CHANGES IN SELF-PERCEIVED HEALTH OF INDIVIDUALS WITH CHRONIC ILLNESS:

THE RELEVANCE OF GREEN SPACE IN THE LIVING ENVIRONMENT

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Abstract

Study objectives: Green space has been associated with a wide range of health benefits, yet nearly all studies on the subject are cross-sectional in design. To investigate the health-promoting potential of green space, this longitudinal study analyzes change in self-rated health of chronically ill persons in relation to the amount of green space in their living environment. A synchronized exploration of green space and chronic illness will provide a unique perspective on the health-promoting potential of natural environments.

Design: 1,318 people with one or more medically diagnosed chronic disease(s) have participated in a panel study, reporting their general health for 2, 3, or 4 years. The percentage of green space (urban green space, agricultural space, natural green space) was calculated for each 4-digit postal code. Linear regression analysis was conducted to investigate the relationship between green space and health change among the cohort. Potential moderating effects of this relationship were explored and the main effect of social capital on health was investigated through stratified analyses by level of urbanity and age.

Main results: The analysis found no relationship between the amount of green space in the 4-digit postal code and change in perceived health among this population of individuals with chronic illness. A significant and positive main effect of social capital on change in health was discovered. The positive influence of social capital was most robust in strongly urban areas and for individuals between the ages of 40-64.

Conclusions: It is possible that subjective measures of health, like the self-report, do not reflect true change in health due to issues of response shift. Change in health among chronically ill individuals may be more accurately measured through subjective measures. The unexpected finding of a positive impact of social capital on change in perceived health is significant. Health-promoting effects of social capital should continue to be explored, especially with regard to the quality of life and wellbeing of individuals with chronic illness.

Keywords: green space, self-rated health, perceived health, chronic illness, health change, social capital

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Mary Wolfe
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Contents

Chapter 1. Introduction

"Everybody needs beauty as well as bread, places to play in and pray in, where Nature may heal and cheer and give strength to body and soul alike."

– John Muir, *The Yosemite,* 1912

1.1 Living Environment and Health

It is widely accepted that individual health is dependent on both biological and personal characteristics, as well as the environment in which one lives. This ecological approach to health places people within a sociophysical context in order to better understand what influences their wellbeing. Within the ecological approach, different dimensions of the living environment are recognized for their impact on individual health. One particular area of interest that has gained much attention in recent years is the relationship between green space and health.

Attempts to understand the human relationship with the natural world are longstanding and widespread. In the last quarter of a century, efforts to examine this relationship have emerged in the disciplines of ecology, biology, psychology, and psychiatry. Central to this realm of knowledge across related fields of study is the notion that contact with nature is beneficial to human health and wellbeing.

A growing body of evidence suggests a positive association between green space in the living environment and individual health. Green environments have been linked to improved self-rated health (De Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Groenewegen, van den Berg, de Vries, & Verheij, 2006; Maas, Verheij, Groenewegen, de Vries, &

Spreeuwenberg, 2006; Mitchell & Popham, 2007); lower blood pressure (Hartig, Evans, Jamner, Davis, & Gärling, 2003); lower levels of obesity (Ellaway, Macintyre, & Bonnefoy, 2005); lower levels of physician-assessed morbidity (Maas et al., 2009); lower mortality risks (Mitchell & Popham, 2008); and increased longevity (Takano, Nakamura, & Watanabe, 2002).

This thesis seeks to expand the body of knowledge surrounding the topic of green space and health. Using data gathered over the course of four years, this project aims to increase the understanding of the salutogenic potential of green space by looking particularly at the self-rated general health of chronically ill individuals and relate it to the amount of green space in their living environment. A synchronized exploration of green space and chronic illness will provide a unique perspective on the health-promoting potential of natural environments.

1.2 RELEVANCE

Ever-Urbanizing World

With one look at the state of our urbanizing world, it becomes clear why more attention must be focused on ways in which urban living can help, or harm, wellbeing. Although urban areas constitute only 2.8 percent of the earth's land surface (United Nations, 2011), 50.5 percent of the world's population (3.5 billion people) lived in cities in 2010 (United Nations Department of Economic and Social Affairs, 2010). By the year 2050, the world population is expected to reach 9.1 billion, while the urban population is projected to gain 2.9 billion more inhabitants until 69 percent of the world population is urban in 2050 (United Nations Department of Economic and Social Affairs, 2010).

The issue of rapid urbanization resonates with international literature regarding the relationship between urbanity and health. People living in urban areas are generally found to be less healthy than people living in more rural areas. Urban-rural variations in health are often attributed to factors such as pollution, environmental quality, and lifestyle—all of which co-vary with degree of urbanity and patterns of selective migration (Verheij, 1996; Verheij, van de Mheen, de Bakker, Groenewegen, & Mackenbach, 1998). If health inequalities are evident on the basis of urbanity, the question remains: What are the health implications of an ever-urbanizing world? If, in fact, nature and green spaces are beneficial to human health, the demand for land fueled by rapid urban expansion threatens the maintenance of existing urban green spaces.

Chronic Illness

While modern westernization has doubled human life expectancy and advances in medical technology continue to improve our capacity to combat infectious disease, such rapid changes in industrialization and urbanization have opened the door to new and different types of health issues. "As more people survive to older age, and as patterns of living, consuming and environmental exposures change, so non-communicable diseases such as coronary heart disease, diabetes and cancer have come to dominate" (McMichael, 2001; Maller, Townsend, Pryor, Brown, & St Leger, 2006). Aging populations experience increased morbidity and mortality rates due to the prevalence of chronic illness. It is predicted that by the year 2020, chronic diseases will be the leading cause of disability throughout the world (World Health Organization, 2002). The incidence of chronic illness will continue to grow worldwide, and if not successfully managed, it will become the most expensive problem ever faced by healthcare systems internationally (World Health Organization, 2002).

With such global salience, the subject of chronic illness is receiving a great deal of medical and technological attention. Advances in these areas are certainly improving survival rates for many people with chronic illness; however, progress can be costly and many drugs have unwanted side-effects (Fuller, Stewart Williams, & Byles, 2010). An alternative way of addressing chronic illness is the approach of lifestyle modifications such as diet and exercise. This approach is seen as a way of alleviating the social and economic burden associated with chronic disease, while avoiding the risks of medication (Wolf et al., 2007).

Medical and lifestyle approaches to addressing chronic illness are widespread, yet traditional models of public health struggle to cope with the nature of modern health risks. This shortcoming has led to a re-evaluation of traditional health models in favor of an ecological model of health where the interdependence between people, their health, and their physical and social environment is considered (Kickbusch, 1989). Perhaps a heightened understanding of how a person's living environment influences his or her health might provide crucial insight into the ways in which quality of life and functional status can be improved for people living with a chronic illness.

Prevention of chronic illness through lifestyle changes is still urgently called for; however, as modernity continues to increase longevity and the population of individuals with chronic illness grows, health-promoting efforts should be directed toward people who are already chronically ill. While it is assumed that the general health and functioning of chronically ill persons will gradually worsen over time, an ecological approach to the issue may shed light on the possibility that living in a favorable environment might postpone deterioration of health.

1.3 CURRENT LIMITATIONS

There are shortcomings within this body of research and they lie in the inability to exclude selection bias and the ambiguity of causality. *Do green spaces really encourage healthier residents, or do healthier people tend to live near greener spaces?* The problematic issues of both selection and causality are seemingly rooted in the popularity of cross-sectional research design. Most studies in the realm of green space and health, apart from some experimental studies, are cross-sectional in nature. While they certainly shed light on the potential link between green space and health, these studies examine data from a "snapshot" in time, revealing associations among variables rather than findings from which causal inferences can be made unambiguously (Bryman, 2008). This limitation, often referred to as "ambiguity about the direction of causal influence," can be remediated in a longitudinal research design in which data are collected in two or more time periods. This type of design provides some insight into the time order of variables, which is a first step toward the ability to make causal inferences (Bryman, 2008).

A single longitudinal study has been conducted in the realm of green space and health to the author's knowledge thus far. Researchers in Tokyo found that living in a neighborhood with abundant walkable green space correlated with a lower mortality risk among senior citizens over a five year time period (Takano et al., 2002). Beyond this project, little is known about the influence of green space in the living environment on a person's health *over time.* In an advisory report, the Committee on Nature and Health of the Health Council of the Netherlands recognizes the contributions of existing studies, but encourages future investigation of "the etiology, course, or prevalence of specific disorders" (Health Council of The Netherlands, 2005). By assessing individuals' health over time—specifically health change among chronically ill—the impact of green space on the "course" or duration of illness will be investigated.

Another current limitation lies in the difficulty of demonstrating an association between health outcomes and residential environments. This is a generally acknowledged limitation due to the fact that health outcomes are often not apparent until many years have passed (Takano et al., 2002). Therefore, linking change in health to specific features of the residential environment is quite difficult as little health change is evident. In a healthy population, one must wait a number of years to see changes in health. Among chronically ill individuals, changes in health often occur at quicker rates and thus, can be observed over shorter periods of time.

Additionally, there is the question of how relevant green space in the living environment actually is in the course of human daily life. Some question whether people depend on their immediate surroundings for daily activities, or if people are willing to move around to meet their needs. Though there is no clear distinction between the two extremes of staying local

or moving about, daily mobility varies greatly by age. Young and healthy people are generally very mobile; they can travel to green spaces at their own disposal, perhaps taking a thirty minute bike ride to picnic in a park across town. In this way, younger, healthier people rely less on their immediate living environment to fulfill daily needs. Conversely, older people with health issues tend to possess greater limitations in mobility. Thus, an older, sicker population experiences a reduced action space and is more dependent on the living environment close to home. Therefore, exposure to natural settings for older people may be limited to green space that already exists within their surrounding residential environment. By focusing on individuals with chronic illness who tend to be older and often less mobile, this thesis seeks to ensure that the study population is, in fact, dependent on their residential environment, thus producing more relevant results about the health impact of green space in the living environment.

1.4 RESEARCH QUESTIONS

The aim of this research is to inquire into the extent to which change in self-rated health of individuals with chronic illness is explained by the amount of green space in their living environment. This study will take into consideration the growing demographic of people living with a chronic illness. The longitudinal nature of its design will contribute to the current gap in epidemiological studies where the passage of time in relation to individual health is not considered.

Seeking to improve the understanding of how green spaces influence people's health, this study will examine changes in health among chronically ill individuals over an unprecedented four year time period. The study population is a unique cohort of participants who have been subject to an independent assessment by a general physician, resulting in a medical diagnosis of a chronic illness. This cohort of chronically ill individuals provides a unique opportunity in which to examine the relationship between one's health and one's living environment because, in many cases, a chronically ill person's functional status and overall health will gradually worsen over time. The cohort has reported their perceived general health over the course of four years. Changes in the self-rated status of their health will be examined in relation to the amount of green space in their living environment, while controlling for socioeconomic, demographic, and other environmental characteristics.

The literature most commonly identifies three causal mechanisms behind green space-health relationship: *1. Green space encourages physical activity 2. Use of green space increases social contacts 3. Green space facilitates stress reduction and mental restoration* These intermediary mechanisms, elaborated upon in Chapter 2, inform the research questions of this study and furthermore inspire the formation of hypotheses.

This thesis seeks to answer the central question:

1. *To what extent are changes in self-rated health of chronically ill persons related to the amount of green space in their living environment, controlling for other relevant characteristics of the person and the environment, and how can this relationship be explained?*

This overarching research question is the impetus for the entire study. If a relationship between change in health and green space is found, then the study seeks to explain the nature of the relationship. To gain a preliminary understanding of the relationship, it is important to look at how green space is used and who is exposed to it. To truly assess "exposure," it is not merely a matter of whether or not there is green space available, but rather whether or not people actually use it.

2. *How does the strength of the green space-health relationship vary from one person to another, and how is this variation related to individuals' amount of exposure to green space?*

Finally, the research seeks to understand *how* the relationship works. Potential causal mechanisms that might mediate this relationship will be explored.

3. *To what extent is the relationship between green space and change in health explained by the mechanism of physical activity?*
4. *To what extent is this relationship explained by the mechanism of increased social contacts?*
5. *To what extent is this relationship explained by the mechanism of stress reduction and mental restoration?*

This thesis aims to strengthen the current understanding of the salutogenic effects of green space. The longitudinal nature of this study will contribute to the existing knowledge base of this field of research—particularly, by revealing how green space might influence health over time. Even more importantly, perhaps, is the potential for this research to expand the awareness of the relevance of the living environment for the health of individuals with a chronic illness. A growing world population of chronically ill persons, at the very least, should prompt the exploration of ways in which such individuals can maintain an active, even thriving, role in society.

Chapter 2. Theoretical Consideration: Green Space and Health

2.1 An Ecological Approach

In the realm of public health, expanded consideration for multiple health-influencing factors has encouraged the adoption of an ecological approach to human wellbeing. Within the ecological perspective, researchers and health care professionals recognize that health is influenced by many factors, and these factors are often interrelated. The ecological approach to health has served as the impetus for many areas of research, namely in revealing the interdependence between people, their health, and their physical and social environments (Kickbusch, 1989); it is the niche for the study of how natural environments and green spaces influence physical and mental health.

As chronic diseases have increasingly replaced acute infectious diseases as the major causes of death in industrialized nations, older theories of disease etiology based on single cause explanations (in which one factor—a microbe—causes a single disease) are becoming more and more outdated. Instead, contemporary theories consider how multiple behavioral, environmental, biological, and genetic factors interact to produce any single disease or multiple diseases over time (House, Landis, & Umberson, 1988). This shift in disease etiology theory embodies the ecological approach to public health and justifies further investigation of how the living environment affects human health.

The idea that humans experience and relate to nature in beneficial ways has been explored in the fields of psychology, psychiatry, biology, ecology, environmental health, landscape

architecture, horticulture, criminology, leisure, recreation, religion, and philosophy (Maller, Townsend, Brown, & St Leger, 2002). Researchers have concluded that humans are not only dependent on nature for material needs, but for psychological, emotional, and spiritual needs as well (Katcher & Beck, 1987; Wilson, 1984; Roszak, Gomes, & Kanner, 1995).

Growing Evidence

Large-scale population studies have produced evidence revealing a lower incidence of self-rated poor health as well as reduced socioeconomic health inequalities among populations with greener local environments (De Vries et al., 2003; Maas et al., 2009; Maas et al., 2006; Maas, van Dillen, Verheij, & Groenewegen, 2009; Mitchell & Popham, 2007; Mitchell & Popham, 2008; Richardson & Mitchell, 2010; Nielsen & Hansen, 2007). Epidemiological studies have examined the influential role of natural environments in the health of urban populations by using small areal units to define green space exposure of residents (Mitchell, Astell-Burt, & Richardson, 2011). Two epidemiological studies in the Netherlands have revealed that residents of neighborhoods with abundant green space tend, on average, to report fewer health problems (De Vries et al., 2003; Maas et al., 2006). In both studies, the positive relation between green space and health was stronger among elderly, housewives, and people of lower socioeconomic status. Such large-scale findings have encouraged the development of explanations behind the mechanisms underlying this relation.

2.2 MECHANISMS AT WORK

Finding a relationship between green space and health is one thing, but explaining how the relationship functions is another feat entirely. How exactly might green space influence the mental and physical health of people who experience it? Researchers have identified and categorized potential intermediary mechanisms in order to shed light on the nature of the relationship. Generally speaking, there are two types of mechanisms that explain health differences across space: selection and causation (Verheij et al., 1998).

2.2.1 Selection Mechanism

Do natural, green surroundings make people healthier, or is it the case that healthy people move to greener surroundings? A selection mechanism occurs if spatial health differences are the result of healthy people moving to greener living environments; they *can* and *do* choose to move to green space. Because wealthier (and thus often healthier) people can choose where to live—with less financial bearing on their choice—it is more likely that they will choose attractive, green areas. Thus, the mechanism of *direct selection* (where moving or staying is based on health reasons) may cause greener areas to be inhabited by healthier

people because their wealth allows them greater access to health services. (De Vries et al., 2003).

From a research standpoint, the selection effect is what researchers attempt to rule out by controlling for relevant demographic and socioeconomic characteristics. For instance, people living in urban areas are often found to be less healthy. Researchers seek to understand if these urban-rural health variations are a result of a selection mechanism, yet the selective migration hypothesis is rarely tested empirically. A Dutch study sought to explore the phenomenon of selective migration by assessing health and health risk factors of urban and rural populations (Verheij et al., 1998). No evidence of direct selection was found, however, as urban-rural migrants were neither healthier nor unhealthier than rural-urban migrants.

Selection effects can also be referred to as "composition effects," where segregation between residential areas is based on personal characteristics of the residents that also affect their individual health. Malström et al. (1999) explain that "similar types of persons have similar illness experiences no matter where they live." These composition effects on health are the result of *indirect selection,* a process, where clustering of similar individuals in neighborhoods is due to selective choices of residence. Researchers believe that this selection indicates that individual health-associated characteristics might account for neighborhood differences in health (Mohnen, 2012). The composition effect results from a selection as opposed to residential context effects on health where "similar types of individuals will have different self-rated health status in different types of neighborhoods (Malström, Sundquist, & Johansson, 1999; Mohnen, 2012).

The current thesis will focus its attention not on these selection mechanisms, but rather on the potential causation mechanisms explaining the relationship between green space and health. Selection effects will be discounted as much as possible by statistically controlling for relevant demographic and socioeconomic characteristics.

2.2.2 Causation Mechanisms

While ruling out selection effects, researchers seek to identify the causation mechanisms behind the relationship between green space and health. If, in fact, health-promoting effects of living in a green environment are present, then a causation mechanism exists (De Vries et al., 2003). The possible mechanisms through which green space might act to benefit health have been explored in both experimental and observational studies, and dominant theory posits three main causal mechanisms: *Green space a. encourages physical activity b. increases social contacts c. facilitates stress reduction and mental restoration.*

2.2.2a Encourages physical activity

The first widely-cited mechanism through which green space might positively influence health is behavioral; it may be the case that green space in the living environment promotes *increased physical activity* (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003; Giles-Corti & Donovan, 2002; Humpel, Owen, & Leslie, 2002; Bedimo-Rung, Mowen, & Cohen, 2005). Individuals with green space such as parks in their neighborhood may be more inclined to exercise, thus, partaking in a healthy lifestyle choice.

A person's level of physical activity is determined by many different factors. An ecological approach to understanding level of physical activity considers not only biological and individual traits such as gender, age, or personal interest in exercise, but also factors of one's social and physical environment (Maas, 2009). One of these potential external determinants of physical activity level may be the amount of green space in the living environment. The character of most green space is such that someone who wishes to utilize the space, perhaps an urban park, must often move about in order to experience it. Open green spaces facilitate dog walking, jogging, cycling, and sports with others. In this way, physical activity is a seemingly inherent feature of using or visiting a green space.

A physically active lifestyle encourages many positive health outcomes, and this relationship is well-established. Exercise has a positive effect on multiple health determinants such as body weight, percentage body fat, blood pressure, HDL/LDL cholesterol ratio, triglyceride levels, glucose tolerance, insulin sensitivity, and bone density (Health Council of The Netherlands, 2004). Exercise decreases the risk of developing a range of illnesses such as cardiovascular disease, type II diabetes, osteoporosis, stroke, depression, and some forms of cancer (U.S.Department of Health and Human Services, Center for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, & The President's Council on Physical Fitness and Sports, 1998; World Health Organization, 2004). Exercise has also been shown to have positive effects on mood and stress level (Barton & Pretty, 2010; Penedo & Dahn, 2005).

The health benefits of an active lifestyle are well-documented and supported in an array of medical literature. Due to increasingly sedentary jobs and a growing reliance on motorized transport, leisure-time physical activity may be important in fulfilling recommended physical activity levels (Bedimo-Rung et al., 2005). Gyms, sport clubs, and other exercise facilities surely provide opportunities for people to maintain a lifestyle complete with regular exercise; however, recreation in natural outdoor settings is becoming more important as our lives are increasingly dominated by indoor activities.

Preference for Nature

Physical activity in outdoor green spaces may be especially appealing due to our inherent preference for natural settings. Generally speaking, humans tend to value natural

environments more than urban environments (Ulrich, 1983; Herzog, 1992; Herzog & Bosley, 1992). Views of nature are preferred over most urban scenes lacking natural elements such as trees and vegetation (Ulrich, 1986).

In exploring environmental aesthetic preferences, researchers have found that people deem urban environments with green facilities more attractive than urban environments with few or no green facilities (Hull & Harvey, 1989; Orland, Vining, & Ebreo, 1992; Sheets & Manzer, 1991; Kuo, Bacaicoa, & Sullivan, 1998). Photo simulations were carried out in a number of studies in order to assess human preference for certain environments. A study in Chicago found that tree density and grass maintenance increased both preference and sense of safety of an urban area (Kuo et al., 1998). In an Arizona study, subjects viewed slides taken before or after vegetation was added along a suburban thoroughfare. Vegetation affected perceptions of the quality of life in the area, the local land use, and self-reported emotional responses to the setting. Subjects also reported higher levels of positive affect while viewing a tree-lined city street than when viewing a street barren of trees (Sheets & Manzer, 1991).

This preference for nature is likely attributable to the mentally restorative effects of natural settings, a causal mechanism that is later discussed in *2.2.2c stress reduction and mental restoration*. The sense of rejuvenation and restoration that is often experienced in green spaces may be an important characteristic of one's chosen exercise setting.

Researchers in the UK found that green exercise led to a significant improvement in self-esteem and total mood disturbance, along with results of anger-hostility, confusion-bewilderment, depression-dejection, and tension-anxiety all improved in participants post-activity (Pretty et al., 2007). A study by Hug et al. in Zurich (2009) found that members of a peri-urban fitness center rated outdoor exercise settings higher in restorative quality. Researchers hypothesize that people find the aesthetic quality of natural features within their outdoor exercise settings (e.g., light, trees, water, clouds, fresh air, bird song) more fascinating than alternative indoor settings (Hug, Hartig, Hansmann, Seeland, & Hornung, 2009).

Quality and Accessibility

Recreation in natural settings seems a viable option for people who need or wish to increase physical activity. Parks and other urban green spaces provide settings and infrastructure for different levels of sport and recreation, such as picnicking, walking, running, cycling, ball games, rock climbing, and dog walking; however, all green space is not created equal. Specific characteristics of green spaces determine their usefulness and level of attractiveness to potential users, thereby determining the extent to which they will be used for physical activity. Several empirical studies have been conducted to understand the specific social and physical environmental factors that encourage people to exercise (Sallis, Bauman, & Pratt, 1998; Sallis & Hovell, 1990; Carron, Hausenblas, & Mack, 1996).

In a review of observational studies, Wendel-Vos et al. (2007) sought to identify potential determinants of physical activity among adults. The presence of a workout companion and availability of equipment were most convincingly associated with different types of physical activity while possible environmental correlates of physical activity included availability, accessibility, and convenience of recreational facilities (Wendel-Vos, Droomers, Kremers, Brug, & Van Lenthe, 2007). Goossen et al. (1997) determined a collection of indicators to measure the recreational quality of rural areas for leisure walking; these indicators were accessibility, land-use, and safety. Findings also revealed that natural areas are preferred to purpose-built recreational facilities (Goossen, Langers, & Lous, 1997).

Ultimately, researchers still seek to understand whether proximity to green space is related to levels of physical activity. In the Netherlands, Maas (2008) found that the amount of green space in the living environment is scarcely related to the level of physical activity and that physical activity pursued in greener environments does not explain the relationship between green space and health. Other studies; however, have found that proximity to green space is positively associated with physical activity. In an American study of eight parks in low-income minority neighborhoods in Los Angeles, researchers found that age (being younger), gender (being male), and distance (living within one mile of a park) were all positively associated with park use and the frequency of leisure exercise (Cohen et al., 2007).

2.2.2b Increases social contacts

The second causal mechanism mediating the relationship between green space and health is also behavioral. Studies suggest that the use of green space *increases social contacts* (Kawachi & Berkman, 2000; Kuo, Sullivan, Coley, & Brunson, 1998). Green space provides opportunities to meet others or participate in group activities (Health Council of The Netherlands, 2005; Maas et al., 2009) and research shows that such meeting opportunities are essential for the development of communities and social ties (Völker, Flap, & Lindenberg, 2007). If green space is, in fact, positively related to health, then perhaps the social aspect of green spaces can explain this relationship.

Both individual and neighborhood level social capital are rooted in social relations. Social capital theory holds that social networks have value and greatly affect quality of life (Coleman, 1988). A high level of social cohesion is commonly cited as a potential condition for good health, and studies are increasingly examining this social-health relationship. Increased social contact promotes integration and quality of life in underprivileged communities, and this has potential to alleviate psychosocial problems affecting inhabitants of these areas (Health Council of The Netherlands, 2005). Social interaction is also beneficial on the individual level. Researchers found that people with many social contacts feel healthier, have a decreased risk of cardiovascular disease, and live longer (Berkman, Glass,

Brisette, & Seeman, 2000; Kawachi, Kennedy, Lochner, & Prothrow-Stith, 1997; Kawachi & Berkman, 2000). Social contact prevents loneliness, yields social support, and encourages healthy behavior (Health Council of The Netherlands, 2005). Additionally, social contact is known to have beneficial effects on mood and stress level (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003).

Green space—Social space

The greenness of shared outdoor spaces has been considered an important aspect of how "useful" a place is in facilitating social contact and cohesion. For instance, a study by Flap and Völker (2005) found that Dutch neighborhoods with more open green space and facilities promote a sense of community. An American study revealed that undertaking activities in natural environments had encouraging effects on social cohesion (Ewert & Heywood, 1991). Community gardens, where residents come together in a green space, have been shown to provide opportunities for socializing and learning from one another, which encourages social cohesion by easing racial, economic, and education-based prejudices (Lewis, 1996; Lewis, 1990). Volunteering with organizations such as "Friends of Parks" also provides an opportunity for improved wellbeing through social connections made possible by a natural setting (Maller et al., 2006).

Researchers in Chicago extensively explored how green public facilities and potential meeting places relate to social ties. Coley at al. (1997) found that the presence of trees was positively linked to greater use of outdoor space by all age groups, and that the amount of time spent in the space was dependent on presence, location, and number of trees in the shared space. Kuo (1998) and colleagues found that levels of vegetation predicted use of common space and strength of social ties. Importantly, the study revealed that use of common spaces mediated the relationship between vegetation and neighborhood social ties. In fact, greener neighborhoods yielded stronger community ties overall. Within an older adult population aged 64 to 91, Kweon et al. (1998) found that the use of green outdoor common spaces modestly predicted both the strength of neighborhood social ties and sense of community. In a Dutch study, Maas et al. (2009) more specifically sought to understand whether social contacts are a possible factor mediating the relationship between green space and health. The team found that a lack of social support partly mediated the association between low green space neighborhoods and poor health in the Netherlands.

Exceptions

Evidence of the beneficial relationship of social ties on health is abundant, but equally relevant is the literature revealing the opposite reality. Some studies have actually found a negative relationship between number of supportive interactions and health indicators, such that people with more health problems experience more social support (Maas et al., 2009; Tijhuis, 1994; van Sonderen & Ormel, 1997). Maas (2009) explains that this negative relationship may be due to an increased need of unhealthy people for social support. It is quite possible that the same association might exist in the present study, where the target

population of analysis is comprised of individuals with chronic illness—a group that is perhaps increasingly dependent on social relations and support over time.

2.2.2c Stress reduction and mental restoration

The final mechanism, which posits that green space *facilitates stress reduction and mental restoration,* relates to the restorative effects of nature. Empirical research suggests that exposure to natural environments is directly related to recovery from stress and mental fatigue (Kaplan & Kaplan, 1989; Ulrich, 1993; Ulrich, 1983). Studies have shown that this mechanism can work by experiencing nature visually (Hartig et al., 2003; Ulrich, 1984). The mere sight of a natural environment can promote mentally restorative experiences.

Hypotheses regarding emotional, attentional, and physiological aspects of health-promoting influences of nature are derived from psychoevolutionary theory. The Biophilia Hypothesis claims that among early humans, knowledge of the natural world (i.e. plants and animals) was beneficial and even crucial to survival. The hypothesis, developed by E.O. Wilson, stresses that due to evolution, humans have innate psychological needs which can only be satisfied by a connection with nature (Wilson, 1984; Kellert & Wilson E.O., 1993). Essentially, if biophilia, or nature-loving, is represented in the gene pool it is because a predisposition in early humans for biophilic responses to certain natural elements contributed greater chances of survival (Kellert & Wilson E.O., 1993). Despite human's transition to village-living eight to ten thousand years ago, our current period of urbanized, apart-from-nature living is merely a blip on the timeline that is human evolution and thus, our need for a bond with the natural world remains an important part of our psyche (Wilson, 1993).

Over the last century, there has developed a great detachment of humans from the natural environment (Beck & Katcher, 1996). This disengagement from nature is epitomized in rational detachment from nature through theorizing, romantic reverence and spiritualizing of nature, or even abstraction of nature into discrete parts (Gadow, 1992). Such a detachment has led to humans seeing themselves as separate from the world they inhabit. In conjunction with this mental disengagement is the physical detachment of leaving rural areas and moving to cities as urbanization persists through modern time.

Such a growing detachment from nature has raised much alarm among researchers. Light is being shed on the destruction of natural systems by our contemporary anthropocentric way of life, and as awareness grows, a new perspective has emerged (Maller et al., 2002). This enlightened outlook is one of interconnectedness; it is recognizing that humans are dependent upon, and a part of, a larger living system (Driver, Dustin, Baltic, Elsner, & Peterson, 1996). This notion is central to the ecological approach to public health, and it is the impetus for current research.

The health-promoting effects of experiencing nature have been studied in multiple countries and in diverse settings. True- and quasi-experimental studies have largely focused on the healthful potential behind visually experiencing nature. The studies have varied by way of exposure method: some participants passively viewed natural scenes or simulated environments while other participants actively and physically experienced natural environments. Studies have also differed in the types of measure used to assess mental outcomes: cognitive, physiological, and affective tests were all utilized in various studies. The conditions for inducing a "negative" mental state, or the antecedent conditions of the experiment, have also varied: some participants experienced mental fatigue while others were subject to stress and anxiety (Van den Berg, Hartig, & Staats, 2007). Regardless of the chosen method, these studies have shown that the mere sight of natural settings is valued by people and is effective in reducing stress and improving wellbeing (Kaplan, 1992a).

A Natural View

"Views of nature" have been explored in various contexts. A widely-cited study by Ulrich (1984) was one of the first to examine views of green space in relation to health. By analyzing the recovery rates of patients who had undergone gall bladder surgery in relation to their hospital room window view, Ulrich found that patients with a natural view recovered faster, spent less time in the hospital, received less negative nurse evaluations, took fewer painkillers, and experienced less postoperative complications than patients who viewed an urban scene (brick wall) from their window (Ulrich, 1984). A similar study by Moore (1981) examined the health of prison inmates in relation to the view from their cell window. Findings revealed that a view of nature was associated with less symptoms of stress, such as digestive disease and headaches, as well as fewer "sick calls" made by prisoners (Moore, 1981).

Understanding the effects of a "natural view" is important as adult urban residents normally spend the greatest portion of their life indoors, either at home or at work (Van den Berg et al., 2007). Natural views are especially relevant for people in stressful indoor environments such as hospitals, nursing homes, and high-stress work offices. A study by Kaplan and Kaplan (1989) revealed that workers with a view of trees and flowers felt less stress, greater job satisfaction, and experienced less sickness and headaches than workers with a view of the built environment. Research by Leather and colleagues (1998) found that a view of natural elements (i.e., trees, vegetation, plants, and foliage) in the workplace buffered the negative impact of job stress on intention to quit. A very recent study by Bringslimark and colleagues (2011) found that workers without windows were approximately five times more likely to bring plants into their workspaces and three times more likely to bring pictures of nature into their workspaces than workers with windows, independent of age, gender, type of office, and job demands. Even residential window views have been considered in research. Kaplan (2001) found that natural views from apartments contributed substantially to

residents' satisfaction with their neighborhood and with several aspects of their sense of wellbeing.

Attention Restoration Theory

The idea that a mere view of nature can facilitate mental restoration is explained by a concept put forth by Rachel and Stephen Kaplan in the 1980s. Attention Restoration Theory (ART) asserts that observation of nature, whether physically present or merely viewing from a window, allows one to recover from mental exhaustion or "mental fatigue." ART has been developed by researchers over time, and the central idea states that the brain exhibits two types of attention: directed attention, which is part of the higher cognitive centers, and soft fascination, which is linked to the oldest parts of the brain (Grahn & Stigsdotter, 2003). Mental fatigue arises from duration of an activity requiring directed attention, or a period of intense focus and concentration on external information (Kaplan, 1987; Kaplan & Kaplan, 1989). Symptoms of mental fatigue include lack of concentration, inability to solve problems, heightened irritability, and greater susceptibility to make mistakes or accidents (Herzog, Black, Fountaine, & Knotts, 1997). Natural environments contain little information that must be sorted and assessed, therefore while in nature, the higher cognitive centers can rest while other areas of the brain are stimulated through soft fascination such as listening to rustling leaves or watching the clouds pass by (Kaplan & Kaplan, 1989). Viewing nature requires only undirected or effortless attention, and this passive experience can recover mental capabilities by way of mental restoration.

Mental restoration is achieved in "restorative environments" or places that foster recovery from this described mental fatigue (Kaplan & Kaplan, 1989; Kaplan, 1992a; Kaplan, 1995; Kaplan, 1992b; Kaplan & Kaplan, 1990). In fact, it is believed that we prefer natural environments due to their restorative properties, and people's beliefs about where to achieve restoration—as well as their need to be restored—shape their relative preferences for natural and urban settings (Van den Berg, Koole, & van der Wulp, 2003). Restorative environments are those which exhibit properties reflected in four specific components which trigger mental processes that contribute to restorative experiences: *fascination* (effortless interest due to esthetically pleasing stimuli); *sense of escape* ("being away" from one's usual setting and daily routines); *extent* (feeling a part of a larger whole); and *compatibility* (a sense of being fulfilled) (Hartig, Mang, & Evans, 1991; Kaplan & Kaplan, 1989). A space that exhibits these characteristics is said to be a restorative environment.

Several studies have investigated the stress reducing or restorative influence of natural environments in order to test the truth behind ART (Kaplan & Kaplan, 1989; Kaplan, 1995). In one study, Ulrich et al. examined stress recovery among subjects who first watched a horror film, and were then subsequently exposed to videos of both natural and urban environments. Findings from a series of physiological and verbal measures indicated that recovery among participants was faster and more complete upon viewing natural rather

than urban environments (Ulrich et al., 1991). Over a decade later, Dutch researchers conducted a similar experimental study by exposing participants to a frightening movie followed by a seven minute film simulating a walk through either a natural or a built environment (Van den Berg et al., 2003). Participants who viewed the natural environment after exposure to the frightening movie exhibited greater improvement in mood and concentration than those who viewed built environments.

Hartig et al. (2003) studied stress recovery and directed attention restoration among young adults in both natural and urban field settings. The team found that participants experienced greater stress reduction and increased attention ability after a walk through a nature reserve than they did through an urban setting. The same nature walk participants additionally experienced a decrease in anger after walking through the nature reserve. Another study involving nature walks took place at the University of Michigan (Berman, Jonides, & Kaplan, 2008). A research team led by Marc Berman gave participants a standard memory and attention test then assigned some of them to walk through downtown Ann Arbor, and others to walk through the campus arboretum. The participants were tested again after completing the walks, and though both groups scored higher after their walks, the nature walk group exhibited more significant improvement. The team concluded that brief interactions with nature produced marked increases in cognitive control.

Berto (2005) also sought to test the hypothesis that exposure to restorative environments facilitates recovery from mental fatigue. In this study, participants were first mentally fatigued by performing a sustained attention test, then visually exposed to three types of photographs: natural scenes, urban scenes, and geometric shapes. Finally, the participants performed the sustained attention test again. Only participants exposed to the restorative natural scenes improved their performance on the final attention test.

A 2009 study in Chicago (Felsten) investigated the restorative quality of various study break location choices among students at the University of Chicago. Researcher Gary Felsten took pictures of lounge areas overlooking urban scenes and buildings as well as lounge areas looking out onto natural scenes. Students rated each image based on its "sense of being away" and other qualities considered by ART as "restorative." Results showed that students rated settings that lacked views of real or even simulated nature to be the least restorative. Even lounges with large indoor nature murals were considered more restorative than lounges with window views of real, but mundane nature with built structures. These findings shed light on the possibility that even simulated nature, such as painted murals, might provide attentionally fatigued students with opportunities for restoration when views of actual nature are unavailable.

A recent study by researchers in Finland set out to explore the restorative experiences of people's everyday "favorite places" (Korpela, Ylén, Tyrväinen, & Silvennoinen, 2010). The

team questioned some 1,273 Finnish city dwellers about the restorative experiences of their favorite places to spend time. Respondents identified their favorite restorative places and rated their perception of health benefits upon visiting them. The self-rated restorative benefits were stronger in outdoor areas, waterside environments, and urban woodlands than in built urban settings or green urban settings like parks. The results revealed connections between the need for restoration (relief from worries and stress) and the use of favorite places. Social scientists refer to such phenomena as "environmental self-regulation strategies."

The results of these numerous studies are consistent with the central claim set forth in ART: natural environments capture our attention in subtle, passive ways and give our mental abilities a chance to regenerate. In urban settings with myriad stimuli, we expend a great deal of direct attention on tasks like avoiding traffic and weaving through pedestrians. In restorative environments we use an indirect form of attention that gives our brain a chance to refresh, much like sleep or other forms of rest. These studies put forth substantial evidence supporting nature's role in effective cognitive functioning, which could ultimately help to explain the beneficial influence of green space on health.

2.3 PEOPLE BELIEVE IN NATURE

Within each of these causation mechanisms, there is perhaps a common thread that is difficult to categorize. It seems that people in urbanized societies share a common belief that contact with nature offers opportunity for restoration from stress and fatigue and is beneficial to health and wellbeing (Van den Berg et al., 2007). This is a general widespread attitude shared among developed nations, and as such, has major societal implications. This shared belief in the healing power of nature is reflected on a national level in some countries. In a Dutch national survey, 95% of respondents believed that a visit to nature is a useful means of stress relief (Frerichs, 2004; Van den Berg et al., 2007). A similar mindset was reflected in Sweden, where residents in nine cities were asked what they would recommend to a friend who was feeling stressed and worried. Results showed that the most common answer to this survey question was to tell the friend to take a walk in the forest (Grahn & Stigsdotter, 2003).

A growing recognition of the connection between human wellbeing and nature has served as the impetus for the subfield of Ecopyshcology. Rooted in the tenets of the Biophilia Hypothesis (discussed above), this field extends beyond traditional therapeutic models to embrace a planetary view of mental health. Practitioners in the field recognize living in balance with nature is essential to multiple facets of human health. Ecopychologists

encourage a view that is consistent with health traditions of indigenous peoples and seek to redefine mental health within an environmental context (Roszak et al., 1995).

Despite one's personal conviction regarding the healing powers of natural environments, it is clear that as a population, we are developing a greater belief in such possibilities as demonstrated in national attitudes and the development of new innovative, holistic approaches to medicine.

Chapter 3. Hypotheses

The conceptual framework of this research centers upon the notion that green space is beneficial to human health. Therefore, the first hypothesis tested in this thesis is a direct-effect hypothesis:

H 1 *The more green space in the living environment of an individual with chronic illness, the less deterioration in self-perceived general health over the course of four years.*

If a relationship is found between green space and health change, then further questions do arise. It is possible that the relationship is not equal in strength for everyone. The amount of exposure to green space is likely to moderate the effect of green space on health. It seems logical that people who are more exposed to green space (more frequent visitation and use) will experience a greater degree of influence of green space on their health compared with people who utilize green space only occasionally.

H 2.1 *Individuals who visit green space more often experience less deterioration in perceived general health.*

H 2.2 *Individuals who have developed a physical disability due to their chronic illness, thereby experiencing reduced action space, experience more deterioration due to a decreased amount of exposure to green space.*

H 2.3 *Older individuals with a chronic illness, who likely work less or experience reduced action space, experience more deterioration due to a decreased amount of exposure to green space.*

H 2.4 *Individuals who report higher measures of neighborhood social capital, who are likely more inclined to feel safe and welcome in green spaces, experience less deterioration in perceived general health over time.*

With an improved understanding of exposure, the question remains: just *how* exactly does this relationship between green space and health work? Recalling the causal mechanisms outlined in Chapter 2, exposure to green space is thought to encourage physical activity, increase social contacts, and facilitate recovery from stress and mental fatigue. From an understanding of these intermediary mechanisms, several hypotheses can be developed to explain how green characteristics of the living environment of people with a chronic illness might be related to changes in their perceived health.

A potential mechanism mediating the green space-health relationship is that the use of green space encourages physical activity, thereby positively influencing self-rated health.

H 3.1a *Individuals with more green space in their living environment are more likely to report greater levels of physical activity.*

H 3.1b *Individuals who report greater levels of physical activity in their daily lives experience less deterioration in perceived general health over time.*

H 3.1c *Therefore physical activity, at least to some extent, explains the relationship between green space and perceived health.*

Perhaps the mechanism at work is related to social interaction. If people who visit green spaces are socializing with others more often, it is possible that they feel healthier and thus, report higher levels of general health. Social interaction might be a mechanism mediating the relationship between green space and health.

H 4.1a *Individuals with more green space in their living environment are more likely to report a greater amount of social contacts.*

H 4.2b *Individuals who report a greater amount of social contacts experience less deterioration in perceived general health over time.*

H 4.3c *Therefore the number of social contacts, at least to some extent, explains the relationship between green space and perceived health.*

The last mechanism that will be explored is that of stress reduction and mental restoration. It is known that diagnosis of a chronic disease is a stressful event in one's life. For participants who have been recently diagnosed with a chronic illness, feelings of stress are common. Perhaps the presence of green space in the living environment might buffer these stressful feelings.

H 5 *Among individuals who have recently been diagnosed with a chronic illness (a stressful life event), those with a greater amount of green space and natural views in their living environment will experience less deterioration in perceived general health over time.*

Chapter 4. Methods

4.1 DATA SOURCES

Several existing large-scale survey data and land-use data sources are utilized for this thesis. Table 4.1 summarizes the data sources used and is followed by a discussion of each source.

Table 4.1 Data used to answer research questions

		SUBJECTS	VARIABLES USED	GEOCODING	SOURCE
DATA AT INDIVIDUAL LEVEL	**Dataset 1** Self-reported health and personal characteristics	Chronically-ill individuals in the NPCD Panel study N = 1318	- perceived general health - demographic variables (age, gender, education level, income) - health characteristics (number of diagnoses, BMI, presence of disability) - qualities of living environment (perceived social capital)	4-digit postal code	NPCD Panel Study
DATA AT POSTAL CODE LEVEL	**Dataset 2** Green space	The Netherlands, areas of 4-digit postal codes	- land use data - percentage of green space	4-digit postal code	National Land Cover Classification database (LGN5)
	Dataset 3 Environmental characteristics	The Netherlands; areas of 4-digit postal codes	- level of urbanity	4-digit postal code	Statistics Netherlands

4.2 STUDY POPULATION

This study uses longitudinal survey data from the *Nationaal Panel Chronisch zieken en Gehandicapten* (National Panel of the Chronically ill and Disabled or NPCD), a national panel study in the Netherlands established to gather information regarding the consequences of chronic illness and disability from a patient perspective (Rijken & van Beek, 2011; Rijken, van Kerkhof, Dekker, & Schellevis, 2005; Rijken & Groenewegen, 2008). Within the selected cohort, respondents are people aged 15 years and older with one or more medically diagnosed chronic disease(s) and are considered a representative sample of the Dutch population of adult, non-institutionalized chronically ill persons. Respondents have evaluated several aspects of their health and lifestyle annually.

3,318 respondents were included in the panel in 2005, which serves as the baseline year for the study. A selection of two specific subgroups was made from this panel: those with a chronic disease who were recruited via general practice (generic sample) and those diagnosed with asthma or COPD recruited via general practice. A third subgroup was not included as it contained people who reported moderate to severe disability based on a screening instrument in several general population surveys; these respondents were recruited for disability-specific research and thus, were not included. After this selection was made, the sample size was 2,012. This selection was a critical step in ensuring that the sample population includes only individuals with a medically diagnosed chronic illness. This study focuses solely on this population due to the expectation that health changes will be seen in a relatively short period of time in a population of individuals with chronic illness.

In this sample, participants have a baseline year of 2005 and have responded to the NPCD survey annually for anywhere from 1 to 4 years. Participants who only responded in the baseline year (completing only 1 survey) were excluded from the study as they lack data from a second point in time from which observations regarding change in health can be assessed. Additionally, cases with missing data for baseline health (year 2005) were also removed. After this selection, 1,326 respondents remained.

The final selection was made in regards to available green space data. These data were not available for 8 cases, thus these were excluded, yielding a final net sample size of 1,318 respondents.

4.3 MEASUREMENTS

4.3.1 Outcome Variable

Perceived General Health

Self-reported health is a well-established indicator of health as its correlation with objective health measurements is high (Simon, De Boer, Joung, Bosma, & Mackenbach, 2005; Rütten et al., 2001; Miilunpalo, Vuori, Oja, Pasanen, & Urponen, 1997; Miilunpalo et al., 1997). Self-rated general health of respondents was measured annually from inclusion at baseline in 2005 to 2008, yielding a 4 year-long panel study of chronically ill persons. Participants reported their health for 2, 3, or all 4 of these years. To control for this variation in participation, the maximum amount of years that each respondent participated was included as a control variable. Self-rated health in the most recent year, or "final year," of participation was utilized as the dependent variable while health in the baseline year was another control variable, allowing for the change in health from baseline (T_0) to the final year of participation (T_1) to be analyzed.

Perceived general health for all years was reflected in a scale score derived from 5 items on the NPCD questionnaire. These items come from the RAND-36 Short-form Health Status Survey assessing perceived general health (5 items). These items are reflected in Box 4.1:

Box 4.1 NPCD Survey Items contained in self-reported health scale

1. Wat vindt u, over het algemeen genomen, van uw gezondheid? | *In general, what would you say your health is?*

   uitstekend | *excellent*
   zeer goed | *very good*
   goed | *good*
   matig | *fair*
   slecht | *poor*

Wilt u het antwoord kiezen dat het beste weergeeft hoe juist of onjuist u elk van de volgende uitspraken voor uzelf vindt. | *Choose the answer that best describes how much you agree with the following statements.*

2. Ik lijk gemakkelijker ziek te worden dan andere mensen | *I seem to get sick easier than other people*
3. Ik ben net zo gezond als andere mensen die ik ken | *I am as healthy as anybody I know*
4. Ik verwacht dat mijn gezondheid achteruit zal gaan | *I expect my health to get worse*
5. Mijn gezondheid is uitstekend | *My health is excellent*

   volkomen juist | *totally agree*
   grotendeels juist | *mostly agree*
   weet ik niet | *I don't know*
   grotendeels onjuist | *mostly disagree*

When constructed, the scale score of perceived general health is a sum of these 5 items, ranging from (1) low to (100) high. The reliability of this scale was computed in order to ensure that the measure consistently reflects the construct being measured (Cronbach's α = .823).

4.3.2 Predictor Variables

Characteristics of the Living Environment

Green Space Amount of green space in the living environment is targeted as a core independent variable in the analyses. In order to assess this characteristic of each respondent's living environment, the percentage of green space was derived from land use data available through the National Land Cover Classification database (LGN5). Based on satellite images from 2003 to 2004, this database contains the dominant type of land use of each 25 x 25 meter grid cell in the whole of the Netherlands (DeWit et al, 1999). Thirty-nine land uses are delineated in this database and it has been a proven valid, accurate, and reliable source for land use data (Maas et al., 2009; Thunnissen & de Wit, 2000; De Wit & Clevers, 2004). Green spaces that dominate (occupy the majority of) each 25 meter grid cell are deemed green space within the dataset. The percentage of green space was calculated for each 2005 4-digit postal code area (n=296) within the sample. The total percentage of green space includes all urban green, agricultural green, forests, and nature conservation areas.

Level of Urbanity A baseline assessment of the residential environment was taken from 2005, which is the year of inclusion of participants in the cohort. Characteristics of the living environment which might produce an association between the sociophysical environment and health, or act as confounders, were included in the analysis. The level of urbanity within each postal code area was one of these potential confounders. Urbanity data were retrieved from Statistics Netherlands for the year 2004, as these were the closest available data to the baseline year of 2005. The levels of urbanity are based on the number of households (addresses) per square kilometer and are widely used in the Netherlands (Den Dulk, Stadt, & Vliegen, 1999).

The original urbanity classification consists of five categories: (1) very strongly urban (over 2,500 addresses per km^2); (2) strongly urban (1,500-2,500 addresses per km^2); (3) moderately urban (1,000-1,500 addresses per km^2); (4) slightly urban (500-1,000 addresses per km^2); and (5) non-urban (less than 500 addresses per km^2). These categories were re-grouped, however, such that slightly urban and non-urban municipalities were merged into one category. This re-grouping strategy is common among social research in the Netherlands

in order to appropriately describe rural areas (Ministerie van Landbouw, 2004; Steenbekkers, Simon, & Veldheer, 2006; Maas, 2009)

Social Capital Each respondent evaluated the social aspects of his or her living environment in a 10-item matrix question from the NPCD questionnaire displayed in Box 4.2. This question contains 10 statements regarding different aspects of social capital; respondents chose their level of agreement with each statement, and the answers were translated into values from 1 to 5. The scale score reflects a sum of these ten scored items and was constructed such that a score from 0 (low) to 100 (high) reflects the level of perceived neighborhood social capital of each respondent at the year of inclusion (2005).

Box 4.2 NPCD survey items used to construct social capital scale

Wilt u aangeven in hoeverre u het eens of oneens bent met de onderstaande uitspraken over uw buurt/woonomgeving? | *To what extent do you agree or disagree with the following statements about your neighborhood/living environment?*

Helemaal niet mee eens | *totally disagree*
Niet mee eens | *disagree*
Geen duidelijke mening | *neutral*
Mee eens | *agree*
Helemaal mee eens | *totally agree*

1. Ik vind het fijn om in deze buurt te wonen | *I like the neighborhood where I live*
2. Ik ben gehecht aan deze buurt | *I feel connected to this neighborhood*
3. Ik voel me thuis in deze buurt | *I feel at home in this neighborhood*
4. Ik voel me verantwoordelijk voor de leefbaarheid in deze buurt | *I feel responsible for the livability of this neighborhood*
5. Ik ken mijn directe buren goed | *I know my neighbors well*
6. Er is een prettige manier van omgang in deze buurt | *There is social interaction in this neighborhood*
7. De mensen in deze buurt kennen elkaar goed | *The people in this neigborhood know each other well*
8. Er is saamhorigheid in deze buurt | *There is unity in this neighborhood*
9. Ik voel me thuis bij de mensen in deze buurt | *I feel at home with the people in this neighborhood*
10. Ik ben tevreden over deze buurtbevolking | *I am satisfied with this community*

In order to ensure that the scale only measured one central theme of social capital, rather than potential subscales of social capital, an exploratory factor analysis was conducted. The analysis revealed that 67.5% of the variance in the scale was explained by only one dimension, which was enough explained variance to retain the 10-item scale as a single scale (Field, 2009). Additionally, in order to confirm that the scale consistently reflected the construct it set out to measure (social capital), a test of reliability was conducted. The analysis revealed a very high reliability (Cronbach's $\alpha = .949$), assuring internal consistency of the scale.

Personal Characteristics of the Individual

Personal characteristics such as sociodemographic and objective health characteristics were included in the analysis order to rule out any third factor, or confounder, which might produce an association between the sociophysical environment and the health outcome. The selected variables, which have been shown to be important in the analysis of health, are described below.

Demographic The demographic characteristics taken into account were *age* (in years) and *gender* (female=1). Age was simply calculated by subtracting year of birth from the year 2005.

Socioeconomic Characteristics reflecting baseline (2005) socioeconomic status included: *educational level* (in 7 categories: (1) none/primary school, (2) low vocational, (3) high school, (4) intermediate vocational, (5) pre-university, (6) applied sciences college, (7) university) as well as *household income* (in 5 categories of net monthly income: (1) less than 1,200 euro, (2) 1,200-1,600 euro, (3) 1,600-2,300 euro, (4) 2,300-3,100 euro, and (5) more than 3,100 euro).

Health Indicators Self-reported health characteristics collected at baseline (2005) were also considered in the analysis in order to assess for individual differences in health among participants. *Perceived general health* in the first year of participation (2005), as reported on the NPCD survey, was included as a control variable. *Body mass index* (BMI) was calculated by dividing respondents' weight by their height in square meters—both of which measures were reported on the NPCD. *Number of chronic diseases* (ranging from 1 to 4 or more) as well as the presence of a mild, moderate, or severe *disability* (disability=1) were derived from GP files of the respondents.

Behavioral In order to understand individuals' amount of exposure to green space, a behavioral characteristic was utilized to operationalize "exposure." On the 2005 NPCD, respondents were asked to report their personal level of *green space use.* Answers for this item ranged from (0) "I never use green space" to (1) "I occasionally use green space" to (2) "I regularly use green space." This variable was re-coded into a dichotomy: either respondents use green space (1) or they do not (0).

Construction of Variables

In order to model change in perceived health over time, two unique variables were constructed. First, a variable was created in which the health response from each participant's final year was recorded—whether their final year of participation in the NPCD was 2006, 2007, or 2008. This new variable represents self-rated health in the final year (T_1). As each respondent participated in the survey for either 2, 3, or 4 years, a variable was created in order to control for this variation. This new variable reflects that amount of years that each respondent completed the NPCD. By constructing these two new variables, a

longitudinal analysis could be modeled as such: T_0 as baseline health in 2005; T_1 as health in the final year of participation; and the inclusion of the number of years since intake as a control variable.

4.3.3 Data Processing

The spatial level of analysis to which all data were aggregated is that of the 4-digit postal code. The self-reported health data were linked with the green space data on the basis of 4-digit postal codes. The Netherlands is divided into 4,000 4-digit postal codes. Each code represents an average of 1,722 households, and these postal codes often correspond with urban neighborhoods (Maas, 2009). In this study, 1,318 respondents lived in 296 different postal code areas with an average of 4.5 persons in each. As there was no evidence of spatial clustering among the subjective health data, a single level of analysis was implemented.

4.4 ANALYTIC STRATEGY

All statistical analyses were carried out using SPSS for Windows, Release Version 18.0 (© SPSS, Inc., 2001, Chicago, IL, USA www.spss.com). Prior to any regression analyses, univariate analyses were conducted to reveal the descriptive statistics of the sample population. The descriptive characteristics are found in Table 5.1 of the results in Chapter 5. Bivariate analysis was then carried out to investigate correlations among all predictor variables as well as with the main outcome variable. This was an important step in order to determine which variables would be included in the regression model; variables were chosen based on existing theoretical framework as well as the significance of their associations with the health outcome variable. Bivariate correlations are found in Table 5.2 of Chapter 5.

Multiple linear regression was used to model the association between green space and change in perceived health among the study population. The longitudinal nature of the design was implemented such that baseline health (in 2005) was included in the model as an independent variable (T_0) and the health outcome in the final year of participation was included as the dependent variable (T_1). The amount of years that each respondent participated (2, 3, or 4 years) was also included as an independent control variable. In this way, change in health was modeled over time. The amount of green space in the living environment was also included as a core independent variable in order to assess the association between green space and the four year health outcomes. Additional predictor variables were included in the model in order to rule out any third factor, or confounder,

that might produce an association between the sociophysical environment and health. The primary regression analysis tests the first hypothesis:

H 1 *The more green space in the living environment of an individual with chronic illness, the less deterioration in self-perceived general health over the course of four years.*

The results of this regression analysis thus represent the relation between green space in the living environment and change in self-perceived health over time, and are shown in Table 5.3.

Next, moderator effects of this potential relationship were explored by creating various interaction terms. Moderators can be represented as an interaction between a focal independent variable and a factor that specifies the appropriate conditions for its operation (Baron & Kenny, 1986). A common framework for capturing the effects of a moderator variable is through the path diagram illustrated in Figure 4.1.

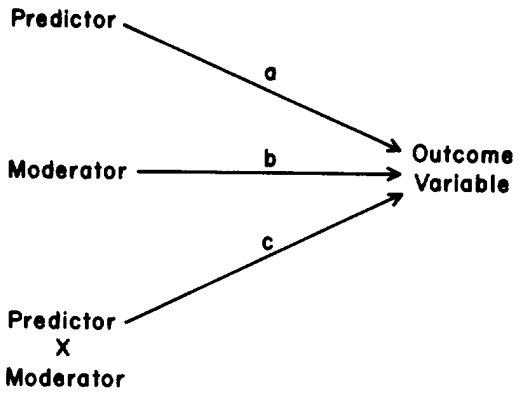

Figure 4.1 Moderator Model (Baron & Kenny, 1986)

Within this framework, moderation implies that the causal relation between two variables fluctuates as a function of the moderator. In this study, four different variables are hypothesized as potentially moderating the effect of green space on health: green space use, presence of a disability, social capital, and age. The following hypotheses were tested using the moderator model framework:

H 2.1 *Individuals who visit green space more often experience less deterioration in perceived general health.*

H 2.2 *Individuals who have developed a physical disability due to their chronic illness, thereby experiencing reduced action space, experience more deterioration due to a decreased amount of exposure to green space.*

H 2.3 *Older individuals with a chronic illness, who likely work less or experience reduced action space, experience more deterioration due to a decreased amount of exposure to green space.*

H 2.4 *Individuals who report higher measures of social capital in their neighborhood, who are likely more inclined to feel safe and welcome in green spaces, experience less deterioration in perceived general health over time.*

Four models were tested, such that amount of green space acted as the core predictor in each model and green space use (H 2.1), presence of a disability (H 2.2), age (H 2.3), and social capital (H 2.4) acted as the moderators in each respective model. Of course, an interaction term was created for each model as well; if this interaction was significant (Path *C* in Figure 4.1), then the moderator hypothesis was supported (Baron & Kenny, 1986). Results from these four models are displayed in Table 5.4.

Hypotheses 3 and 4, described in Chapter 3, target the mediating mechanisms behind the relationship between green space and health, positing that perhaps green space encourages physical activity or increases social interaction, thereby positively influencing perceived general health. To test these two hypothesized causal mechanisms (increased physical activity and social interaction), a series of mediation analyses were conducted.

To test for mediation, according to Judd and Kenny (1981), a series of regression models should be estimated: first, regressing the mediator (physical activity or social interaction) on the independent variable (green space); second, regressing the dependent variable (health) on the independent variable (green space); and third, regressing the dependent variable (health) on both the independent variable and on the mediator. Figure 4.2 illustrates these three regression models as a path diagram. If the effect of the independent variable on the dependent variable is less in the third equation (Path *C* in Figure 4.2), then a mediational model is upheld (Baron & Kenny, 1986).

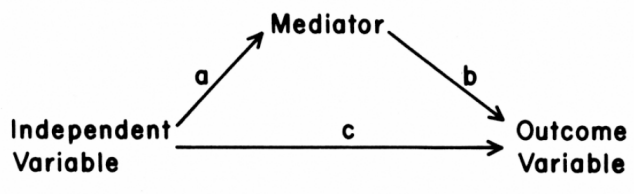

Figure 4.2 Mediational Model (Baron & Kenny, 1986)

If level of physical activity or social interaction mediates the relationship between green space and change in health, then adding these two variables to their respective models will significantly decrease the main effect of green space on health (Path *C* in Figure 4.2). This would show that, to some extent, the health-promoting effect of green space is explained by the tendency of green space to encourage physical activity or facilitate social interaction.

Finally, Hypothesis 5 was tested to explore the mechanism of stress reduction and mental restoration.

H 5 *Among individuals who have recently been diagnosed with a chronic illness (a stressful life event), those with a greater amount of green space and natural views in their living environment will experience less deterioration in perceived general health over time.*

In this study, the recent diagnosis of a chronic disease was used as an indirect indicator of stress. Specifically, individuals with a diagnosis of a chronic disease within the two years prior to intake were deemed as having a "recent" diagnosis. In a regression model, diagnosis date (recent or not recent), percentage of green space in the living environment, and health outcome were included and the effect of green space on health was investigated in regard to diagnosis date, looking specifically for a buffering effect of green space on change in health. A buffering effect is evident if, among individuals with a recent diagnosis, those with more green space in their living environment experience less health deterioration than those with less green space.

Chapter 5. Green Space and Change in Self-Perceived Health

5.1 Descriptive Characteristics of the Study Population

This chapter begins with a univariate analysis of the data for descriptive purposes. Results from this preliminary analysis are found in Table 5.1, which displays the descriptive characteristics of the study population.

Characteristics of the Living Environment

As seen in Table 5.1, approximately half of the study population lives in a postal code containing more than 50% green space. Likewise, nearly two-thirds (68.5%) of the study population live in a moderately urban or non-urban area of the Netherlands.

Demographic and Socioeconomic Characteristics

As chronic illness more often affects older individuals, it is not surprising that the mean age of the sample is 64.3 years. There is quite a range of ages, however, as individuals as young as 23 and as old 102 are included in the study population. The education and income levels of the sample are fairly diverse and generally representative of the population as a whole.

Health Characteristics

The mean baseline self-rated health (T_0) of the study population is a score of 54.0, falling almost in the middle of the 0 to 100 scale. Similarly, mean self-rated health in the final year of participation (T_1) is a score of 53.4. For the entire study population, the mean score of perceived health changed very little over the study period. The majority (71.5%) of the sample have only one medically diagnosed somatic chronic disease and nearly 58% have a mild, moderate, or severe physical disability.

Table 5.1 Descriptive characteristics of the study population (n=1,318)

	Percent	Range	Mean	S.D.
Characteristics of the Living Environment:				
Green space (% within postal code)				
Very little green space (0-29.43%)	26.6%			
Moderate green space (29.44-57.58%)	24.0%			
Much green space (57.59-82.73%)	25.3%			
Very much green space (82.74-100%)	24.1%			
Level of urbanity				
very strongly urban >2,500 addresses/km^2	13.5%			
strongly urban 1,500-2,500 addresses/km^2	18.0%			
moderately urban 1,000-1,500 addresses/km^2	26.1%			
non-urban <1,000 addresses/km^2	42.4%			
Perceived social capital (scale 0-100)		10-90	39.7	9.7
Demographic Characteristics:				
Gender (Female)	57.4%			
Age (in years)		23-102	64.3	15.3
Socioeconomic Characteristics:				
Level of education				
none/primary school	11.0%			
low vocational	27.5%			
high school	18.2%			
intermediate vocational	18.0%			
pre-university	7.5%			
applied sciences college	12.9%			
university	4.9%			
Income				
≤ 1199 €	20.2%			
1200-1599 €	22.1%			
1600-2299 €	26.3%			
2300-3099 €	18.4%			
≥ 3,100 €	13.0%			
Health Characteristics:				
Baseline perceived health (scale 0-100)		0-100	54.0	20.6
Perceived health in final year (scale 0-100)		0-100	53.4	22.0
Body Mass Index (BMI)		13.5-55.8	26.1	4.4
Number of (somatic) chronic diseases				
1	71.5%			
2	20.1%			
3	6.3%			
4 or more	2.1%			
% with a physical disability	57.9%			

5.2 BIVARIATE RELATIONSHIPS

After the descriptive characteristics of the study population were gathered, a bivariate analysis was conducted. Basic correlations between the outcome variable and all predictor variables were determined, and the resulting correlation matrix is displayed in Table 5.2. Significant correlations are flagged, and many of these significant correlations are in line with expectations gathered from the literature. For instance, the outcome variable "Health Outcome" is significantly and positively correlated with Baseline Health, Income, and Education level while the same Health Outcome is negatively correlated with Age, Number of Diagnoses, BMI, and Presence of a Disability.

It is worth noting that in this preliminary stage of the research, Health Outcome is not significantly correlated with the target independent variable of this study, "Percentage of green space in the living environment." As the analysis will model change in health over time, and the bivariate correlations merely capture a single point in time, this lack of a significant correlation is momentarily overlooked.

Table 5.2 Bivariate correlation matrix of individual variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. Health outcome	1.00	--	--	--	--	--	--	--	--	--	--	--	--
2. Baseline health	.751**	1.00	--	--	--	--	--	--	--	--	--	--	--
3. Years participated	-.023	.004	1.00	--	--	--	--	--	--	--	--	--	--
4. Income	.218**	.186**	-.026	1.00	--	--	--	--	--	--	--	--	--
5. Gender	-.051	-.030	.013	-.147**	1.00	--	--	--	--	--	--	--	--
6. Age	-.185**	-.104**	.067*	-.183**	-.134**	1.00	--	--	--	--	--	--	--
7. Education	.136**	.109**	-.002	.446**	-.081**	-.324**	1.00	--	--	--	--	--	--
8. # Diagnoses	-.137**	-.151**	-.047	-.049	.017	.199**	-.089**	1.00	--	--	--	--	--
9. BMI	-.099**	-.049	.058*	-.057*	-.042	.202**	-.116**	.064*	1.00	--	--	--	--
10. Disability	-.450**	*.455**	.051	-.242**	.098**	.271**	-.186**	.147**	.121**	1.00	--	--	--
11. Urbanity	-.022	.007	-.004	.028	.025	-.012	.092**	.029	*.021	.045	1.00	--	--
12. Green space use	-.035	-.019	.008	.001	-.010	-.005	.004	.000	.018	-.046	.025	1.00	--
13. % Green space	-.008	-.033	-.019	-.014	-.010	-.009	-.062*	.007	.009	-.036	-.789**	-.021	1.00

* p≤0.05; ** p≤0.01

5.3 GREEN SPACE AND CHANGE IN SELF-PERCEIVED HEALTH

Table 5.3 shows that both before (Step 1) and after (Step 2) green space is accounted for in the model, the significant predictor variables remain the same. Baseline health of an individual is a very strong predictor of perceived health in the final year (β=.687, p<.001). Table 5.3 also shows in Step 2 that among individuals with a chronic illness, older people (β=-.082, p<.001) and people with a disability (β=-.100, p<.001) experience significantly greater deterioration in perceived health over time. Chronically ill persons with a higher income report significantly less deterioration in perceived general health over time (β=.051, p<.05).

As seen in Step 2 of Table 5.3, the influence of green space on the change in perceived health of individuals in this cohort was quite small and not significant (p=.450), thus rejecting Hypothesis 1.

Table 5.3 Multiple linear regression analysis of green space on change in perceived health (n=1,318)

	PERCEIVED HEALTH IN FINAL YEAR (T_1)		
	B	**(std. error)**	**β**
STEP 1			
Baseline health 2005 (T_0)	.733	(.022)	.688***
Years participated	-.409	(.540)	-.014
Gender (1=Female)	-1.029	(.852)	-.023
Age	-.117	(.030)	-.081***
Income	.853	(.359)	.051*
Education	-.077	(.277)	-.006
Disability	-4.440	(.977)	-.100***
Urbanity	-.474	(.384)	-.023
STEP 2			
Baseline health 2005 (T_0)	.732	(.022)	.687***
Years participated	-.423	(.541)	-.015
Gender (Female)	-1.019	(.852)	-.023
Age	-.118	(.030)	-.082***
Income	-.856	(.359)	.051*
Education	-.076	(.277)	-.006
Disability	-4.450	(.977)	-.100***
Urbanity	-.844	(.623)	-.041
Green space	-.017	(.023)	-.023

R^2=.59 for Step 1, ΔR^2=.00 for Step 2 * p≤0.05; ** p≤0.01; *** p≤0.001

5.4 POTENTIAL MODERATING EFFECTS

Despite the lack of a significant association between green space and perceived health change, the potential to uncover potential moderating effects was still strong. The analysis continued by exploring four prospective moderators of this relationship proposed in Hypothesis 2: green space use, presence of a disability, age, and social capital. The models in Table 5.4 show that of the four mechanisms explored, none of the interactions with green space are significant, thus, there is no significant factor found to moderate the green space – health relationship within the scope of this analysis.

In Table 5.4, it is noteworthy that the main effect of social capital in Model 4 is significant. This unexpected finding will be explored further in Chapter 6.

Table 5.4 Multiple linear regression analysis for potential moderating effects on the relationship between green space and change in perceived health

	CHANGE IN HEALTH OVER TIME			
	B	**(std. error)**	**β**	**N**
MODEL 1				
Green space use†	-1.903	(1.335)	-.034	685
Green space * Green space use	-.035	(.048)	-.042	
MODEL 2				
Disability†	-4.245	(.989)	-.095	1,178
Green space * Disability	.009	(.028)	.009	
MODEL 3				
Age†	-.105	(.030)	-.073	1,178
Green space * Age	-.001	(.001)	-.025	
MODEL 4				
Social capital†	.146	(.045)	.062***	1,137
Green space * Social capital	-.002	(.002)	-.021	

* p≤0.05; ** p≤0.01; *** p≤0.001

† main effects; centered if continuous (to increase interpretability of interactions)

note: all analyses controlled for baseline health, years participated, gender, age, income, level of education, presence of disability, and urbanity

5.5 NO FOUNDATION FOR MEDIATING OR BUFFERING EFFECTS

If a robust relationship were to exist between green space and change in perceived health, such a relationship would have been uncovered in the basic regression analysis (summarized in Table 5.3). With the lack of a robust relationship, the potential to explore moderating effects survived; however, the potential for mediating effects was eliminated. Likewise, the potential for a buffering effect was dismissed. After all, there is no purpose in exploring causal mechanisms (physical activity, social contacts, mental restoration) if a relationship does not exist at all. Thus, Hypotheses 3, 4, and 5 were not tested in a formal analysis.

Chapter 6. Exploration of an Unexpected Finding: Social Capital and Self-Perceived Health

There was a surprising finding in the moderator effects analysis that inspired further exploration. As seen in Model 4 of Table 5.4 (reproduced below in Table 6.1), the main effect of the "moderating" variable social capital on health outcome was profound, while the interaction term was not significant. Therefore, social capital is not moderating any effect of green space on health, but rather having an independent influence on the perceived health of chronically ill individuals in this study population. Perceived social capital is positively and significantly associated with an improvement in perceived health of individuals over time (β=.062, p<.001).

Table 6.1 Multiple linear regression analysis for potential moderating effect of social capital on the relationship between green space and change in self-perceived health

	CHANGE IN HEALTH OVER TIME			
	B	**(std. error)**	**β**	**N**
MODEL 4				
Social capital†	.146	(.045)	.062***	1,137
Green space * Social capital	-.002	(.002)	-.021	

* p≤0.05; ** p≤0.01; *** p≤0.001

† main effects; centered if continuous (to increase interpretability of interactions)

note: analysis controlled for baseline health, years participated, gender, age, income, level of education, presence of disability, and urbanity

6.1 THE EFFECT OF SOCIAL CAPITAL FOR DIFFERENT PEOPLE, PLACES

From the results displayed in Table 6.1, it became clear that the main effect of social capital on health change was significant. In order to better understand this effect, a set of stratified analyses were conducted to explore the ways in which the influence of social capital on health varied across different levels of urbanity as well as different age groups. Results of these stratified analyses are displayer in Table 6.2.

Table 6.2 Stratified regression analyses for the effect of social capital on change in perceived general health by level of urbanity and by age

	CHANGE IN HEALTH OVER TIME			
	B	**(std. error)**	**β**	**N**
Very strongly urban	.293	(.122)	.135*	158
Strongly urban	.131	(.111)	.053	216
Moderately urban	.191	(.088)	.081*	292
Non-urban	.080	(.071)	.033	471
75+ years	.091	(.081)	.046	314
65-74 years	.161	(.093)	.071	270
40-64 years	.163	(.076)	.060*	482
≤39 years	-.349	(2.771)	-.018	71

* p≤0.05; ** p≤0.01; *** p≤0.001

6.1.1 Level of Urbanity

First, regression analyses were stratified by level of urbanity in order to look for differences in the effect of social capital on health based on the urbanity of the residential environment. According to literature, social capital is generally lower in urban areas compared to rural ones, yet it exhibits the most independent association with health in urban or moderately urban areas (Mohnen, 2012).

As seen in Table 6.2, the effect of perceived social capital on change in perceived health is significant and strongest in areas of the Netherlands classified as very strongly urban (β=.135, p<.05). The positive effect of social capital is also significant in moderately urban areas (β=.081, p<.05). In summation, chronically ill individuals living in very strongly urban or moderately urban areas of the Netherlands benefit from higher levels of social capital as it positively influences their change in self-perceived health over time.

6.1.2 Age

Next, the analysis was stratified by age groups in order to understand how social capital exhibited different influences on the perceived health change of people of different ages. The basis for this stratification was such that social interaction and social capital may be exercised and utilized differently among people of different age groups. The results of this stratified analysis are found in Table 6.2.

As seen in Table 6.2, when stratified by age group, the regression analysis reveals that 40 to 64 year-olds living with chronic illness experience a significant positive impact of social capital on their perceived health change (β=.060, $p<.05$).

Chapter 7. Discussion and Implications

"We are drowning in information, while starving for wisdom.
The world henceforth will be run by synthesizers,
people able to put together the right information at the right time,
think critically about it, and make important choices wisely."

– E.O. Wilson, *Consilience: The Unity of Knowledge,* 1998

An ecological approach to public health posits that beyond basic selection effects that cause spatial health differences among a population, specific social and environmental processes also influence our health. In general terms, literature suggests that green space in the living environment facilitates beneficial health effects for the average person. The proposed salutary effects of green space are believed to work through causal mechanisms of increased physical activity and social contacts as well as mental restoration. This study sought to investigate the extent to which the health-promoting effects of green space were true for a population of individuals living with chronic illness.

7.1 Green Space and Health Among Chronically Ill

The amount of green space in the living environment of chronically ill persons was examined in relation to the change in self-rated health over four years. The results indicate that the amount of green space in a chronically ill person's living environment is not associated with their self-perceived health over time. No significant relations were found between the percentage of green space in the four digit postal code area and whether or not the self-

rated health of chronically ill people improved, deteriorated, or remained generally stable over time.

From what is known in the literature on chronic illness, perhaps this study's finding that chronically ill individuals who are older or have a physical disability experienced significantly greater deterioration in perceived health over time is not surprising. Additionally, in accordance with literature on health inequality, it is also no surprise that individuals with a higher income reported significantly less deterioration in perceived health over time.

With a lack of evidence to support an association between green space and change in self-rated health among the study population, there were no grounds upon which to base an analysis of potential mediating effects. Alas, it is fundamentally illogical to explore causal mechanisms if there is no evidence of a relationship in the first place (thus dismissing Hypotheses 3, 4, and 5). Despite a lacking main effect of green space in the regression analysis; however, it was still possible to explore potential moderating effects of certain predictor characteristics of the cohort which might dictate varying effects of green space on health. An examination of interaction terms revealed that neither the amount of green space use, presence or absence of a disability, age, nor level of social capital significantly moderated the effect of green space on perceived health change.

7.2 Social Capital and Health

Despite the lack of a moderating relationship, the main effect of social capital on health was striking: Perceived social capital is positively and significantly associated with an improvement in self-perceived health of chronically ill individuals over time. Furthermore, stratified analyses revealed that perceived social capital had the strongest positive health effects in very strongly urban and moderately urban areas as well as for chronically ill people between 40 and 64 years old.

As discussed in Chapter 2, the ecological approach to public health places people in a sociophysical context to better understand individual variations in health. Just as this approach was best suited to explain possible health-promoting effects of green space, so too does it adequately frame an investigation of the influential role of social capital in human health. A fairly new hypothesis suggests that differences in neighborhood social capital might explain health variations between residential neighborhoods (Subramanian, Lochner, & Kawachi, 2003; Cattell, 2001; Kawachi, Subramanian, & Kim, 2008; Poortinga, 2006; Snelgrove, Pikhart, & Stafford, 2009; Mohnen, 2012; Lomas, 1998) Rooted in social relations, neighborhood social capital is the network-oriented state of common norms, behavioral reciprocity, mutual trust, and social cohesion among residents (Mohnen, 2012). Researchers

believe, in general, that more neighborhood social capital leads to better individual health of residents—independent of sociodemographic and physical conditions of the residents and of the neighborhood. This study's finding that social capital had the strongest positive health effects in very strongly urban and moderately urban areas is consistent with other studies revealing that social capital exhibits the most independent association with health in urban or intermediate urban-rural areas (Mohnen, 2012).

7.3 STRENGTHS AND LIMITATIONS

At the current time, this is the first study to investigate whether or not the widely-explored salutary effects of green space function the same way for individuals living with a chronic illness. Furthermore, while most research explores the effect of green space on health from a single point in time, the present study is only the second one (Takano et al., 2002) to examine this relationship longitudinally, which provides some insight into the time order of variables, thus creating the potential for more accurate causal inferences to be made.

The health data and green space data used in this study were derived from different databases, thus there is no single source bias. The use of objective environmental measures, such as urbanity and percentage of green space, reduces the risks of respondent bias. Even the implementation of the subjective environmental measure of perceived social capital is advantageous because a respondent's perception of spaces may motivate his or her behavior more than the actual reality of safety or friendliness of an area. It is believed that combining objective and subjective measures of the environmental setting improves understanding (Coley, Sullivan, & Kuo, 1997; Kuo et al., 1998; Kweon, Sullivan, & Wiley, 1998; Maas et al., 2009).

Along with its strengths, this study recognizes its limitations. The data on green space do not account for small green spaces in the living environment. As the data were derived from 25 by 25 meter grid cells, a cell was only regarded as green space if vegetation dominates the cell. Consequently, small spaces like gardens and street trees are not necessarily included in this study.

Unlike longitudinal studies that assess mortality rates over time (Takano et al., 2002), the present study looked instead at change in health among individuals who are still alive. While objective mortality rates provide a very clear outcome (alive or deceased), subjective measures may not reflect such obvious results. Self-reported health measures are well-established indicators of objective health (Simon et al., 2005; Rütten et al., 2001; Miilunpalo et al., 1997; Miilunpalo et al., 1997), but they are not without shortcomings. Additionally, it

is possible that self-reported measures of health operate differently for individuals with chronic illness than they do among a "healthy" population.

The lack of a definite link between objective circumstances and self-reported wellbeing has given rise to the concept of a hedonic treadmill. First introduced in 1971, the concept posits that even though external forces are always changing our lives, human happiness is a relatively constant state (Brickman & Campbell, 1971). The hedonic treadmill, or hedonic adaptation, works in such a way that when a person's living conditions change, the person adapts rapidly to the new circumstances, thus returning to their personal baseline of happiness. A similar idea can be applied to health: when something affects our health positively or negatively, we often return to a "center" state of attitude regarding our own health. In the realm of longitudinal health-related research on quality-of-life, this phenomenon is known as "response shift."

Response shift is a term that refers to a change in the meaning of one's self-evaluation, and can occur in any field where self-reports are utilized. Response shift within the area of health-related assessment applies to a situation when an individual changes their own meaning of their self-evaluation of a specific personal construct such as quality-of-life, happiness, or in the case of this study, general health. Such a shift is the result of either a change in the respondent's internal standards of measurement, a change in personal values, or a redefinition of the construct (Sprangers & Schwartz, 1999). Researchers believe that these changes may be linked to the process of accommodating and assimilating the illness over a period of time.

Perhaps chronically ill individuals experience "ups and downs" in their health status over time, but they adjust to such fluctuations and accept such changes as the "natural course of their diagnosis." When asked to report their own health annually, it is possible that true changes in health are not accurately reflected as a result of this hedonic response shift. In fact, several studies have found that people with severe chronic illness report a quality of life level that is neither inferior nor better than that of healthier peers (Stensman, 1985; Breetvelt & Van Dam, 1991; Andrykowski & Hunt, 1993).

In the current study, health perception of individuals at inclusion (2005) was a very strong predictor of health perception of individuals in the final year of participation. For instance, people who perceived their health as poor at T_0 were very likely to maintain a poor view of their health at T_1. Thus, self-perceived health of respondents remained generally stable over time. Perhaps individuals in this study, despite changes in their health from year to year, returned to a relative state or "baseline" of their own health perception—exhibiting a form of hedonic adaptation or response shift. Future research may seek to utilize more objective measures of health of chronically ill patients, such as those reported by their general practitioners, in order to avoid self-reported relativism of health.

7.4 FUTURE RESEARCH

The evidence supporting salutary effects of green space is mounting, and the future in this field of study is bright. As previously mentioned, forthcoming research in this area might benefit by looking at green space on a smaller spatial scale, such as one that would account for gardens, tree-lined streets, and shrubbery. These types of "micro" green space may be especially important for chronically ill individuals who experience a reduced action space and may not easily travel to large, intentional green spaces like parks or nature reserves. In regards to data measurement, future research might uncover more significant changes in health over time by utilizing objective health data rather than self-reported data, consequently avoiding problematic issues of health-related relativism and adaptation to chronic illness associated with the hedonic treadmill and response-shift phenomena.

As it was beyond the scope of this thesis, the link between social capital and health has not hitherto been explored at length. Significant findings in this regard, however, have surfaced over the course of this study. The positive effect of social capital on self-rated health of chronically ill people is a preliminary finding full of potential. Such a discovery begs further questions: How does the relationship between social capital and health work? Is the effect stronger for individuals with a chronic illness than those without?

Chronic diseases are of long duration, slow progression, and generally cannot be prevented by vaccines or cured by medication. As medical technology continues to pursue the development of treatments that improve the wellbeing of individuals living with a chronic illness, there may be alternative solutions at the community level. Social capital is believed to operate through psychological and biological processes that improve wellbeing, and growing evidence suggests that people whose lives are rich in social capital cope better with trauma and fight illness more effectively (Putnam, 2012). The potential health-promoting effects of social capital should continue to be explored, especially in regard to chronic illness.

7.5 CONCLUSION

In this study, the amount of green space in the living environment did not prove to have a significant association with self-perceived health change among people with chronic illness. In testing potential moderating effects of various cohort characteristics, it was also revealed that neither the amount of green space use, presence or absence of a disability, age, nor level of social capital significantly moderated the effect of green space on perceived health change.

The main effect of perceived neighborhood social capital on health was significant. Among this group of individuals with chronic illness, social capital was positively and significantly associated with an improvement in perceived general health over time. Perceived social capital had the strongest positive health effects in very strongly urban and moderately urban areas of the Netherlands as well as for chronically ill people between 40 and 64 years of age.

Findings from this study should not detract regard for the importance of the health-influencing role of the living environment of people with chronic illness. Future research should continue to explore how both the social and physical environment of chronically ill persons influence the state of their wellbeing. Additionally, the results of this thesis suggest that self-reported measures of health may be problematic in any attempt to assess change in health over time among a chronically ill population due to the phenomenon of response shift. Future endeavors to explore the salutary potential of green space for individuals with chronic illness should look to utilize more objective health measures in order to reveal a truer reflection of longitudinal health change.

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