-0.055	0.286	0.184
Exterior Built Environment	-0.066	-0.195	0.062	0.312	0.085	-0.057	0.228	0.240
Age					1.044	0.655	1.433	**<.001**
Sex					0.0883	-0.743	0.576	.804
Marital Status					0.727	-0.139	1.593	.100
Income					0.081	-0.056	0.219	.246
Education					-0.300	-0.783	0.183	.223
Model-fit	.479				<.001			
Goodness-of-Fit	.004				.771			
Cox & Snell	.006				0.146			
n=231								

significant impact on cardiovascular disease risk. In fact, the only variable that is significant is age, which is not surprising given its existing link with cardiovascular disease risk.

Finally, because the health variable of diabetes increased significantly between waves one and three of data collection, I conducted an ordinal logistic regression to see if its significant change could be attributed to changes in either the interior or exterior built environment. Please see Table 4.9 for the ordinal logistic model. As with the others, I ran two ordinal logistics. The first did not include the control factors, while the second did. In the first model, the model fit and the goodness of fit statistics indicated that the model was not a good fit

Table 4.9. Logistic Regression of Built Environment Variables on Diabetes

	Model 1				Model 2			
Variable	Estimate	95% Confidence Interval		P-value	Estimate	95% Confidence Interval		P-value
		Lower	Upper			Lower	Upper	
Interior Built Environment	0.178	-0.028	0.385	.091	0.226	0.004	0.449	**.046**
Exterior Built Environment	-0.116	-0.292	0.060	.198	0.009	-0.190	0.208	.931
Age					0.812	0.302	1.322	**.002**
Sex					0.211	-0.637	1.059	.626
Marital Status					1.217	0.140	2.295	**.027**
Income					0.106	-0.086	0.298	.280
Education					-0.519	-1.183	0.146	.126
Model-fit	.142				.002			
Goodness-of-Fit	.735				.206			
Cox & Snell	.017				.093			
n=231								

for the data, much like the previous two models. However, the second model proved to be a good fit for the data. The interior built environment significantly affected diabetes status. With every one unit increase in interior built environment factors, the log odds of having diabetes increased by 0.226. As discussed earlier, the higher the interior built environment index, the worse the interior conditions are, such as the presence of peeling paint or bad plumbing. Thus, this model shows that after relocation, the likelihood of having diabetes increased as interior conditions worsened. Even though the interior built environment improved on average for the cohort, a poor indoor environment is connected with diabetes prevalence. The control variables that significantly explained changes in diabetes status were the control variables of age and (interestingly) marital status.

4.4 Hypothesis Testing

To conduct this study, I developed four hypotheses to determine whether health was influenced by the built environment, and if so, to what extent. To recap, I hypothesize that factors that contribute to cardiovascular disease risk, such as diabetes, high blood pressure, and obesity, will decline after relocation into the private market. Secondly, I hypothesize that the decline in these cardiovascular disease risk factors will be partially explained by improvements in the built environment. Third, I hypothesize that subjective overall health will improve after relocation, and fourth, that the improvement in subjective overall health will be partially explained by improvements in the interior and exterior built environment.

The results above show that the hypotheses were not supported. For the first hypothesis, the t-tests show that there is not a significant difference in cardiovascular disease risk after relocation. However, all built environment variables were significantly different. This is further supported by the ordinal logistic regression. In the results, the only variable that had a significant effect on cardiovascular disease was the control variable of age. Therefore, I must conclude that significant changes in the built environment are not significantly associated with a change in cardiovascular disease risk.

The third hypothesis examines the effects of the built environment variables on overall health. The t-tests show that there is not a significant difference in subjective overall health after relocation. The ordinal logistic results show that both the interior and exterior built environment have a significant effect on overall health. However, since the t-tests show that there is no significant differences in health, the ordinal logistic results do not help justify the hypothesis. Therefore, I must conclude that significant changes in the built environment are not significantly associated with a change in overall health.

5 DISCUSSION

Although none of the hypotheses were supported by the analysis, there is still a significant story to tell with the data. Residents were significantly more satisfied with both their new housing and their new neighborhoods. These results are similar to other research into public housing relocation, in that most residents felt that their situation had improved and they were more satisfied with their housing (Boston 2005; Brooks et al. 2005; Goetz 2003). One of the most important items of note in this analysis is the significance of the built environment data. Both the interior built environment index and the exterior built environment index significantly changed after relocation.

What is interesting is that while the interior built environment was significantly improved, the exterior built environment got significantly worse. A potential explanation for the improvement of interior built environment conditions lies with the Department of Housing and Urban Development standards for Section 8 housing. HUD has strict standards for this type of housing, including annual checks and stringent maintenance standards. When these standards are violated, residents are required to relocate to new housing that does meet these standards. Therefore, most if not all former public housing residents will relocate into areas with an improved interior built environment. While conducting the built environment assessments, it was remarkable how similar the public housing projects were to each other. In fact, while the conditions between public housing projects varied, one third of residents had two negative exterior built environment conditions, another third had three, and the final third had four. The presence of sidewalks and curbs went down in the wave 3 data, along with the presence of crosswalks and stop signs. Interestingly, the presence of graffiti and unboarded abandoned buildings went down as well, while the presence of boarded buildings nearly doubled in the new neighborhoods. Finally, indicators that were not present in the public housing projects, such as abandoned cars, damaged street signs, and for sale signs, were all present after relocation. Please see Figure 5.1 for a chart showing each exterior built environment indicator and their presence before and after relocation.

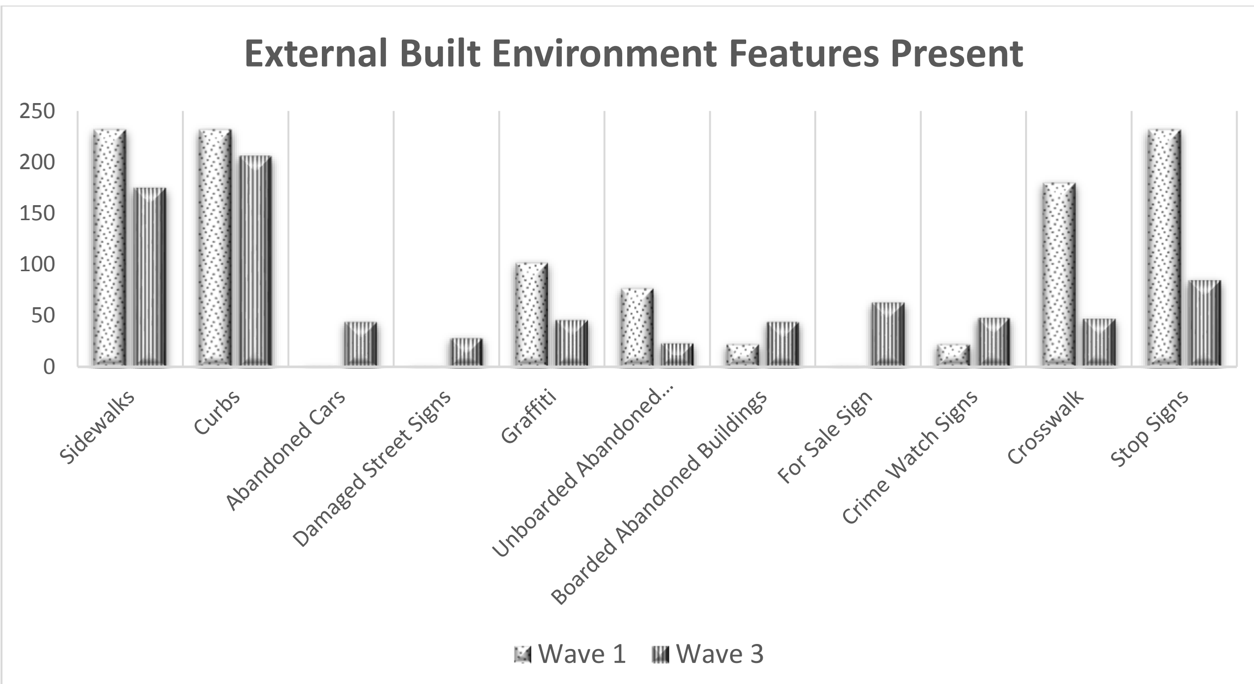

Figure 5.1. Exterior Built Environment Features and Differences Post-Relocation.

These results are in line with prior research that show that public housing residents do not experience an improvement in their health after relocation (Goetz et al. 2010). One reason for this could be that residents simply did not move far enough away. Boston (2005) shows that residents who moved to the suburbs benefitted more than those who relocated but stayed in the immediate area. Because most residents moved very near their old public housing projects, the same factors that negatively affected their health before have continued to do so after relocation (Sallis et al. 2006). There are other reasons that could explain the lack of a decline in cardiovascular disease risk in this population. First, while some indicators such as blood pressure and obesity could vary more easily in the short-term, other factors such as diabetes and a diagnosis of existing cardiovascular disease are not likely to change as quickly. Thus, it could be that since the cardiovascular disease risk index included both variable and stable indicators of cardiovascular disease, it did not change much due to the stability of hard-to-change factors. Second, it may be that the timeline for examining change was too short. The baseline data was collected before relocation, while the third wave of data was collected only two years after relocation. It may take more time for cardiovascular health to improve or decline.

Although not an original focus of the study, the significant findings regarding diabetes are worth mentioning. It is interesting that residents were significantly more likely to develop diabetes after relocation. Further, a decline in the interior built environment conditions is associated with an increase in diabetes prevalence in this population. As most residents experienced an improvement in their interior built environment, it is interesting to see that the few who experienced a decline in their interior built environment had much higher log odds of developing diabetes. Future research should address this association to explain why this connection exists.

There are a few limitations to this study; the first being sample size. This sample is close to, but not completely representative of, the public housing population in general. The sample was fairly homogenous, with many of the individuals being African-American, unmarried, and female. However, the homogeneity of the sample is representative of the public housing population in Atlanta. Thus, it is unlikely that these results could be generalizable to the national public housing population, but could conceivably be generalized to Atlanta. Future research could focus on increasing the generalizability of the results to a broader population. The sample size could also have affected the statistical results. The lack of statistical power may have resulted in some of the non-significant findings. The second limitation involves the cardiovascular disease index. When we interviewed the public housing residents, we neglected to ask them about their physical activity or cholesterol levels. Thus, I was unable to use a validated index of cardiovascular disease risk such as the Framingham Heart Study index (available at https://www.framinghamheartstudy.org/risk-functions/coronary-heart-disease/10-year-risk.php) to determine risk. By not including cholesterol or physical activity in my index, I may have neglected two large risk factors of cardiovascular disease that needs to be considered. Third, the interior and exterior built environment were measured using different standards. The interior built environment was measured using subjective self-reported interview questions, while the exterior built environment was conducted by objective assessors. This could potentially impact results, as residents could have answered questions improperly or incorrectly. However, as most questions involving the interior built environment consisted of yes/no questions regarding whether the conditions existed, it is likely that residents answered the questions accurately. Finally, using self-reported health measures could be considered biased, as each individual has different criteria upon which to measure their own health. However, significant bias is unlikely, because self-reported health has been found to be a reliable predictor of cardiovascular risk in past research (Møller, Kristensen, & Hollnagel 1996; Spertus, Jones, McDonell, Fan, & Fihn 2002)

Future research in this field could address these limitations in a number of ways. First, asking residents about their cholesterol would allow measurement of cardiovascular disease risk through the valid index created through the Framingham Heart Study. Second, a future study could include objective biometrics, such as blood pressure readings and cholesterol checks to prevent subjective and recall bias. Finally, while the sample was fairly representative of the Atlanta public housing population, it was a small sample. Conducting a study with a larger sample size would help improve statistical power and generalizability.

6 CONCLUSION

In 2009, public housing residents in Atlanta were relocated into the private market. Prior research of relocated public housing residents indicates that health does not improve significantly after relocation. However, the literature states that the built environment does improve for residents after relocation. Overall, this research contributes to the literature in that it provides support for previous research that states that the health of public housing residents does not improve after relocation into the private market. It also provides support to the research that states that the built environment does improve after relocation. However, this study goes further and indicates that while the interior built environment improved significantly after relocation, the exterior built environment became significantly worse. These results should be taken into consideration when determining whether other public housing projects are to be demolished and their residents relocated.

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APPENDIX A

Cardiovascular Disease Index Indicators

Variable	Full Survey Question	Measure	Type of Variable
Cardiovascular Disease	In the last 12 months, have you been told by a doctor, nurse or other health professional that you have or had coronary heart disease, a heart attack, myocardial infarction, or angina?	Yes/No (after recode)*	Dichotomous
Blood Pressure	In the last 12 months, have you been told by a doctor, nurse, or other health professional that you have high blood pressure?	Yes/No (after recode)*	Dichotomous
Diabetes	In the last 12 months, have you been told by a doctor that you have diabetes?	Yes/No (after recode)*	Dichotomous
Obesity	About how much do you weigh without shoes? About how tall are you without your shoes?	Yes/No (after recode)*	Dichotomous

*****Original question had multiple responses, but were condensed into a yes/no dichotomy.

Exterior Built Environment Index Indicators

		Reverse Coded?
Presence of Sidewalks	Count	Yes
Curbs	Count	Yes
Graffiti	Count	No
Abandoned Vehicles	Count	No
Damaged Street Signs	Count	No

Unboarded Abandoned Buildings	Count	No
Boarded Abandoned Buildings	Count	No
For Sale/For Rent Signs	Count	No
Crime Watch Signs	Count	Yes
Crosswalks	Count	Yes
Stop Signs/Street Lights	Count	Yes

Interior Built Environment Index Indicators

Variable	Full Survey Question	Measure	Type of Variable
Leaky Roof	A leaky roof or ceiling?	Yes/No	No
Plumbing Not Working	Is there a sink, toilet, hot water heater, or other plumbing that doesn't work in your apartment or home?	Yes/No	No
Broken Windows	Are there broken windows in your apartment or home?	Yes/No	No
Electrical Problems	Are there exposed electrical wires or other electrical problems in your apartment or home?	Yes/No	No
Pests	Are there mice or rates in or around your apartment or home? Are there pests, such as cockroaches, in or around your apartment or home?	Yes/No	No
Working Smoke Detector	Is there a working smoke detector in your apartment or home?	Yes/No	Yes
Water Damage	During the last 12 months, has there been water damage to the floors or walls, or ceiling from leaks, broken pipes, heavy rain, or floods?	Yes/No	No
Stove/Oven Doesn't Work	Is there a stove or refrigerator that doesn't work in your apartment or home?	Yes/No	No
Peeling Paint	Is there peeling paint in your home or on its exterior?	Yes/No	No
Furnace Doesn't Work	Is there a furnace or heater that works poorly or doesn't work at all?	Yes/No	No

Control Variables and Measures

Education	What is the highest grade or year of school you completed?	Count from 0-20. Recoded into 0=No HS Diploma and 1=HS diploma	Continuous
Marital Status	Are you currently . . . ?	Married Divorced Widowed Separated Never married Living with someone, but not married Recoded into 0=Not Married 1=Married/Cohabiting	Nominal
Income	Is your total monthly income . . . ?	Less than $250 Between $250 and $499 Between $500-$749 Between $750-$999 Between $1,000 and $1,249 Between $1,250 and $1,499 Between $1,500 and $1,999 Between $2,000 and $2,499 Between $2,500 and $2,999 More than $3,000	Interval
Age	In what year were you born?	Count Recoded into Young, Middle Age, Elderly	Interval

Sex	Are you male or female?	Male Female	Dichotomous