THE RELATIONSHIP BETWEEN NEIGHBORHOOD ENVIRONMENTS, WALKING, AND QUALITY OF LIFE AMONG LOW-INCOME SENIORS IN ST. PAUL, MINNESOTA

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Abstract

This study aimed to explore the relationship between demographic characteristics, objective and perceived neighborhood environments, walking behaviors and quality of life among low-income older adults in St. Paul, Minnesota. The conceptual model developed for this study was based on previous research models including the Ecological Model of Health Behaviors by Sallis and colleagues (2008) and Quality of life by Lawton (1991). However, these models cannot explain the relationship between walking behaviors and quality of life. Thus, empirical studies were also considered.

For objective neighborhood environments, Pedestrian Environment Quality Index (PEQI) was used to observe the neighborhood environments. Moreover, publicly available data including Part 1 Crimes, traffic accident calls, traffic accidents at intersections, vacant buildings, the number of destinations, land use, and transportation were used to draw maps with Geographical Information System. For this study, the elderly residents living in HUD Section 202 housing were recruited, who are aged 65 years old or over. For the perception of neighborhood environments, accessibility to destinations, comfort and convenience, attractiveness, and safety from traffic and crime were measured with a self-administered survey questionnaire. In the survey questionnaire, demographic characteristics, overall quality of life and walking days in winter and summer were also asked.

From the objective neighborhood environment data, it was difficult to judge which neighborhood is more walkable since the neighborhood environments with many destinations have a lot of vehicle accidents, crimes, and vacant buildings, negatively

related to walking. Therefore, ANOVA analysis, logistic regression analysis, multiple linear regression analysis, and bivariate analysis were utilized for quantitative analyses.

The study findings are as follows:

First, quality of life and walking behaviors in winter did not differ by individual housing location; however, walking behaviors in summer were different by grouped housing locations. This may be associated with objective environmental factors including safety (traffic accidents at intersections and crimes) and attractiveness (vacant buildings).

Second, the perceptions of neighborhood environments were different by grouped housing locations. In the neighborhoods where the older respondents perceived the highest number of potential destinations, they perceived their neighborhood environments as the lowest attractiveness and safety.

Third, the significant factors predicting walking or non-walking were 1) self-rated health (+) and unattractiveness (-) in winter; and 2) attractiveness (+) or unattractiveness (-) in summer. Moreover, more walking was associated with 1) living alone (-) and self-rated health (+) in winter; and 2) traffic accidents at intersections within 400m network buffers (-), self-rated health (+), and utilitarian destinations (+) in summer. Interestingly, self-rated health of older adults were less significant for walking behaviors in summer.

Last, the most significant factor expecting better quality of life was better self-rated health. Objective and perceived neighborhood environment factors were not statistically associated with walking but safe and attractive neighborhood environments were associated with more walking. Thus, more walking potentially influences health outcomes and quality of life for older adults for the future. These study findings are implicated policy makers, urban designers and housing developers.

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CHAPTER I

INTRODUCTION

Background

Since the baby boomer generation started to reach 65 years old, studies focusing on the elderly have increased significantly due to the dramatic rise in the number of elders. The U.S Census Bureau expects that the population aged 65 and over will "double from 36 million in 2003 to 72 million in 2030" (U.S. Census Bureau, 2005, p.6). The proportion of the elderly population will increase from 12% to 20% in the same time period (U.S. Census Bureau, 2005). It is projected that the population of older adults will be 86 million by 2050 in the U.S. (United Nations, 2012).

As people age, their physical, psychological, economic, and social aspects change. In particular, older adults experience the change of household composition and shrinking financial resources after retirement. Although they spend less on housing compared to the group under 65 years old, the share of income spending on housing for them is more than 30% since they have income which is considerably lower than the younger group whose age range is 55 to 64 years old. Moreover, as health issues become important to older persons, they come to spend tremendous financial resources on these issues (Moon, 1988). Thus, reducing expenditures on housing becomes essential and affordable and adequate housing is an important concern to the elderly. Although the majority of the elderly live independently, insufficient research on independent living and its built environment has been performed compared to the research on institutions in the United States (Gitlin, 2003). The U.S. Census Bureau reported that 41.9% of non-institutionalized elderly

populations have disabilities (2000). This means that the mobility issues are critical concerns for the elderly population. Living environments including the home and neighborhood settings are important to the elderly population, especially for those with mobility disabilities. However, few studies have been focused on their neighborhood environments.

Historically, the U.S. government has responded to the housing needs of older adults by citizens through a variety of federally funded assistance programs. The Section 202 housing is a representative type of assisted housing programs for low-income elderly residents. The purpose of the Section 202 program is to supply affordable housing for the elderly with supportive services. Section 202 housing offers very low-income elders with options enabling them to live self-sufficiently. The U.S. Department of Housing and Urban Development (HUD) supports the development of Section 202 housing through financing for the construction, rehabilitation, or acquisition of housing development that offer very low-income older adults' housing including supportive multi-family rental housing for the frail elderly. HUD also provides subsidies for residents to reside in the housing in affordable price. The subsidy commonly combines the Section 202 units with rental assistance through the Section 8 program providing subsidized rent for tenants (U.S. HUD, 2013). In addition, Section 202 housing includes supportive services such as cooking, cleaning, and transportation.

HUD offers capital without interest to privately owned nonprofit organizations to finance the development and construction of Section 202 housing for the elderly. The forgivable loan does not need to be paid back so long as the housing serves very low-

income older adults for 40 years. The rental assistance (Section 8) is offered to cover the gap between the HUD-operating cost for the housing and the rent from the tenants. The rent assistance is initially provided for 3 years and is renewable on the basis of the available funds (U.S. HUD, 2013). Eligible prospective households are expected to include at least one very low-income household member aged 62 years old or older. Eligible private nonprofit organizations should meet the following conditions:

1) "Meets the definition of private nonprofit organization under part 891;
2) Has Articles of Incorporation which provide no more than minority control by the public body or tribe; and
3) Is not receiving a majority of its operational funding from the public body or tribe" (U.S. HUD, 2013).

Potential developers apply for funding announced in the Federal Register through Notice of Funding Availability (NOFA). Section 202 funding is a still ongoing elderly housing program supporting the funds for the construction, rehabilitation, and acquisition of multifamily housing. Moreover, HUD's Section 202 housing program offers million dollars in tenants' rents and tenants only pay 30% of their adjusted incomes as rent (U.S. HUD, 2013).

Obama administration announced that the funding was awarded under Section 202 and 811 housing programs for the construction or major rehabilitation for more than 189 housing projects in 42 states and Puerto Rico in 2011. In Minnesota, HUD provided four private nonprofit organizations with total $31,648,500 including three year rental subsidy for four developments with total 204 units in Minneapolis, St. Paul, Chaska, and Rochester (U.S. HUD, 2011).

The research about the neighborhood environments for Section 202 housing is important because it is still on-going project and information about how neighborhood environments influence quality of life for low-income elders will help policy makers and developers to select and develop better neighborhood environments for low-income elders.

The low-income elderly population is likely to have relatively high proportions of women, single persons, former renters, low-income tenants, and users of public transportation due to a smaller proportion of licensed drivers (Leung 1992; Smith 1991). These elderly have limited housing choices and their neighborhoods' environments are important because they are more likely to depend on public transportation and walking. If they have mobility disabilities, their housing environments and neighborhood environments greatly influence their independent living. Kendig (2003) pointed out that previous studies in the multidisciplinary field of environmental gerontology have concentrated on time use and active space use for understanding microenvironments and macroenvironments. However, the research on macroenvironments of neighborhoods has been insufficient although the research is important to elders. Golant (1992) also argued that the housing needs of seniors should be expanded to the broader perspective of place of residence (neighborhood) as well as housing environment itself. Several studies note that geographical proximity to amenities, social ties and out-of-home services may be especially important for older people who are subject to mobility limitations such as seniors in government-subsidized housing. It has been known that physical environments (such as highway conditions, sidewalks, and outdoor lighting), destinations (such as shopping opportunities, health facilities, recreational facilities, and personal business

services), convenience, and safety (lower crime perception and safety from traffic) in neighborhood environments contribute to the psychological well-being of the urban seniors (Burby and Rohe, 1990; La Gory, Ward, and Sherman, 1985; Lawton, 1980; Smith and Gauthier, 1995).

Purpose

The purpose of this study is to analyze the relationship between quality of life of elderly residents and their neighborhood environments. Moreover, the relationship between the elder's walking, and quality of life is examined. One of key issues in this study is examining how the built environment enables elders to live independently and to increase their quality of life. Although Kendig (2003, p. 612) mentioned that "the macro-scale environments of neighborhoods, regions, and urban-rural divides are so significant in structuring experiences of aging", most of studies about built environments were related to micro-scale such as housing interiors. Moreover, a number of studies have been focused on the relationship between walking and health such as obesity in neighborhood levels rather than well-being and quality of life (Berke, Koepsell, Moudon, Hoskins, & Larson, 2007; Lee, 2004). This study explores how walking and perceived and objective neighborhood environments influence elders' quality of life in HUD-subsidized housing (Section 202 program) in St. Paul, Minnesota.

Research Questions

The following questions were examined in this study.

1) How are quality of life, walking days in winter and walking days in summer different by the housing locations?
2) How are the older adults' perceptions on their neighborhood environments different on the basis of housing locations?
3) How significantly is walking selection (walking and non-walking) of older adults associated with demographic characteristics, objective neighborhood environments, and perceived neighborhood environments in winter or summer?
4) How significantly is walking of older adults associated with demographic characteristics, objective neighborhood environments, and perceived neighborhood environments in winter or summer?
5) How significantly is the overall quality of life of older adults associated with demographic characteristics, objective neighborhood environments, perceived neighborhood environments, and walking?

Overall, this study examined the perceptions among American older adults regarding their quality of life and walking. To be more specific, demographic characteristics, objective and perceived neighborhood environments were examined as predictors of walking behaviors of the low-income elderly. Demographic characteristics, objective and perceived neighborhood environments, and walking behaviors also were explored as predictors of quality of life.

CHAPTER II

LITERATURE REVIEW

The Background of the Elderly Population

Definition of the Elderly

Aging refers to the life course and is the development process through time. "Old age is usually defined as starting at age 65, but this is a social definition resulting mainly from the establishment of retirement norms and legislation related to old age security payments" (Driedger & Chappell, 1987, p. 3). The definition of the elderly varies by countries but the chronological age of 65 has been accepted as a definition of older persons or the elderly by most developed countries (World Health Organization [WHO], 2012). The elderly is divided into four groups: *the young old* who are usually in the age group of 65 to 74; *the middle age* who are usually in the age group of 75 to 84; *the oldest old* who usually are in the age group of 85 and over; and *centenarians* who are in the age group of 100 and over (Driedger & Chappell, 1987; U.S. Census Bureau, 2005).

For the purpose of this study, older adults are defined within the age group of 65 year or older although HUD-subsidized housing (Section 202) accepts seniors who are aged 62 years old or over as residents.

Physical Health of the Elderly

Self-rated health evaluation of elders. The National Health Interview Survey reported that approximately 41.6% of community based older adults categorized their health as excellent or very good condition (National Center for Health Statistics, 2011). The evaluation about health status reported by older women and men showed little

difference although African American and Hispanic American tended less often to report their health in excellent or good condition than white elders.

Chronic illnesses, obesity and health care costs. According to Ferrini & Ferrini (2008), morbidity rates offer information about the occurrence of disability and disease. Older adults have the most prevalent morbidity rates in all age groups since chronic illnesses are more prevalent. At least one chronic disease occurs in most of older adults. According to Ferrini and Ferrini (2008), between 2002 and 2003, the most commonly reported chronic diseases by older adults are the following: hypertension (51%) which is most prevalent; arthritis (48%); heart disease (31%); cancer (21%); and diabetes (16%). The percentage of diagnosed diabetes is increasing in all age groups. Of the older adults, 20.5% were diagnosed with diabetes in 2011 (National Center for Health Statistics, 2011). The prevalence of diagnosed diabetes in older men is higher than in older women. As expected, severe chronic diseases and the increased number of the diseases are generated more with advanced ages.

Of older adults, 27.8% aged 60 and over are obese and the rate is second highest among all age groups. The older men (29.1%) are more likely to be obese than older women (26.7%). The highest group in obesity is aged between 40 and 59 and the rate is 32.4%. As age increased, the rate of the persons who met the federal physical activity guideline decreased which contributes to obesity. Of the people aged 75 and older, around 30% and of the people aged between 65 and 74, around 40% met the federal physical guidelines in 2008. Women are more sedentary in all ages.

Since older adults have a higher prevalence of chronic disease than younger age groups, they are hospitalized more frequently, are prescribed more medicine, and more

frequently visit physicians. In addition, seniors are the major users of institutions for long-term care. The average health expenditure from out-of-pocket is $3,899 and the amount occupies almost 13% of their annual income. The payment is more than twice as much as the general population (approximately 6%) in 2003 (Ferrini & Ferrini, 2008).

Health and disabilities. Aging-related problems such as chronic pain from rheumatism and arthritis, declining sensory perception including vision and hearing, reduced bone mass and muscle, and slower reactions frequently limit elders' physical abilities. These disabilities contribute to the degree of engagement in physical activity in built environments. These declining health statuses prevent the elderly from living independently and result in being dependent on others to perform everyday activities (U.S Census Bureau, 1995). It is reported that in 2012, 36% of older population have some disabilities including "difficulty in hearing, vision, cognition, ambulation, self-care, or independent living" (U.S. Department of Health and Human Services, Administration on Aging, 2013). Some have minor disabilities but others require assistance in meeting important personal needs. Approximately 37% of the elderly reported that they had one or more severe disabilities and 16% of older persons reported that they needed some assistance in 2005. It is reported that disabilities increase as age increases. Of older persons aged over 80, 56% reported that they have a severe disability. Moreover, 29% of older persons over 80 reported that they needed assistance (U.S. Department of Health and Human Services, Administration on Aging, 2009). There is a strong correlation between disability status and reported health status. Among older people age 65 and over reporting a severe disability, 64% of them reported that their health status is fair or poor. Among the people reporting no disability, only 10% of them reported that their health

status is fair or poor. A severe disability is also related to lower income levels and lower educational levels (U.S. Department of Health and Human Services, Administration on Aging, 2009).

Limitation in activity increases because of chronic disease as people aged. Approximately, 25% of seniors aged 65 to 74 reported that they have activity limitations because of chronic health conditions. On the other hand, the percentage of activity limitations doubled in those aged 75 years old and older. Some elders have severe activity limitations (Ferrini & Ferrini, 2008).

Physical Activity Tendency of the Elderly

Benefits of physical activity. According to the *Healthy People 2020* (U.S. Department of Health and Human Services, 2012), Americans of all ages can benefit from regular physical activity in the aspect of quality of life and the improvement of health in spite of the presence of a disability or chronic disease. Physical activity lowers the risk of stroke, coronary heart disease, early death, type 2 diabetes, high blood pressure, falls, breast and colon cancer, and depression among adults and older adults.

Facilitators and barriers of physical activity. The report *Healthy People 2020* (U.S. Department of Health and Human Services, 2012) mentioned that 43.5% of people aged 18 years old or over engaged in at least moderate physical activity for the minimum of 150 minutes per week or vigorous physical activity for the minimum of 75 minutes per week in 2008. Physical activity levels vary on the basis of personal, economic, social, and environmental factors among all age groups according to the *Healthy People 2020* (U.S. Department of Health and Human Services, 2012).

Understanding the facilitators and barriers for physical activity plays a pivotal role in ensuring the effective interventions to enhance physical activity levels. The following factors are positively related to physical activity of both adults and older adults: postsecondary education; enjoyment of exercise; higher income; self-efficacy; expectation of benefits; social support from peers, spouse, or family; enjoyable scenery, accessibility and satisfaction with facilities; and safe neighborhood. The negative factors in physical activity include advancing age, lack of time, low income, rural residency, low motivation, and perception regarding the needed effort for exercise, perception of poor health, being disabled, and overweight or obesity. Among older adults, physical activity is also influenced by lack of social support, fear of injury, cost of program, and lack of transportation to facilities. Almost half of older adults (48.5%) had non-leisure time involving physical activity in 2010 (National Center for Health Statistics, 2012).

Prevalence of physical activity by gender. According to data from the Center for Disease Control and Prevention (CDC, 2012), the prevalence of physical inactivity drops in all older adults but in the U. S. the prevalence of inactivity in women was more evident. Behavioral Risk Factor Surveillance System (BRFSS) data revealed that the percentage of people who regularly enjoy physical activity increased between 1986 and 1990 in the age group of 55 years old and older; this tendency was more prevalent in women rather than men (Caspersen & Merritt, 1995).

Types of physical activity. Verbrugge and colleagues (1996) found that recreational activities in older adults were lower than in other ages. Older adults spent recreational time for socializing, traveling, entertaining, and walking. For men, sports are reduced compared to all age groups. Walking is the most common activity among older

adults including all socio-demographic strata in the United States (Crespo, Keteyian, Heath, & Sempos, 1996; Sacco, Gan, Boden-Albala, Lin, Kargman, Hauser, Shea, & Paik, 1998; Walsh, Pressman, Cauley, & Browner, 2001). Other physical activities among the elderly are likely to be low intensity activities including walking, gardening, and bicycling. According to Walsh and colleagues' research, walking is the most common physical activity (51%) among white elders. Gardening (35%), swimming (16%) and bicycling (13%) were the other common physical activities among them. BRFSS indicated that walking trends increased in 3.5% of male older adults in the U. S., who reported walking as a leisure-time activity from 1987 to 2000 (Simpson, Serdula, Galuska, Gillespie, Donehoo, Macera, & Mack, 2003). The trend is similar between male and female older adults and the prevalence became higher according to educational level. Moreover, the percentage of male adult's walking as physical activity for leisure-time had increased in all ages.

In conclusion, physical activity has increased among adults and older adults in the United States. The most frequent physical activity is walking.

Types of walking. The most common physical activity by all age groups, walking, is influenced by the built environments in the neighborhood. There are two types of walking: 'utilitarian or instrumental walking' and 'recreational walking' (Joseph & Zimring, 2007). The purpose of utilitarian walking is to arrive at destinations such as a wellness center or a grocery store. Utilitarian walking would be the consequence of utilitarian or routine activities. The purpose of recreational walking is diversion, exercise, pleasure, taking a walk and improving health and functioning.

To sum up, literature reviews about health found the following. Physical health problems can cause other health problems so preventing initial physical health problems is important. Physical functioning (disabilities) is an important factor explaining quality of life of older adults. Quality of life is influenced by physical health and built and social neighborhood environments. Thus, neighborhood environments supporting walking of the low-income elderly are important because: 1) health can be maintained by walking and 2) the low-income older adults have limited income to afford personal transportation. In addition, walking helps to improve physical health or retard physical limitations or disabilities. The elderly who have regular physical activity also tend to have sounder mental health and are more satisfied with their lives. If the neighborhood built environment allows for utilitarian walking to destinations and recreational walking for pleasure, the elderly population could enhance or maintain better physical health. Moreover, neighborhood environments allowing to access destinations and people by walking or public transportation may improve quality of life of low-income older adults because they have no barrier on mobility.

Neighborhood Environment Characteristics Supporting Physical Activities

Walkable neighborhood environments need to be accessible to destinations, need to be comfortable and convenient for walking and for living and need to be safe and attractive. Specific urban planning and design characteristics can be categorized into land use patterns such as density and mixed use development; transportation systems including street networks and transit systems; and urban design characteristics such as destination, safety, and aesthetics (Frank, Engelke, & Schmid, 2003). These specific characteristics supporting walkability are reviewed in the next section.

Accessibility to Destinations

Land use pattern. Land use patterns characterize the collection of structures and other features including parks, and buildings in the built environment (Frank et al., 2003). The arrangement of features determines the proximity between destinations in the built environment. It is possible that some destinations are close but those are not connected well. For example, big box shopping centers are car-oriented places. If there is a wall between a big box shopping center and housing area, the place is not well connected although the destination is physically close (see Figure 1). In contrast, some destinations are not close but they are well connected. Both cases are difficult to approach destinations. There are two key elements in land use patterns: density and mixed-use development.

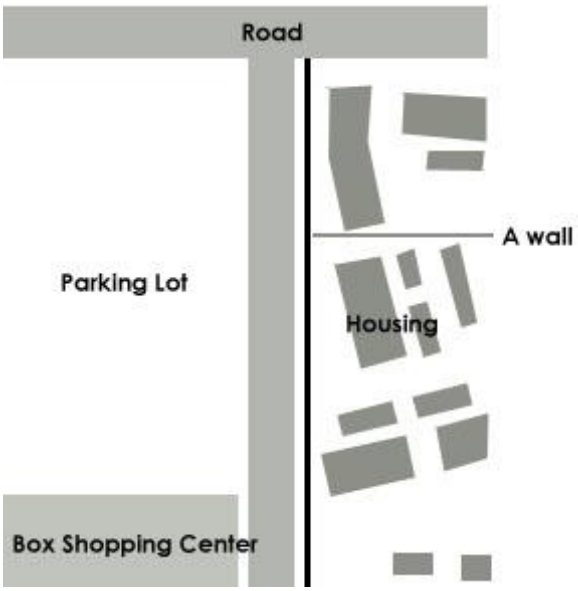

Figure 1. A wall prevents connectivity regardless of proximity. Adapted from "Health and Community Design: The Impact of the Built Environment on Physical activity," by L. D. Frank, P. O. Engelke, and T. L. Schmid, 2003, *Island Press,* p. 138.

Density. Density is an objective measure of urban form (Frank et al., 2003) and is measured in the aspect of the number of persons and households per a given area including a square kilometer or mile (Dunphy and Fisher, 1996). Higher density areas increase proximity so it is likely that higher density areas will promote more walking and transit use but single-occupant vehicle usage will decrease (Frank & Pivo, 1994). There are various ways for measuring density: residential density by calculating the total number of residents per a given area; household density by calculating the total number of households per a given area; employment density by measuring the total number of employees per a given area; and net residential density by indicating the total residents per a given residential land (Frank et al., 2003; Frank, Stone Jr., & Bachman, 2000; Handy, Boarnet, Ewing, & Killingsworth, 2002).

There are two reasons for measuring population density (Frank et al., 2003). First of all, higher population densities enable transit to be more viable since highly concentrated population offers more financially feasible transit to transit users. Second, it is believed that higher population densities are translated into shorter distances to travel. It is also believed that higher density promotes more frequent non-motorized travel including walking and bicycling, and physical activity (Frank & Engelke, 2001; Handy et al., 2002; Lee & Moudon, 2008; Saelens, Sallis, Black, & Chen, 2003; Saelens & Handy, 2008). For example, Handy and colleagues (2002) found that higher density is positively related to walking behaviors. Rodríguez and colleagues (2008) found that population density is positively associated with walking. Lee and Moudon (2008) explored that older residential developments and higher density with smaller street blocks helped residents to engage in more physical activity including brisk walking. Saelens & Handy (2008) found

that density is positively associated with utilitarian walking but it was not clear for recreational walking. The residential areas tend to be more dense in the neighborhoods with lower socioeconomic status and these neighborhoods generally have more renters than owners and more opportunities for walking for transportation purposes (Lee, Cubbin, & Winkleby, 2007; Ross, & Mirowsky, 2001). Moreover, the skyline of buildings were more varied in high density neighborhoods than in low density neighborhoods (Chaudhury, Sarte, Michael, Mahmood, Keast, Dogaru, & Wister, 2011)

Mixed-use development. The term mixed-use development describes the co-existence of multiple uses in the same area (Frank et al., 2003). Theoretically, mixed-use development includes the mixture of all uses in a limited geographic space including residential, commercial, retail, civic, industrial and entertainment. To be more specific, each destination can be categorized into the following: supermarkets, hardware stores, local shops, laundry and dry cleaners, post offices, libraries, greengrocers, primary schools and other schools, video outlets, cafés, pharmacies, bus or train stops, natural bushlands, parks, sports fields, beaches, parks, rivers, and fitness or recreation centers (Leslie, Saelens, Frank, Owen, Bauman, Coffee, & Hugo, 2005).

The mixture of uses reduces distance between destinations. As distance is considered an important obstacle to non-motorized travel, it is believed that mixed-use development is a good strategy to promote non-motorized travel. The most common mixed-use development in residential areas includes retail and commercial uses and it has been believed to strongly promote non-motorized travel (Kaczynski & Sharratt, 2010; Cervero & Duncan, 2003). Nagell and colleagues (2008) found that the relationship

between commercial establishments and walking time was greatest within a 400 meter buffer (a quarter-mile buffer) among the elderly.

In the United States, urban development has evolved to create specialized subregions. Sections of some of these regions include a lot of employment (Central Business District, CBD) but other regions are dedicated mainly to housing (Anas & Xu, 1999). In areas with high employment, services including hair salons and banks, and retail destinations such as lunch counters commonly meet needs of the high number of office workers. It is believe that balanced employment/housing can reduce automobile usage and shorten commute trips (Frank et al., 2003).

Destinations. A number of studies explored destinations promoting non-motorized travel such as walking. The most popular destination to walk at least once a week for all age groups is grocery stores (Lee & Moudon, 2008). Other destinations frequently visited by walking were banks, drug stores, cafés or coffee shops, post offices, clothing stores, video stores and book stores. The most important factor is utilitarian destinations. The existence of the following factors within a 1,000 meter (m) buffer encourages walking: post offices, convenience stores, the cluster of restaurants, grocery stores and retail stores, and the nonexistence of giant box stores. Big box stores promote automobile-oriented travel rather than walking. This is the same result that small size blocks promote walking which means the limited travel distance because it reduces travel distance. Research by Parra and colleagues (2011) found that residents having four to six or more destinations within a walkable distance of 10 minutes doubled the chance of using walking and bicycling as a means of transportation.

According to Lee and Moudon (2008), sufficiently active group lived in single-family housing and in built environments with more encouraging infrastructure for active living such as walking and biking. The environments included on average fewer vehicular lanes, small street blocks, and slower speed posted on average. Physical activity facilities including sports facilities, fitness centers, and parks are important factors stimulating physical activity. Park users, including older adults, participating in moderate physical activity can obtain psychological health benefits. Godbey and Blazey (1983) found that they had a better mood after moderate physical activity in a park. It is also expected that they obtained physical benefits from exercise in a park. Walking, sitting, looking, talking, and exercise are the most common activities by older adults in parks. They frequently visit parks on a consistent basis, utilize the same park for several years, and stay for a common amount of time during each visit. Recent studies about regional and local parks illustrated that the majority of park users tend to engage in sedentary recreational activity. Although they engage in sedentary activity (Cordell, McDonald, Teasley, Bergstrom, Martin, Bason, & Leeworthy, 1999), they are able to positively influence their mental health and stress (Bedimo-Rung, Mowen, & Cohen, 2005). Moreover, the perception of having a park near a residents' living place is a great source of pleasure (Kaplan, 1980).

Transit-oriented development. A transportation system is defined as "the network of physical infrastructure within a region, such as its street network, its transit systems, and separated systems for non-motorized users such as jogging and biking paths" (Frank et al., 2003, p. 100). In addition, a transportation system is a mode-specific term. For instance, the total infrastructure is dedicated to specific users such as car drivers, bike

users, or pedestrians. Transportation determines how effectively destinations are connected to each other (Frank et al., 2003). First, a transportation system can offer few or many links between destinations. A well connected network provides many available routes between destinations. Second, a transportation system can be fragmented or continuous. For example, a fragmented network for pedestrians means abruptly discontinuous sidewalks.

There are two modes of transportation: motorized transit system and non-motorized travel including walking (Frank et al., 2003). Transit systems require non-motorized travel because one has to walk both ends of a transit journey incorporating transit into built environments. This means that transit stops should be located in walkable distances between destinations. In contrast, in suburbs, transit stops are enclosed by parking lots to attract commuters to use transit systems. Although they arrive to destinations with transit systems and walking, commuters use automobiles to go from their homes to transit stops. If built environments support transit systems to commuters' destinations, this is called "transit-oriented development" (TOD; Frank et al., 2003, p. 131). Calthorpe argued that users "like transit to extend their range of destinations. These needs can be satisfied in both high-density urban centers and small mixed-use towns, but not in sprawling, unplanned suburbs" (1993, p. 27-28). Thus, the TOD conception "is simple: moderate and high-density housing along with complementary public uses, jobs, retail and services, are concentrated in mixed-use developments at strategic points along the regional transit system" (Calthorpe, 1993, p. 41). TOD is also defined as moderate and high density residential area development including shopping and employment

opportunities, and transit stops within walkable area (California Department of Transportation, 2002).

Frank & Pivo (1994) explored the relationship between land-use mix, population density, employment density, and single-occupant vehicle (SOV) use. SOV and other characteristics are negatively associated with walking in work and shopping trips. However, the relationship between land-use mix, population density, employment density, and transit and walking were continuously positive for shopping and work trips. Walking was most sensitive to the increase of population density but the reduction in choosing SOV travel was not significantly related to increases in population. Handy and colleagues (2002) found that transportation systems, urban design, and land use patterns, which help produce healthier, active, and more livable communities, encourage non-motorized travel including walking and bicycling. Rodríguez and colleagues (2008) explored the concept that perceived insufficient parking spaces and its cost in local shopping areas are positively associated with more overall walking and more transport (utilitarian) walking and self-reported transit accessibility is also related to utilitarian walking. Free car parking is considered as promoting driving but allotment of parking through controls or high pricing is related to more non-motorized travel, fewer single-occupancy vehicle uses, and fewer car miles (Pucher and Buehler, 2006). Accordingly, Leslie and colleagues (2005) found that the residents in highly-walkable neighborhoods may tend to use public transport more on a regular basis because a lot of bus routes cross their neighborhood than residents in low-walkable neighborhoods with few bus routes. However, car ownership (96.5%) was high in both groups. It is interpreted that infrastructure such as public transit influences walkability and residents' perceptions. The residents'

perceptions are more accurate in highly walkable neighborhoods because they are more exposed to their environments than residents in car-oriented neighborhoods. Smith and Gauthier (1995) found that the comparatively dense public transit systems are beneficial to the majority of residents especially those who do not possess a car, such as residents of low-income senior housing, but they argued that the public transit will only partially compensate for restrictions in the availability of services within the close area.

Street network and connectivity. "Street networks influence trip route and mode choice through the ways in which trip origins and destinations are connected. Networks can be rated as either high in connectivity, where there are a large number of blocks and intersections per some unit of area, or low in connectivity, where there are fewer blocks and intersections over the same area. There are generally three types of street network including the organic, grid, and hierarchical street networks" (Frank et al., 2003, p118). The organic network is naturally made without urban planning while planed networks include grid and hierarchical street networks. Figure 2 shows how the distance between two destinations is different according to street networks. Figure 2 on the left side is the West Side neighborhood with a grid network and the Figure 2 on the right side is the Greater East Side neighborhood with a hierarchical street network in St. Paul. The Westside neighborhood is more highly connected than the Greater East Side neighborhood so the walking distance is dramatically shorter although the linear distance between two destinations are the same.

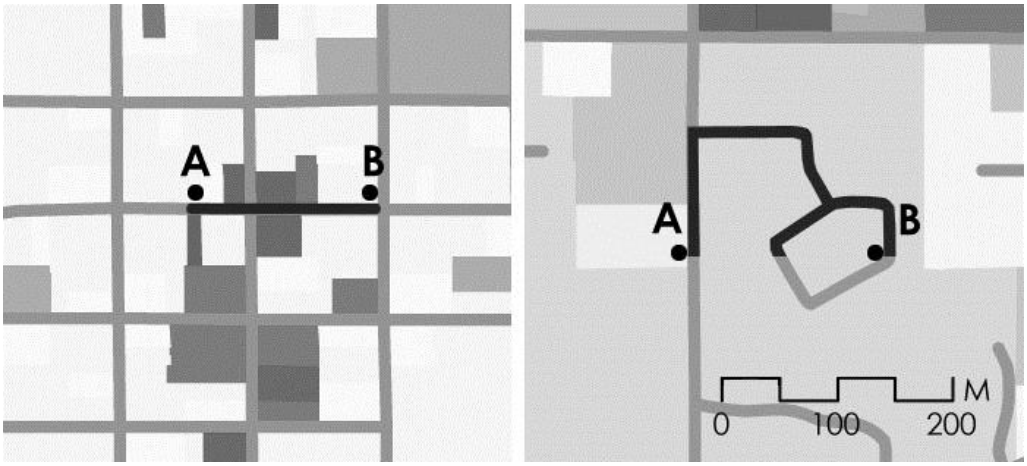

Figure 2. Maps of two neighborhoods in St. Paul.

Many studies have explored how walkability is influenced by street networks and connectivity (Berke, Koepsell, Moudon, Hoskins, & Larson, 2007; Handy et al., 2002; Heinrich, Lee, Suminski, Regan, Reese-Smith, Howard, Haddock, Poston, & Ahluwalia, 2007; Leslie et al., 2005). Research by Leslie and colleagues (2005) and Handy and colleagues (2002) found that highly-walkable neighborhoods have better connectivity than lower-walkable neighborhoods. Berke and four colleagues (2007) found that better connectivity of streets and denser networks in neighborhoods are more walkable. Heinrich and colleagues (2007) explored intersection density (street connectivity) is positively related to physical activity including walking. Street connectivity is measured by the number of real intersections in a particular area (Leslie et al., 2005). According to Leslie and colleagues, the walkable street networks are associated with the following: "not many cul-de-sacs; walkways connecting cul-de-sacs to streets, pathways; short distance between intersections; many four-way intersections; many alternate routes; infrastructure for walking footpaths (sidewalks) on most streets; well-maintained footpaths (sidewalks); an easily accessible park or nature reserve; footpaths (sidewalks)

separated from streets by grass/dirt strip; footpaths (sidewalks) separated from road/traffic by parked cars; and an easily accessible bicycle/walking path" (2005, p. 233).

Walkable distances are usually considered between 90 meter to 1,000 meter (90 m to 1,000 m) or 1 to 15 minute walk from a place to a place for healthy adults (Hoehner, Ramirez, Elliott, Handy, & Brownson, 2005; Lee & Moudon, 2008). Hoehner et al. (2005) examined 5 minutes walking distance, a 400 m buffer. Pikora and colleagues (2002) examined a 400 m radius buffer or a distance to walk within 5 minutes to examine neighborhood environments associated with walking. McCormack and colleagues (2008) found that the distance to bus stops, convenience stores, post boxes, transit stations, news agencies, and shopping malls within 400 m and transit stations, convenience stores, news agencies, shopping malls and schools within 1,500 m were related to regular utilitarian walking. A few studies focusing on walkability about the elderly population consider a 1,000 m buffer as maximum walkable distance (Berke, Gottlieb, Moudon, & Larson, 2007). Hess assumed walking speed of older adults 0.8 m per second (2012). The calculated distance that older adults can walk within 15 minutes is 720 m. According to this calculation, the maximum distance older adults can walk for destinations is 800 m. Handy (1996) explored that individual limitations and motivations are the main determinants of the choice for walking and urban form related factors encourage and discourage walking in the case with motivations and the lack of limitations.

Urban Design Characteristics

Urban design is defined as the decisions made by professionals about how natural and built environments will be associated with one another in a particular space. In the decision-making process, urban designers think about how people will recognize and

interact with the natural and built environments (Saelens, Sallis, Frank, 2003). Urban design characteristics affect individual's perceptions about whether they desire to walk, bike, or engage in recreational exercise at a specific place (Frank et al., 2003).

Comfort and convenience. The distances in which the individual is engaging in such activities are shorter than those made by public transit or car, at best a few miles (Cervero & Duncan, 2003). Thus, the person is greatly affected by urban design characteristics including parks, streets, plazas, squares, lawns, buildings, sidewalks, crosswalks, bus stop shelters, curbs, trash bins, plantings, billboards, curbs, fences, and the other elements. Heath and colleagues (2006, p. S55) argued that two interventions including "community-scale and street-scale urban design and land use policies and practices" were effective in encouraging physical activity. Community-scale urban design means street layouts, transit-oriented development, locations of stores, the density of development, and jobs and schools within walkable distance from housing.

The specific examples of street-scale urban design intervention are improved lights, enhanced aesthetics, and redesigned streets including forming squares, creating/ renovating playgrounds, traffic calming features, one-way streets, and bicycle lanes. Community-scale urban design was already discussed so street-scale urban design will be discussed in this section. Those also influence attractiveness and safety. The factors related to personal comfort is buffer zones with benches, trees, and landscaped strip. According to Rodríguez and colleagues (2008), availability, connectivity, and maintenance of sidewalks were related to utilitarian walking but those are not significant.

Attractiveness. Generally, neighborhood aesthetics include the followings: trees along the streets; shade for the sidewalk by trees and awnings; freedom from litter; many interesting things to look at during walking; many attractive sights such as landscape views; and attractive houses and buildings. According to Leslie and colleagues (2005), it was found that aesthetics are higher in lower-walkable neighborhoods than in highly-walkable neighborhoods. They found that lower-walkable neighborhoods have a much hillier and bushier topography with more shrubs, trees, open green spaces and scenic views than high-walkable neighborhoods. Shop windows, common doorways, signs, awnings, and changes in building characteristics encourage animating the pedestrian zone. The vertical mix of uses, including offices over stores or apartments, creates visual variety, a wider range of pedestrian activities and their presence for 24 hours on the street (Owen, 1993).

Safety

Safety influencing walkability means usually safety from traffic and crime.

Safety from traffic. The factors associated with safety from traffic are the presence of marked crossings, traffic or pedestrian signals and signage systems such as stop sign, traffic signal, yield sign, pedestrian crossing sign, pedestrian signal, pedestrian overpass, under pass or bridge, and ramps or curb cuts including materials and heights.

Nagell and colleagues (2008) found that the proportion of low traffic volume and high traffic volume streets was related to the total sum of time for walking among elders who reported some degree of physical activity such as walking each week in their local neighborhood. The relation between street volume and walking time was clearest at the half-mile buffer measurement. Streets with sidewalks and crosswalks where pedestrians

can travel are usually perceived as safe places. The safety perception is impacted by the high speed of automobiles through the street although the traffic is lighter (Handy, 1996; Owen, 1993). Road design standards for almost fifty years have favored with high-speed, motorized travel which discourages walking and bicycling for utilitarian and recreational purposes. This street design is automobile-oriented development associated with single family housing (Southworth, 1997). Urban design characteristics such as parking lots, arrangement and design of buildings, and other features also influence the desire to use non-motorized travel in the neighborhood (Owen, 1993). To be more specific, narrow street widths, on-street parking and the use of 'roundabouts' with plants on intersections encourages traffic to slow down.

Safety from crime. Crime-related design factors are street lighting and observable space (Newman, 1972). Two studies measured the possibility for walking outcomes and surveillance and dealt with various street characteristics encouraging crime vulnerability and surveillance (Pikora, Giles-Corti, Knuiman, Bull, Jamrozik, & Donovan, 2006; Craig, Brownson, Cragg, & Dunn, 2002). Those features include front porches, maintenance, and escape routes. Craig and colleagues (2002) found that "safety from crime" and "potential for crime" were significantly associated with an overall environmental score which was consequently related to more walking. Other characteristics in built environments offer visual cues influencing safety perceptions.

Disorder of built environments is one factor influencing safety perceptions according to a couple of studies. In the aspects of objectively rated and perceived disorder, lower levels of disorder were inversely related to utilitarian walking because physical disorder was mainly focused on lower-income areas (Hoehner et al., 2005;

Pikora et al., 2006). Moreover, disorder is likely to cluster in dense urban areas with more nonresidential land uses suggesting that neighborhood walkability and study context may have the confounding relationship between physical activity and disorder (Taylor, Koons, Kurtz, Greene, & Perkins, 1995). In addition, socio-economic status is complicated. Thus, adjustment for potential confounding variables is needed.

Doyle, Kelly-Schwartz, Schlossberg, and Stockard (2006) found that higher crime rates and less walkability were correlated with respondents reporting chronic illness related to obesity and lower ratings in self-reported health among lifelong residents in a neighborhood. The effect regarding high crime rates was stronger for women compared to for men. Social relationship in neighborhoods may influence safety. Sense of community found no statistically significant association with physical activity (Ainsworth, Wilcox, Thompson, Richter, & Henderson, 2003; Evenson, Sarmiento, Tawney, Macon, & Ammerman, 2003; Wilbur, Chandler, Dancy, & Lee, 2003). However, Evenson and colleagues (2003) found that the question of 'seeing people who exercise or knowing neighbors who exercise in the neighborhood' was significantly related to physical activity.

In conclusion, neighborhood walkability is associated with land use pattern, density, mixed-use development, types of destinations, transit-oriented development, street network and connectivity, urban design characteristics such as sidewalks and attractive scenery, and safety related to social environment and built environments in neighborhood. Although the association between urban design characteristics and walking is not significant, research found that design characteristics helped make neighborhood environments for walking more comfortable and convenient. Most of the

studies explored the relationship between healthy adults and walking so fragile elders might be more influenced by urban design characteristics including availability and maintenance of sidewalks, beautiful scenery, and available benches to take a rest.

Quality of life

Definition of Quality of Life

The World Health Organization (WHO) describes quality of life as a personal perception of life in the context of the value systems and culture which are related to personal goals, standards, expectations and concerns. The broad concept is categorized into the following: level of independence, physical health including bodily states and functions, psychological health, social relationship, and relationship to environmental features (WHOQOL Group, 1993). In the following section, the relationship between quality of life, physical activity and other factors will be explained.

The Relationships between Quality of Life, Physical Activity, and Other Factors

There are various factors influencing quality of life including neighborhood environment satisfaction, transport mobility, physical activity, physical health, mental health, and socioeconomic factors. Penedo and Dahn (2005) reviewed publications about physical health and mental health benefits from physical activity. They found that participants taking part in regular physical activity had more desirable health outcomes including better physical functioning ability and mood states, and better broad and health-related quality of life. Patterson and Chapman (2004) expected that a more convenient neighborhood promoting walking might increase quality of life and neighborhood satisfaction but the result of urban-suburban differences in functional ability and income

overshadowed any effects of type of residential area or urbanism. Older women in urban neighborhoods which are pedestrian-friendly with nearby services tended to walk to services although they were less healthy than those in suburban neighborhoods. A more walkable neighborhood, however, was not related to global measure of quality of life and neighborhood satisfaction. However, perceived neighborhood attributes such as safety from traffic and safe parks were positively related to health related quality of life (HRQOL) among elderly (Parra, Gomez, Sarmiento, Buchner, Brownson, Schimd, Gomez, & Lobelo, 2010). Furthermore, street noise was negatively related to HRQOL. This literature indicates that urban neighborhoods may let urban older residents be more active and to access services through walking in spite of declining health. The general measurements of quality of life do not question participants about satisfaction of specific neighborhood built environment characteristics which are associated with walking. Thus, the quality of life or satisfaction about neighborhood's built environments in walkable neighborhoods might be higher than in less walkable neighborhoods, especially for the older adults who do not own a car or cannot drive.

Friedman and colleagues (2012) found that social cohesion and safety is significantly associated with quality of life but walkability was not significantly related to quality of life. This research has limitations since measurement of walkability was limited to urban design characteristics including continuous sidewalks, crossable interactions, lighting at night, curb cuts, uneven sidewalks, cracks in sidewalks, benches to sit, and excessive noise from traffic such trains and car alarms. Nevertheless, qualitative studies pointed out that living in neighborhood environments such as the attractive environments allowing nice walks, accessibility to destinations and services

(transportation), and safety are associated with good quality of life (Bowling, Gabriel, Dykes, Dowding, Evans, Fleissig, Banister & Sutton, 2003; Gabriel & Bowling, 2004). Moreover, Tilt and colleagues (2007, p. 375) found that walking to destinations including "restaurants, libraries, coffee shops, playgrounds, and post offices" is important for the study participants' quality of life in the neighborhood.

Other studies found that urban design characteristics were not statistically significantly associated with walkability (Rodríguez et al., 2008). However, other studies found that low-walkable neighborhoods had more aesthetically pleasing urban design characteristics including more scenic views, open green spaces, trees, and shrubs then highly-walkable neighborhoods (Leslie et al., 2005). Studies by Rodríguez and colleagues (2008) have found that highly accessible destinations and transit in neighborhoods associated with walkability. Thus, to measure neighborhood walkability and quality of life, other factors including destinations, transit access, and perceived safety influencing walkability need to be included.

Social supports compensate for quality of life which was decreased by physical disability and depression (Friedman et al., 2012). Quality of life among older adults is categorized into the following: "having good social relationships, help and support; living in a home and neighborhood that is perceived to give pleasure, feels safe, is neighborly and has access to local facilities and services including transport; engaging in hobbies and leisure activities (solo) as well as maintaining social activities and retaining a role in society; having a positive psychological outlook and acceptance of circumstances which cannot be changed; having good health and mobility; and having enough money to meet basic needs, to participate in society, to enjoy life and to retain one's independence and

control over life" (Gabriel and Bowling, 2004, p. 675). Their findings show that intimate social relationships with their neighbors tends to be essential to older adults who are sick, lack of transportation, or have physical mobility problems which prevents them from visiting their friends who are far away. In other words, higher levels of depression and physical disability or disability problems reduced the chance of a high quality of life. Social support was protective in that it bolstered higher quality of life. Moreover, older residents' neighborhood environments enabling them to access neighborhood facilities and friend's homes without help are important if, in particular, older adults do not their own transportation. Otherwise, distances or convenience to access neighborhood facilities through public transit or walking might influence quality of life if older residents do not possess a car.

Quality of life can be improved by interventions such as walking programs. Fisher and Li (2004) explored how executing a neighborhood-based walking intervention program from low to moderate intensity is viable and favorable for encouraging quality of life among older adults at a community level. This is interpreted that a neighborhood built environment that encourages voluntarily regular walking can promote quality of life of residents.

CHAPTER III

CONCEPTUAL PERSPECTIVE

This chapter explains the conceptual frameworks which are used in this study. On the basis of previous studies, the relationship between objective and perceived neighborhood environments and physical activity (walking) is an indication of quality of life (Fagerström & Borglin, 2010; Patterson & Chapman, 2004). To explain the quality of life of older adults, satisfaction about neighborhood environments is a related variable. In this chapter, conceptual models about objective and perceived neighborhood environments and walking behaviors are reviewed. Moreover, the models are extended to understand quality of life of older adults.

Ecological Model of Health Behavior

The Ecological Model of Health Behavior stresses the policy and environmental contexts of behaviors as incorporating psychological and social influences. The Ecological Model of Health Behavior considers multiple influential levels as guiding the expansion of more broad interventions (Sallis, Owen, & Fisher, 2008).

The term *ecology* is originated from biological science and is associated with the interrelationship between environments and organisms. Ecological model evolving in behavioral sciences and public health concentrates on the nature of humans' transactions with their physical and sociocultural environments (Stokols, 1992). It is thought that healthy behaviors are maximized when policies and environments sustain healthful choices and individuals are educated and motivated to make the healthful choices (Ottawa Charter for Health Promotion, 1986). However, the outcomes of health behaviors

in policies and environments can provide weak and short term effects. For example, just offering a variety of vegetation and sidewalks does not guarantee that people will use these resources as expected.

The essential concept of an ecological model is that health behavior has multidimensional influences such as "intrapersonal (biological, psychological), interpersonal (social, cultural), organizational, community, physical environmental, and policy" (Sallis et al., 2008, p. 466). The following section expands on the four essential principles of ecological models of health behavior (Sallis et al., 2008).

First, there are various influences on particular health behaviors such as "factors at the intrapersonal, interpersonal, organizational, community, and public policy levels" (Sallis et al., 2008, p. 466). Concepts incorporate physical environments and socio-cultural factors which may occupy more than one level.

Second, there are influences on behaviors interacting across these different levels. This means that variables interact with each other. For instance, individuals who have higher motivation to lose weight may react in a different way than those who have lower motivation. The people might avoid buying food at fast-food restaurants and to increase physical activity by walking more. Moreover, education about active living may work better when policies support insurance discounts for regular activity and physical counseling.

Third, the most effective way to change behavior is multi-level interventions. A direct inference of ecological models is that single-level interventions are likely to be less powerful or not to have a population-wide impact. For example, just putting more fruits

and vegetables in all convenience stores may be insufficient to change human behaviors if communication, motivational campaigns, and education do not support the environmental change.

Fourth, ecological models are most powerful if they focus on specific behaviors. For example, the presence of cycling trails in suburban neighborhoods is not likely to relate to alcohol consumption. The demand to identify policy and environmental variables, which are behavior-specific, challenges the usage of Ecological Model of Health Behavior because lessons are learned with a specific behavior. For instance, lessons learned from promoting jogging are different from the lessons learned from promoting walking. The Ecological Model of Health Behavior can be utilized to the basis of behavior-specific models that are applicable to interventions and research.

On the basis of four principles of ecological view points, Sallis and colleagues (2006) combined concepts and findings from the fields of behavioral science, health, city planning and transportation, economics and policy studies, and leisure sciences to construct the ecological model in Figure 3. The model is organized with an onion structure to symbolize the multiple levels of influence with three peculiar features (Sallis et al., 2008). First of all, the model is organized with four domains of physical activity revealing the principles of ecological perspectives. Second, some kinds of important influences are not specifically bound to settings in which the behavior takes place. Third, cultural and social environments work at multiple levels.

Figure 3 shows an ecological model constructed around four domains of active living with many levels influencing specifically to each domain (Sallis et al., 2006). The

four domains of active living include household, occupation, recreation and transportation. From Figure 3, wide categories of intrapersonal variables are illustrated in the center. In this model, person's perception of environments is differentiated from objective characteristics of environments and both of them tend to be important influences. Behavioral interaction between the individual and the environment is shown in each active living domain.

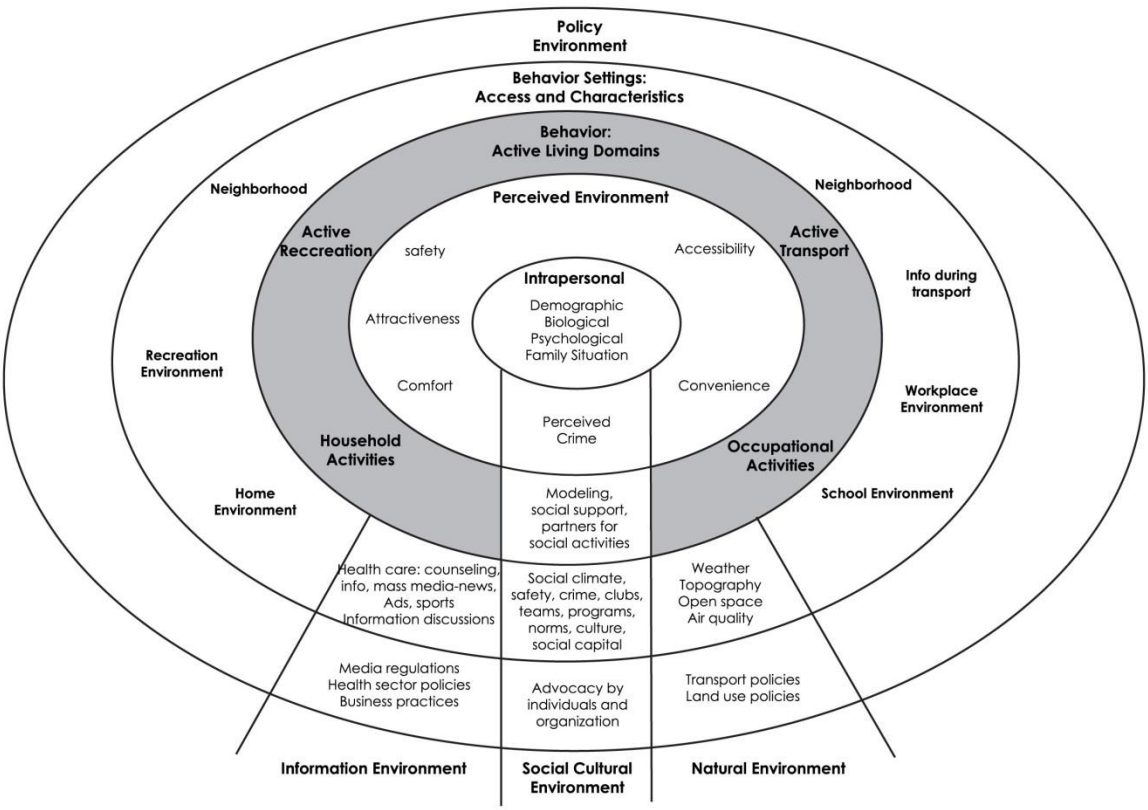

Figure 3. Ecological model of four domains of active living. Adapted from "An Ecological Approach to Creating Active Living Communities," by J. F. Sallis, R. B. Cervero, W. Ascher, K. A. Henderson, M. K. Kraft and J. Kerr, 2006, *Public Health, 27,* p. 301.

The physical activity (active living) domains tend to be affected by environments and policies. The behavior level is emphasized since the outcomes result from interest. Behavior settings are the area where physical activity may originate. Thus, assessing behavior characteristics and settings are helpful. There are similarities and differences of

important environmental factors for active living domains. For instance, walkability in neighborhoods means the capability to walk to nearby destinations such as grocery stores. This characteristic is important to active walking for workplaces and transport. Sidewalks around homes and workplaces would be important for transport, recreational and work-related physical activity. The influence on physical activity could be greatly expanded. For instance, various community organizations including social service agencies, sports clubs, churches, and child care centers could offer programs, places, and policies relevant to physical activity. These polices can influence physical activity through various mechanisms including the programs, incentives, and built environments. In particular, zoning, land use, development, and transportation regulations could influence active living domains. Polices including traffic demand managements, budgets for public recreation facilities, provision of health care facilities, incentives, and counseling for active living can also make a difference.

In Figure 3, cultural and social environments are across the other levels (Sallis et al., 2006). Family structure incorporates demographic variables while social climate, programs, crime, and culture vary by behavior settings. Similarly, social supports influence behaviors while advocacy by persons and organizations influences policy change. The Natural environment includes topography, weather, open space, and air quality and their effects are not limited to certain behavior settings (Sallis et al., 2006). Transportation policies can influence air quality and land use policies can influence availability of open space such as parks.

Information virtually exists in every behavior setting and commercial encouragement of inactive behaviors is common in particular (Sallis et al., 2006). The information environment can incorporate the following: news, program components of mass media, and advertising; counseling in health care domains; and sports-related information to discourage sedentary sitting and active participation. Setting-specific information sources could be the internet and television within homes, electronic and printed notices at work, and promotional materials in recreational facilities. Moreover, signs about pedestrian zones, park access, radio broadcasts, billboards promoting healthy behaviors, and commercial signs can be various sources of information. To promote active living, multilevel intervention strategies are needed. Many of the proposed influences on active living have not been examined so the studies from various disciplines are needed (Sallis et al., 2006).

Although the health behaviors are maximized through interventions such as health promotion programs and policies in the Ecological Model of Health Behavior, health behaviors are usually generated in the neighborhood environment setting. For example, using recreational facilities for physical activity and walking intervention programs in the neighborhoods promote more walking behaviors of older adults but the neighborhood environments need to be safe in the aspect of traffic and crime or have accessible recreational destinations. Moreover, accessible destinations and attractive neighborhood environments support walking behaviors in a daily life without intervention programs. Therefore, this study examined intrapersonal environments (demographic characteristics), perceived environments (accessibility, convenience and comfort, safety, perceived crime,

and attractiveness), and behaviors (walking) with regard to the quality of life among older adults.

Quality of Life

Quality of life is defined as the multidimensional evaluation of the person-environment system of an individual by social-normative and intrapersonal criteria (Lawton, 1991). This definition is attached to a conceptual framework that the author has called "the good life" (Lawton, 1983, p. 349). A conceptual framework for quality of life necessitates *multidimensional* views. Studies in classical treatments of quality of life in the social science field and a medical quality of life have agreed that many fields are important to quality of life and the remaining problem is identifying which ones are significant and how to unite them (Lawton, 1991).

The WHO definition of health (Callahan, 1973) includes "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (p.77). From the aspect of *evaluation*, the definition has the clear meaning that the undesirability and desirability of a phase of life is entailed including favorable versus unfavorable and good versus bad. Moreover, less definitive meaning is that the evaluation may start in any direction from a neutral point (Lawton, 1991). Medical quality of life typically deals with negative deviation from general status. However, Rowe and Kahn (1987) distinguished *successful aging* from *usual aging*. *Usual aging* means the physically substantial average decline with advancing age. On the other hand, *successful aging* is defined as people who show little or no loss in physical and psychological functions.

The structure of quality of life incorporates four aspects including *intrapersonal (subjective), social-normative, and temporal aspects* and *person-environment system* (Lawton, 1991). In the *intrapersonal* aspect, the quality of life is expressed as an indispensable ingredient of a broad concept; that a person has internal principles and evaluations of life which are idiosyncratic and not comprehensively explainable by any external standard. The term, *subjective* or *perceptual* is more often used than *intrapersonal*. This means that quality of life is a totally subjective evaluation. In the *social-normative* aspects, the evaluation of quality requires "the use of both the intrapersonal and the social normative perspectives" (Lawton, 1991, p.7). In the aspect of the *person-environment system*, it articulates three important assumptions. First of all, environment influences the individual's well-being. All environments are not same in providing his/her quality of life. Second, people can affect their environments, they can choose their environments, and they form ideas of their needs. Last, the transactional system between individual and environment is reciprocal and dynamic. In the *temporal* aspect, quality of life accentuates the dynamic and ongoing characteristics of the *person-environment system*. To be more specific, the quality of the present and the remembered past is associated with the quality of the anticipated future. For example, if an individual has chronic illness, the individual understands the future likely includes illness and treatment. The prognosis will influence his or her behavioral pattern and subjective status of the current time and the manner decisions are made in regard to health care alternatives.

The content of quality of life has been hypothesized the following: behavioral competence, perceived quality of life, psychological well-being, and objective

environment (Lawton, 1991; see Figure 4). Each four sections may be differentiated into many dimensions. Lawton (1982) defines *behavioral competence* as "the theoretical upper limit of capacity of the individual to function in the areas of biological health, sensation-perception, motor behavior, and cognition" (p. 38). *Behavioral competence* symbolizes "the social-normative evaluation of the person's functioning in the health, cognitive, time-use, and social dimensions" (Lawton, 1991, p.8).

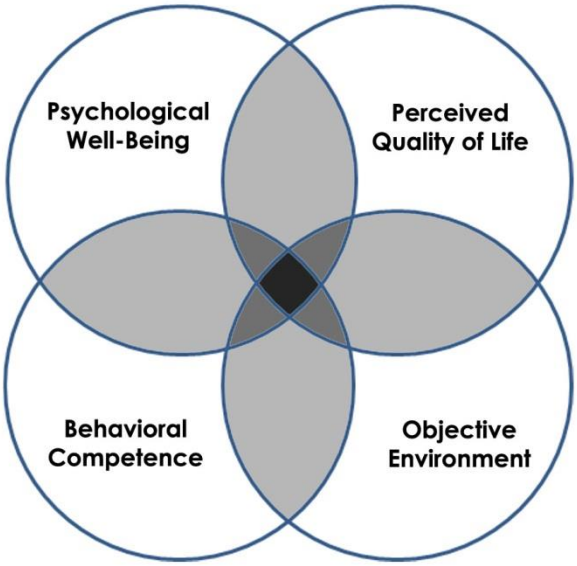

Figure 4. Four sectors of quality of life. Adapted from "The Concept and Measurement of Quality of Life in the Frail Elderly", M. P. Lawton, 1991, *A Multidimensional View of Quality of Life in Frail Elders,* p. 8.

The important characteristics from Figure 5 are that this hierarchy and its classifications can contain observable aspects of an individual. Some of the classifications include roles/activities such as hobbies, sports, employment, family provider, spouse, or friend. Criteria for the social-normative assessment of behavioral competence are a common component in social science. However, criteria for biological health status are difficult to categorize. Cognition and Activity of Daily Living (ADL) are the most common measurements of functional ability. The reason why these five domains were selected is that they allow any aspect of competence to be contained in one

or another field due to their hypothesized hierarchy within and across fields from the biological domain to the social domain.

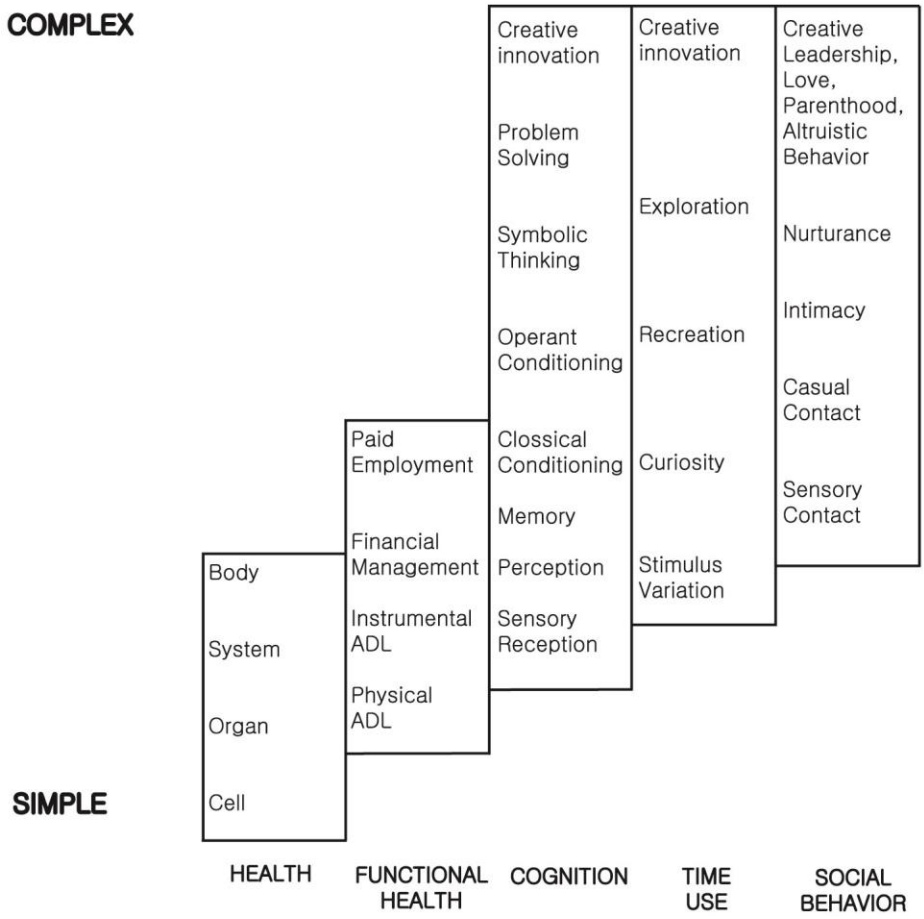

Figure 5. Hierarchy of behavioral competence. Adapted from "The Concept and Measurement of Quality of Life in the Frail Elderly", M. P. Lawton, 1991, *A Multidimensional View of Quality of Life in Frail Elders,* p. 9.

Perceived quality of life possesses an internal structure which parallels directly the domain of behavioral competence (Lawton, 1991). While competence needs to be measured by observation or performance, perceived quality of life is defined by subjective perception. Self-rated heath status is an operational health condition in perceived quality of life. In many studies, the universal term *perception* has been defined as a factor of quality of life.

There is no conceptual rationale or specification about the perceptual dimensions to assess. Discomfort and pain, which are important to chronic illness, are in health-related quality of life systems, which only represent perceived quality of life. There are other factors to consider in perceived quality of life. Pain, quality of spare time in general, cognitive self-efficacy, and the relationship with children and spouse may be related to perceived quality of life in the frail elders. According to Lawton (1991), perceived quality of life and behavioral competence are essential domains of quality of life. The other domains such as psychological well-being and environment are central elements of a loose fundamental model.

The best-known studies about perceived quality of life were performed by Campbell, Converse and Rodgers (1976) and by Andrews and Withey (1976). Those studies explored individuals' satisfaction with self, friends, family, work, activities, income, housing, neighborhood, and so on. The research teams also investigated the relationship between generalized psychological well-being and satisfaction in the fields mentioned above. Moreover, they explored how these satisfactions are various with important demographic characteristics including marital status, age, and race (Lawton, 1983). The authors categorized overall life satisfaction into neighborhood, housing, time used, family and friendships. However, WHO has focused on health-related quality of life and categorized perceived quality of life into physical satisfaction, psychological satisfaction, social relationship satisfaction, and environment satisfaction (1998).

The problem measuring perceived quality of life with satisfaction is that the elder's evaluation of their daily life may be over-evaluated. Their lack of assessment tools and lowered aspirations may result in a higher expressed satisfaction (Campbell et

al., 1976). Although there is no best perceived quality of life of measurement, evaluating satisfaction of overall life would be a good indicator for perceived quality of life.

Psychological well-being is the critical outcome in a causal mode. *Psychological well-being* is defined as the emphasized evaluation level of the individual's competence and perceived quality in all sectors of life (Lawton, 1991). Common indicators of *psychological well-being* incorporate cognitive judgments of overall life satisfaction, mental health, negative and positive emotion which is experienced as traits or states. A central point of *psychological well-being* is the capability of the individual to sustain loss and to incorporate optimistic information about the self.

Environment is hypothesized to afford behavioral competence and to constitute the essential conditions requiring the extents of perceived quality of life (Lawton, 1991). Environmental features have a more diffuse relationship between dimensions including behavioral competence and perceived quality of life. Some objective features in environment are directly significant to some sectors of behavioral competence. For instance, the environmental features in a dwelling-unit are relevant to mobility, water and air quality are important to biological health, and the richness of a behavior setting in an individual's environment is essential to competence over time for the elderly. The domain of *environment* is causally related to some types of behavioral competence. For instance, home and neighborhood environments are objective physical units affecting the performance of behavior but do not guarantee positive outcomes. Home, neighborhood, and social environments are examples of environments which can be evaluated subjectively. Although a common characteristic of environment does not imply a simplistic linear effect, it indicates that the importance of all external environments to a

certain individual is limited and conditioned by its importance about perceived quality of life and behavioral competence.

According to Lawton (1991), objective and subjective assessment of person and environment is essential in the research of quality of life. One reason is that the formulation of ethical and lawful principles requires that we judge objectively the effect environments have on individuals. Another reason is that objective measures about individuals and environments offer an anchoring point for deviant individual perceptions. For example, although ADL competence for individuals may be the same, their perceptions influencing quality of life related to their disability might be different.

Overall, the Ecological Model of Health Behavior by Sallis, Owen, and Fisher (2008) explains health-related physical activities with intrapersonal environments (biological, psychological, and demographics), perceived neighborhood environments (safety from traffic, comfort and convenience, accessibility to destinations, and attractiveness), behavior settings (active living domains), and policies. The Ecological Model of Health Behavior is helpful to explain how perceived neighborhood environments and demographic characteristics are specifically related to physical activity. The broad perspective of quality of life gives us ideas about how behavioral competence, environments, and subjective evaluation of an individual's life (psychological well-being) influence quality of life. The subjective evaluation of behavioral competence and the objective evaluation of environments are expressed as life satisfaction and these evaluations influence an individual's quality of life.

Conceptual Model

This study concentrates on the relationship between objective and perceived neighborhood environments, physical activity (walking), and quality of life. Objective and perceived neighborhood environments and walking were used as essential factors understanding quality of life for older adults.

Extending the Ecological Model of Health Behavior by Sallis, Cervero, Ascher, Henderson, Kraft, & Kerr (2006) and quality of life by Lawton (1991) can only explain limited areas. To be more specific, the Ecological Model of Health Behavior by Sallis and colleagues (2006) explains the relationship between physical activity and perceived neighborhood environments including attractiveness, comfort and convenience, accessibility, safety, and perceived crime but this model cannot explain quality of life. Moreover, the model of quality of life by Lawton (1991) can explain the relationship between perceived quality of life, objective environments, psychological well-being and behavioral competence. However, with Lawton's model, it is difficult to define operational variables because the model gives only a broad perspective about quality of life. However, previous studies have contributed to a common assumption that health status and physical activity (walking) can be recognized as important components affecting quality of life (Blanchard, Setin, Baker, Dent, Denniston, Courneya, & Nehl, 2004; Fagerström & Borglin, 2010; Fisher & Li, 2004; Friedman et al., 2012; Spinney, Scott, & Newbold, 2009).

On the basis of Lawton's model, Sallis and colleagues' model, and previous empirical studies, the conceptual model emphasizes demographic characteristics,

objective neighborhood environments, perceived neighborhood environments, walking, and quality of life in this study (see Figure 6). The goal of this study is to analyze the relationship between quality of life, demographic characteristics, various aspects of objective and perceived neighborhood environments and walking. This study also aims to explore the relationship between demographic characteristics, objective and perceived neighborhood environments and walking behaviors. A variety of indicators about demographic characteristics, objective and perceived neighborhood environments, and walking are identified. The proposed conceptual model in Figure 6 includes the following facets: 1) demographic characteristics; 2) objective neighborhood environments; 3) perceived neighborhood environments; 4) physical activity (walking); and 5) perceived quality of life. The objective and perceived neighborhood environments by older residents and physical activity are the important factors to explain quality of life in this study. The objective and perceived neighborhood environments are also important to explore walking behaviors of older residents.

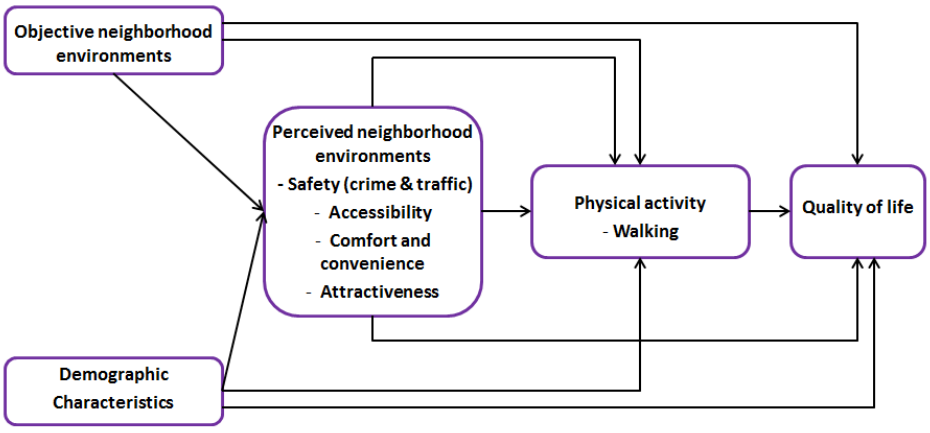

Figure 6. Conceptual model for this study

CHAPTER IV

METHODOLOGY

Research Objectives

The purpose of this research was to assess the relationship between neighborhood environments, walking behaviors, and quality of life of American older adults living in HUD-subsidized housing in St. Paul, Minnesota. First, this study aimed to explore the relationship between objective and perceived neighborhood environments and walking behaviors among low-income older adults. Second, this study investigated the relationship between the quality of life of the residents, the objective and perceived neighborhood environments, and physical activity level, especially for walking. For this study, understanding objective neighborhood environments and older adults' perceptions of their neighborhood environment is important for walking behaviors and quality of life.

The research objectives are as follows:

1) To identify how quality of life, walking days during the winter, and walking days during summer are differently associated with the housing locations among low-income older adults.
2) To explore that the neighborhood environment perceptions differ from the housing locations.
3) To investigate how demographic characteristics and objective and perceived neighborhood environments are related to the choice of walking or non-walking among the low-income elderly in winter or summer.

4) To explore the way demographic characteristics and objective and perceived neighborhood environments are associated with walking during the winter or summer among low-income elders.
5) To identify demographic characteristics, objective and perceived neighborhood environments, and walking in winter or summer are associated with quality of life.

Exploratory interviews were conducted with the housing managers in HUD-subsidized housing in the St. Paul area. The primary purpose of the interviews was to identify how many elderly persons reside in the housing where housing managers were willing to participate in this study.

The data collection procedures were divided into two parts. Objective neighborhood environment characteristics were measured for neighborhood walkability by the observation of the researcher and publicly available data such as crime, vacant buildings, and vehicle accidents. Moreover, the number of intersections within 1,000 meter radius buffers (1,000 m RBs) and the number and type of destinations identified by observations by the researcher within 400 m RBs and Google maps within 1,000 meter network buffers (1,000 m NBs) were utilized. For perceived neighborhood environments by residents, survey questionnaires were used. First, for the observation of objective neighborhood environments for walkability, Pedestrian Environment Quality Index (PEQI) and other data explained above was used. Second, the perception of the neighborhood environment by the elderly residents was measured using a survey questionnaire. Demographic characteristics regarding respondents, walking and quality of life were also measured by the survey questionnaire.

Observation Procedure

To measure objective neighborhood environments for walkability, it is necessary to select specific housing properties. In order to select specific housing properties, a purposive sampling procedure was used. There are twelve Section 202 HUD-subsidized housing developments in St. Paul, Minnesota (see Figure 7).

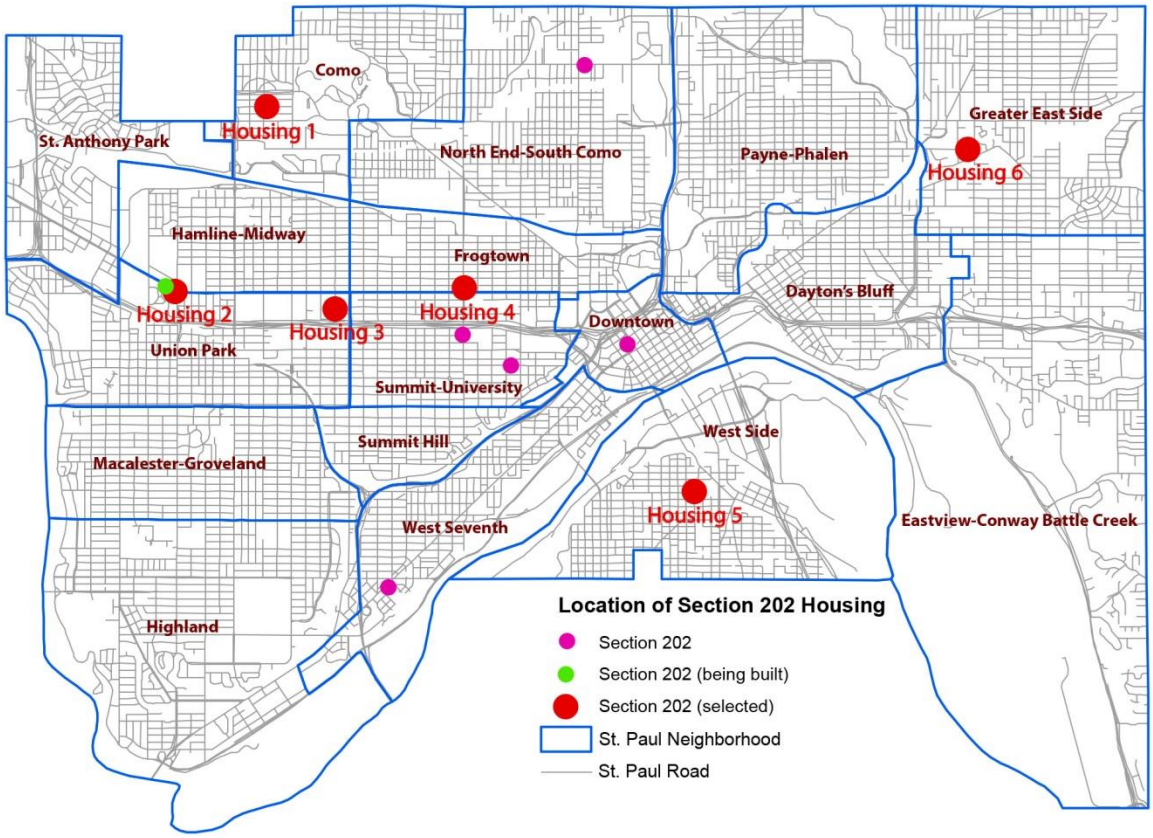

Figure 7. The location of Section 202 housing in St. Paul, Minnesota

Among twelve Section 202 housing properties, one housing property is still being built. Thus, eleven Section 202 housing managers were contacted for this research. The contact procedure of housing managers from eleven Section 202 housing properties was the following: The housing managers were contacted first by phone and then in person or by email to explain the purpose and procedures of the study. If housing mangers did not

want to participate in the study or did not respond by phone calls or by emails, the housing properties were excluded. If housing managers agreed to participate in this study and signed the consent form, the observation procedure began. Six housing mangers signed the consent form for this study. Contacting housing managers before the observation procedure was important in order to link data from observation phase with the survey data.

According to the literature review, well connected streets are more walkable to residents and people are more likely to walk in a place with mixed use, high density, and more destinations including grocery stores, banks, and so on (Lee & Moudon, 2008). Before starting observation, how walkable the neighborhoods with selected housing sites were investigated through the website, www.walkscore.com. The website categorizes neighborhood walkability into four groups including car-dependent neighborhoods; somewhat walkable neighborhoods; very walkable neighborhoods; and walker's paradise (Walk Score, 2013).

Table 1

Walkability Classification (Walkability was calculated on the basis of amenities and was evaluated from www.walkscore.com)

	Housing Location / Zip code	Walkability
Housing 1	Almond Ave / 55108	46 (car-dependent)
Housing 2	University Ave W / 55104	85 (very walkable)
Housing 3	Dunlap St. N / 55104	71 (very walkable)
Housing 4	Dale St. N / 55103	71 (very walkable)
Housing 5	Humboldt Ave / 55107	62 (somewhat walkable)
Housing 6	Magnolia Ave E / 55106	42 (car-dependent)

As seen in Table 1, the three neighborhoods, with Housing 2, Housing 3, and Housing 4, evaluated as very walkable neighborhoods are located near University

Avenue where a new light-rail is being constructed. On the other hand, two neighborhoods, with Housing 1 and Housing 6 evaluated as car-dependent neighborhoods are located in the Greater East Side neighborhood and Como neighborhood in St. Paul. One neighborhood with Housing 5 in West Side was evaluated as somewhat walkable neighborhoods.

The website evaluated neighborhood walkability on the basis of the distances between HUD-subsidized housing and destinations including groceries, restaurants and bars, shopping, coffee shops, schools, parks, book stores, entertainment facilities and banks. However, the information does not include quality of built environments such as sidewalks, and safety from crime and traffic. Moreover, several destinations are excluded in the neighborhoods because retail stores have voluntarily registered their businesses on the website. Thus, the website was only used to obtain basic information about destinations in neighborhoods where HUD-subsidized housing properties are located.

Before measuring neighborhood walkability by measurement tools, it is important to explain measurement methods for distances since the number of destinations and the length of distances are different according to the measurement methods. The method measuring the distances between destinations was categorized into two ways: the crow-fly (airline) distance and the network distance (Frank et al., 2003). The crow-fly distance method measures the straight-line distance between two destinations regardless of street network. The network distance measures the shortest distance a person can walk along the street network between two destinations. One kilometer buffer lines totally differ by the crow-fly (airline) distance and the network distance (see Figure 8). One kilometer is

usually considered the distance to walk within 12 to 13 minutes. One kilometer buffer is considered walkable distance because one kilometer is likely to be the maximum distance to walk for utilitarian walking by healthy adults and was considered the walkable extent as a perceived neighborhood border among pervious study's participants (Lee, 2004).

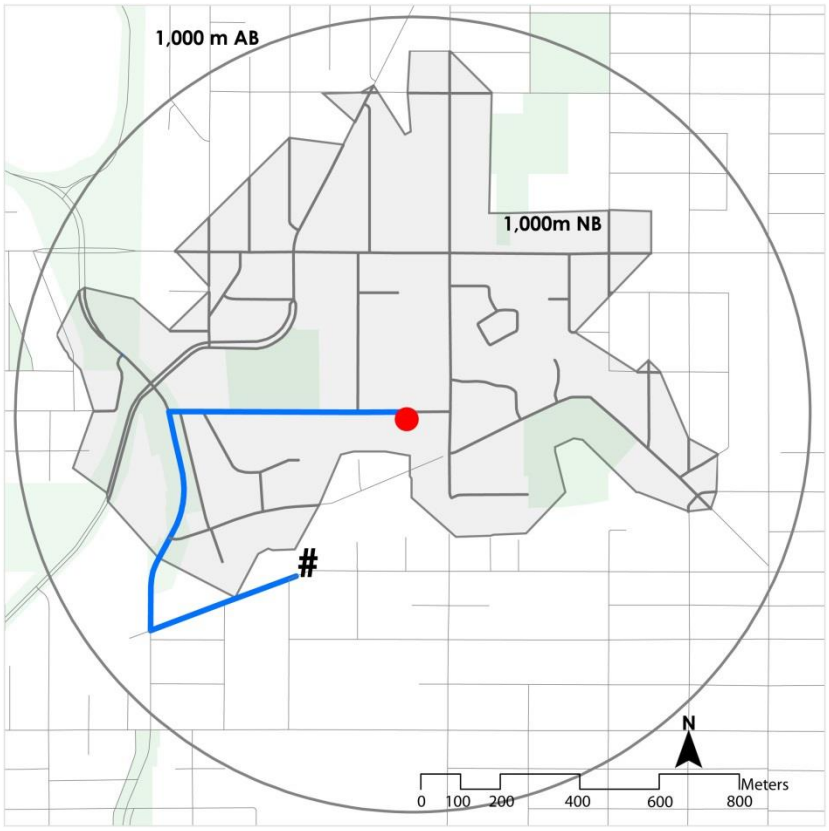

Figure 8. Examples of the distance measurement with airline buffer (AB) and network buffer (NB).

To measure the objective walkability within the neighborhoods, the following methods were utilized. First of all, Pedestrian Environment Quality Index (PEQI) was used to measure walkability in this study. PEQI was developed by the San Francisco Department of Public Health as a measurement to evaluate and to enhance pedestrian environments during the planning process in 2008 (UCLA Center for Occupational & Environmental Health, 2013). Previous published research illustrates how the measurement tool was used to evaluate how the built environment influences whether

human beings walk in neighborhood environments. PEQI targets all of the population not only the elderly.

There are tools measuring walkability targeting the elderly population which focus more on the destinations for the elderly. However, those are not used in this study for the following reasons. Senior Walking Environmental Assessment (SWEAT) and Senior Walking Environmental Assessment Tool - Revised (SWEAT-R) which is a revised version of SWEAT were developed after extensive reviewing of audit tools for seniors and literature about urban planning and health (Cunningham, Michael, Farquhar, & Lapidus, 2005). According to Chaudhury and colleagues (2011), SWEAT-R offered descriptive physical environmental information on neighborhoods including destinations, functionality, aesthetics, and safety for walking of the elderly. However, this environmental audit tool cannot offer visualized information on the neighborhoods.

PEQI is categorized into five domains including intersection safety, traffic, perceived safety and land use, street design, and perceived walkability (UCLA Center for Occupational & Environmental Health, 2013). However, the original PEQI version is difficult to apply beyond San Francisco because there is no program to calculate final scores from the raw scores. Thus, the adapted PEQI version by UCLA Center for Occupational and Environmental Health was used in this study. This tool mainly focuses on safety from traffic and perceived crime and street design but this tool is weak for investigating destinations which are strongly associated with walking. Thus, this tool was augmented with a Geographical Information System (GIS) program. The biggest strength of PEQI is that it can visualize walkability in neighborhoods using a GIS program.

First of all, descriptive analysis was used to explain individual neighborhood environments. Land use maps and a public transit map were used to show how the land near the housing has been used and where public transit is located.

Second, as explained above, destinations within 400 m (quarter mile), 800 m (half mile) and 1,000 m (0.625 mile) NBs were explored through data from Google map and Walkscore.com and the data was input in GIS. The maximum walking distance for the elderly is usually considered 800 m distances by researchers (Hess, 2012; Nagell et al., 2008). In addition to 800 m distances, researchers have considered that resources within 400 m distances are significantly related to older adults' walking (Nagell et al., 2008). However, other researchers also consider 1,000 m buffers to be a walkable distance for older adults (Berk et al., 2007).

There are two ways to measure the distance to the destinations: airline buffer and network buffer systems (see Figure 8). The first method, crow-fly distance, also called airline buffer, measures the distance between two destinations as "the difference between the straight-line distances between two destinations" (Frank et al., 2003, p.100). The second method is the distance of the street network. Figure 2 shows how connectivity of streets can influence the distance between two destinations. The distances between high connectivity networks would be closer than the distances between low connectivity networks. This means that the area one person can travel by walking can be reduced by the network connectivity. Through GIS, all distances from the housing to all destinations can be measured and the average distance can be calculated with 400, 800, and 1,000 m

NBs. PEQI data and destinations in GIS can show which destinations are accessible since PEQI data shows which segments are more walkable.

Third, intersection densities which mean street connectivity on the basis of the number of real intersections within 400, 800, and 1,000 m airline buffers (ABs) were measured. The intersection density was calculated by airline buffers to compare the same areas.

Fourth, a publicly available vacant building list, crime, and traffic accident data were used to determine how many vacant buildings are located near the housing properties; how many Part 1 crimes, including homicide, rape, robbery, aggravated assault, burglary, theft, auto theft, and arson had occurred by police grid; and how many traffic accidents had occurred by police grid and intersections near the selected housing in 2012. It was difficult to know how many crimes and traffic accident calls had generated within the buffers because the data was generated by police grid not airline buffers. Thus, the GIS maps by police grid were overlapped with the 400, 800, and 1000 m ABs. However, identifying the location of vacant buildings and traffic accidents near intersections was clear so the GIS maps were drawn by 400, 800, and 1,000 m network buffers (NBs).

Last, as explained above, airline buffers were measured up to 400 m (one quarter mile) with PEQI from the selected housing. This distance was selected based on previous studies that identified commercial destinations including bus stops, postal boxes, convenience stores, shopping malls, news agencies, and transit stations. These destinations are most associated with walking within a 400 m buffer, especially for

seniors (McCormack at al., 2008; Nagell et al., 2008). Airline buffers instead of network buffers were used with PEQI because airline buffers can cover the same areas in each neighborhood.

Sampling Procedure

As explained in the observation procedure, among 12 housing properties, 11 Section 202 housing managers excluding one housing property which is being built were contacted to request cooperation for this study. Among 11 housing managers, a total of six housing managers signed the consent form providing the cooperation for this study. Five housing properties among 11 housing properties were excluded for the following reasons. First, the researcher could not contact a housing manager. Second, a housing manager did not answer the phone or did not reply to the email request to arrange a follow-up meeting in person. Third, a housing manager refused to participate in this study because she thought that the majority of residents were disabled and could not properly answer the survey questionnaire. Fourth, one housing development was excluded in this study although the housing managers wanted to participate in this study because she could not obtain the permission from her company's committee members in time for this study. Last, the majority of residents in one housing property have difficulty in reading either in their primary language or English. Thus, the residents in this housing development were excluded from this study.

Among six housing properties, one property is managed with market rate rent not HUD-subsidized rent under Section 8 program although the housing was built by Section 202 program. The housing built within the Section 202 program was excluded in this

study because it is expected that the resident's income in the housing is not as low as the other residents in the other Section 202 housing properties combined with the Section 8 rent assistance. However, there is a housing property under the Section 8 program for the elderly residents in the same campus with the Section 202 housing. Thus, the property with Section 8 rent assistance was selected for this study.

Instrument and Pilot Study

On the basis of literature and measurement tools, a questionnaire was designed. The questionnaire in this study includes the following: 1) demographic characteristics; 2) perception of neighborhood environments; 3) walking behaviors; and 4) quality of life. The approximate numbers of elderly residents who can use English and the total number of residents were identified after contacting housing managers.

Table 2

Percentage of English Speakers by Housing Location

	Percentage of English speakers
Housing 1	95% of English speaker and 5% of English non-native speakers including one Chinese speaker among 125 residents
Housing 2	98% of English speakers and 2% Chinese speaker
Housing 3	57% of English speakers, 14% of Vietnamese speakers, 12% of Cambodian speakers, and 17% of other language speakers
Housing 4	59% of English speakers, 4% of Chinese speakers, and 37% of Vietnamese speakers
Housing 5	88% of English speakers and 12 % of Vietnamese and Russian speakers
Housing 6	100% of English speakers

As shown in Table 2, most of residents are English speakers excluding Housing 3 and 4 and the majority of non-native English speakers were Vietnamese. However, it was expected that the returned written survey questionnaires would be from less than ten people from six housing properties although the English survey questionnaire would be translated into the Vietnamese survey questionnaire on the basis of a 30% response rate.

Thus, translation into Vietnamese was not considered because of budget restriction. However, the English survey questionnaire was translated into Chinese version by Chinese native speakers free of charge.

The questionnaire was written in English so most of participants in this study were English speakers. Before the pilot study and questionnaire survey were initiated, Institutional Research Board (IRB) at the University of Minnesota approval was obtained for the survey questionnaire, the letter about the research cooperation, and the consent form from housing managers.

St. Paul Public Housing Authority was contacted to recruit the low-income elderly residents for pilot studies. The first pilot study was arranged by a St. Paul Public Housing Authority staff member with seven public housing residents who are aged 65 years old or over. During pilot study and questionnaire survey, the elderly participants were informed of their rights including voluntary participation and withdrawal which is guided by IRB. The pilot study was designed to examine how understandable the survey questionnaire was for the participants and the time needed to fill it out. The survey questionnaire was revised after performing the first pilot study. The second pilot study was also arranged by a St. Paul Public Housing Authority staff member with six public housing residents who are aged 65 years old or over. The procedure was the same with the first pilot study. After the second pilot study, the survey questionnaire was revised again. After the pilot studies, a total of thirteen $10 gift cards were offered as the compensation to the participants.

Questionnaire Packages and Contact Procedures

The distributed survey questionnaire package included a letter explaining the research purpose, the consent form, the survey questionnaire, and the contact card for incentives. All materials were written in English. Survey questionnaires packages translated into Chinese were also prepared. Before distributing the survey questionnaire packages to participants, the older adults were informed about the significance and purpose of this research at their communal meeting, lunch time, coffee mornings, or a special meeting for this study after setting up the date with the housing managers in five housing properties. In these meetings, it was explained that complete anonymity and confidentiality were guaranteed via a given consent form to every older adult. It was also explained that there would not be negative consequences from participating in this survey. If the elderly participants requested assistance to fill out the questionnaire, it was explained that the assistance would be provided by the researcher. In one site, the housing manager recommended distributing the packages without a meeting to explain the significance and purpose of this research to residents since there was no communal meeting held. The housing manager recommended distributing the survey questionnaire packages without a meeting with residents. After the meetings, flyers recruiting survey participants were posted on the bulletin boards in the housing properties. In addition to that, survey questionnaire packages were placed in residents' mailboxes or in front of residents' doors with the cooperation of the housing managers.

The total number of the survey questionnaire packages distributed was 410 as shown in Table 3. The survey questionnaire packages were placed based on the number of residents in five housing properties but fewer packages were placed in Housing 1 since

there are 30 residents with memory issues in the housing. To exclude the residents with memory issues, the housing manager or staff member placed the survey questionnaire packages on behalf of the researcher to protect the residents' privacy.

Table 3

The Number of Survey Questionnaires Distributed

	Number of survey questionnaires placed
Housing 1	95 out of 125 (excluded 30 residents with memory issues by the housing manager)
Housing 2	50
Housing 3	49
Housing 4	49
Housing 5	123
Housing 6	44

Table 4

The Number of Incentives Offered in Each Housing Property

	Number of incentives offered
Housing 1	Four $30 gift cards
Housing 2	Two $30 gift cards
Housing 3	Two $30 gift cards
Housing 4	Two $30 gift cards
Housing 5	Five $30 gift cards
Housing 6	Two $30 gift cards

After distributing the survey questionnaire packages, the first reminder cards were placed in the residents' mailboxes or in front of the residents' doors two weeks later after obtaining permissions from the housing managers. The researcher requested the residents' contact information on the reminder cards for research participants who wanted to obtain the summary of this study result. The second reminder cards were also placed in the residents' mailboxes or in front of the residents' doors two weeks later after the placement of the first reminder cards. Two weeks later after the second reminder cards, data collection ceased. Randomly selected participants were offered $30 gift cards as

incentives. The number of incentives was calculated on the basis of the number of residents in the housing as shown in Table 4. A $30 gift card was provided approximately every 25 resident so the total number of incentives offered was different in each property.

Table 5

Survey Response Rates

	Response rate
Housing 1	30 out of 95 (31.6% but 23 are useful; 24.2%)
Housing 2	21 out of 50 (42.0% but 17 are useful; 34.0%)
Housing 3	27 out of 49 (55.1%; but 22 are useful; 44.9%)
Housing 4	25 out of 49 (51.0%; but 24 are useful; 48.9%)
Housing 5	27 out of 123 (22.0%; but 25 are useful; 20.3%)
Housing 6	26 out of 44 (59.0% but 21 are useful; 47.7%)

The total returned survey questionnaires were 156 out of 410 (38.0%). The response rates in each housing property were the following (see Table 5). However, there were 24 unusable returned survey questionnaires so the final response rate was 32.2%. The number and percentage of usable survey questionnaires are also indicated in Table 5.

Empirical Model

The empirical model used in this study is illustrated in Figure 9 based on the Ecological Model of Health Behavior by Sallis, Cervero, Ascher, Henderson, Kraft, & Kerr (2006), the Quality of Life by Lawton (1991), literature reviews, and measurement tools including walking and quality of life. This empirical model consists of variables regarding how older adults perceive their neighborhood environments including safety from crime and traffic, accessibility to destinations, comfort and convenience, and attractiveness; walking behaviors; and their quality of life. Moreover, this model considers how objective and perceived neighborhood environments influence walking.

To measure quality of life, the older adults' perception is important because individuals may perceive differently their neighborhood environments although they experience the same neighborhood environments. The different perception of neighborhood environments may result in different perceived levels of quality of life. Understanding residents' perception of neighborhood environments on the basis of their demographic characteristics is important since those factors interact with walking and quality of life. The empirical model is shown in Figure 9.

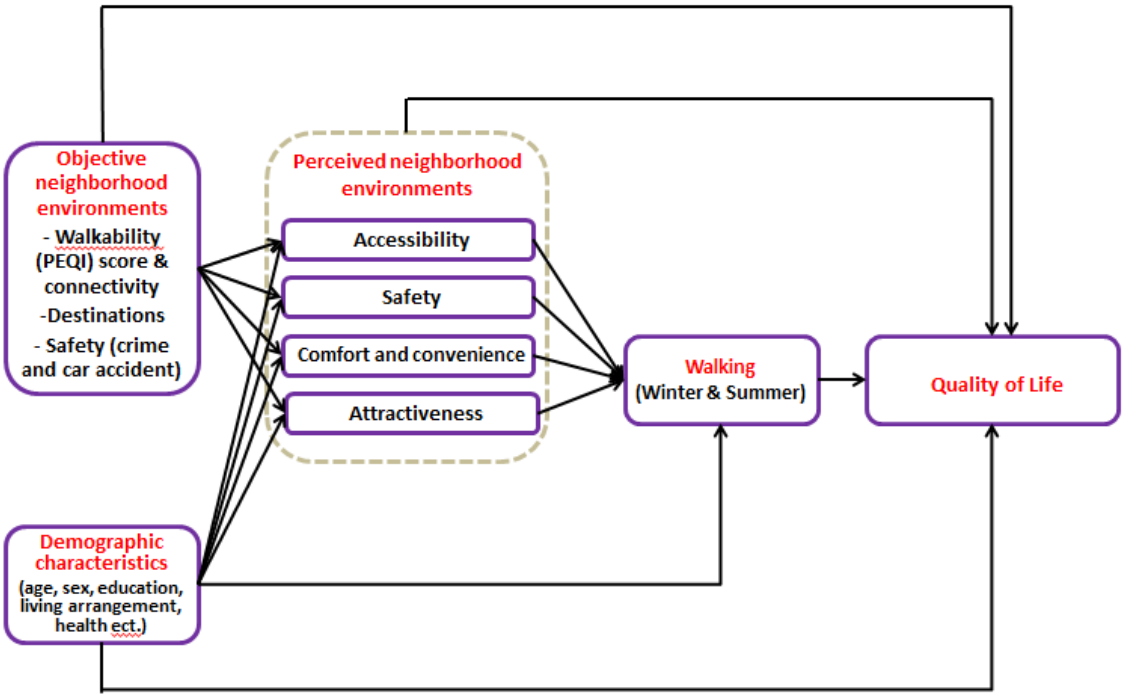

Figure 9. Empirical model for this study

Description of Variables

All variables are revised from previous studies and measurement tools shown below:

1) Demographic characteristics adapted from the following studies including Hwang (2004), and Patterson and Chapman (2004). Disability was measured

by the measurement tool from Assessment Tool (Canada Mortgage and Housing Corporation, 2012).

2) Objective neighborhood environments were measured by walkability scores, destinations, connectivity, safety from crime and traffic, and vacant building locations. Walkability scores were calculated by UCLA PEQI which was developed by San Francisco Department of Public Health in 2008 and adapted by University of California, Los Angeles (UCLA). Destinations, connectivity, safety from crime and traffic, and vacant building locations were measured on the basis of studies by Heinrich and colleagues (2007), Lee and Moudon (2008), Leslie and colleagues (2005), and Gauvin and colleagues (2012).
3) Walking behaviors were measured by International Physical Activity Questionnaire (IPAQ; Craig, Marshall, Sjostorm, Bauman, Booth, Ainsworth, Pratt, Ekelund, Yngve, Sallis, & Oja, 2003).
4) Perceived neighborhood environments were measured on the basis of Pediatric Quality of Life Inventory (PedsQL 4.0) which is developed by Varni and colleagues (Varni, Seid, & Kurtin, 2001; Varni, Seid, & Rode, 1999). However, this measurement focuses on children's quality of life aged between eight and twelve so this measurement was revised combining SWEAT-R which is the objective neighborhood environment measurement tool for older adults. To be more specific, destinations were adapted from SWEAT-R.
5) Quality of life was measured by revised WHO Quality of Life-BREF which is a brief version of quality of life measurement developed by WHO (WHOQOL Group, 1998). However, only one question about quality of life was asked.

Exogenous Variables

The exogenous variables consist of the demographic characteristics and objective neighborhood environment assessment from observed data.

Demographic characteristics. The demographic characteristics for this study include the following: age, race, sex, education level, living arrangement, car ownership, self-rated health, and disability. The variables are shown in Table 6.

Table 6

Demographic Characteristics of Respondents

Variables	Measurement and units	Question number
Age	Continuous variables in years	Q 4-1
Race	1) White; 2) Black; 3) Asian; 4) Hispanic; 5) Two or more races; 6) Native	Q 4-2
Sex	1)Male; 2) Female	Q 4-3
Education level	1) Less than high school; 2) High school graduate; 3) Some college, no degree; 4) College graduate (bachelor's degree); 5) Graduate or professional degree; 6) Other	Q 4-4
Living arrangement	1) Living along; 2) Living with my spouse; 3) Living with other;	Q 4-5
Car ownership	1) Yes; 2) No	Q 4-6
Self-rated health	1) Very poor; 2) Poor; 3) Average; 4) Good; 5) Excellent	Q 4-7
Disability (I have difficulty with)	1) I have poor balance; 2) I have reduced mobility; 3) I use a cane or walker; 4) I use a wheelchair; 5) I have poor vision; 6) I have a hearing loss	Q 4-8

Objective neighborhood environments. The objective neighborhood environments were measured by a walkability score based on the PEQI, the number of destinations, and connectivity with the number of intersections in the same area (see Table 7).

Table 7

Objective Neighborhood Environments with Selected Housing

Variables	Measurement and units	Method
Crime (Part 1 Crime)	Continuous variable (The number of crime within police grid)	GIS
Safety (traffic accident calls)	Ordinal variable (The order of car accident calls within police grid)	GIS
Safety (traffic accidents at intersections)	Continuous variable (The number of destinations within 400 m NBs)	GIS
Destinations	Continuous variable (The number of destinations within 400 m NBs)	GIS
Connectivity	Continuous variable (The number of intersections within 400 m ABs)	GIS
Vacant Buildings	Continuous variable (The number of destinations within 400 m NBs)	GIS
Walkability score on street	Continuous variable (0 to 100 within 400 m ABs)	PEQI
Walkability score at intersection	Continuous variable (0 to 100 within 400 m ABs)	PEQI

Endogenous Variables

Perception of neighborhood environments. Perceived neighborhood environments include accessibility, comfort and convenience, attractiveness, and safety from traffic and crime. Variables supporting accessibility (destinations), safety from crime and traffic, comfort and convenience, and attractiveness in the neighborhood environment are shown in Table 8.

Table 8

Perceived Neighborhood Environments Supporting Accessibility to Destinations, Safety from Crime and Traffic, Comfort and Convenience, and Attractiveness

Variables	Measurement and units	Question number
Perceived neighborhood environments supporting accessibility		
1. Grocery store; 2. Convenience store or mobile food vendors; 3. Restaurants or coffee shops; 4. Retail stores; 5. Institutions (post office, police station, or courthouse); 6. Health facilities (hospital, clinic and pharmacy); 7. Recreational facilities; 8. Natural areas (park, river, lake, or forest);	1) Strongly disagree; 2) Somewhat disagree; 3) Neutral; 4) Somewhat agree; 5) Strongly agree; 6) N/A	Q 1-1 ~ Q 1-8
Perceived neighborhood environments supporting safety from crime and traffic		
1. Too much traffic and too much cars passing by too fast; 2. Enough crosswalks; 3. Enough traffic signals at crosswalks or intersections and enough time to cross streets; 4. Many barriers preventing walking; 5. Dogs, gangs, or strangers; 6. Enough lighting; 7. Safety for walking during the day;	1)Strongly disagree; 2) Somewhat disagree; 3) Neither disagree nor agree; 4) Somewhat agree; 5) Strongly agree; 6) N/A	Q 1-9 ~ Q 1-15
Perceived neighborhood environments supporting comfort and convenience		
1. Continuous sidewalk availability; 2. Well maintained sidewalk; 3. Benches and places to take a rest; 4. Enough trees; 5. Public transit stops such as bus or light rail	1) Strongly disagree; 2) Somewhat disagree; 3) Neutral; 4) Somewhat agree; 5) Strongly agree; 6) N/A	Q 1-16 ~ Q 1-20
Perceived neighborhood environments supporting attractiveness		
1. Well maintained attractive buildings, homes or gardens; 2. Beautiful nature and green spaces; 3. Many abandoned houses, vacant lots, graffiti; 4. Abandoned cars, litter, trash, broken glass or drug-related items	1)Strongly disagree; 2) Somewhat disagree; 3) Neutral; 4) Somewhat agree; 5) Strongly agree; 6) N/A	Q 1-21 ~ Q 1-24

Walking. Variables for walking are shown in Table 9. Variables associated with walking are walking days during a week in past seven days (in winter) and in summer.

Table 9

Walking Days in Winter and Summer

Variables	Measurement and units	Question number
1. Walking days outside for at least 10 minutes at a time in your neighborhood during the last 7 days (winter); 2. Walking days outside for at least 10 minutes for a week during the summer	1) 1 day 2) 2 days 3) 3 days 4) 4 days 5) 5 days 6) 6 days 7) 7days 8) N/A	Q 3-1 ~ Q 3-2

Dependent Variables

Quality of life. The quality of life indicator includes overall quality of life (see Table 10).

Table 10

Overall Quality of Life

Variables	Measurement and units	Question number
Overall quality of life	1) Very poor; 2) Poor; 3) Neither poor nor good; 4) Good; 5) Very good	Q 4-1

Data Analysis Procedures

The survey data was analyzed using the statistical program, Statistical Program for Social Sciences (SPSS 17.0 version). The analysis included two parts both data description and modeling tests.

Data Description

Percentage distributions and frequencies were calculated for demographic characteristics, perceived neighborhood environments, walking, and quality of life but objective neighborhood environment data were included in modeling tests.

Modeling Test

In order to test the empirical model for this study, three types of regression models including bivariate, logistic, and multiple linear regression models were used. The models tested in this study were based on the conceptual framework and the empirical model found in previous studies. This study focused on demographic characteristics, objective neighborhood environments, perceptions of older adults of their neighborhood environments, walking, and quality of life. On the basis of research questions, hypotheses were examined. The hypotheses and equation formula are the following:

Quality of life, walking days in winter, or walking days in summer = f (Housing locations)

H1: Quality of life, walking days in winter, or walking days in summer is perceived differently on the basis of housing locations.

$$SS_T = SS_{WG} + SS_{BG}$$

Perceived neighborhood environments = f (Housing locations)

H2: Neighborhood environments are perceived differently on the basis of housing locations.

$$SS_T = SS_{WG} + SS_{BG}$$

The selection of walking during winter or summer = f (demographic characteristics, objective neighborhood environments, and perceived neighborhood environments)

H3: Demographic characteristics, objective and perceived neighborhood environments are associated with the choice of walking during the winter or summer among low-income elders.

$\log\left(\frac{p(y=1)}{p\,(y=0)}\right) = \alpha + \beta_{1}X_{1} + \beta_{2}X_{2}$

$\log\left(\frac{p(y=1)}{p\,(y=0)}\right)$ = walking / non-walking in winter or summer

α = constant

$\beta_{1\text{-}2}$ = coefficients

X_1 = demographic characteristics and objective neighborhood environments

X_2 = perceived neighborhood environments

Walking days during the winter or summer = f (demographic characteristics, objective neighborhood environments, and perceived neighborhood environments)

H4: Demographic characteristics, objective and perceived neighborhood environments are associated with walking days in winter or summer among low-income elders who selected walking.

$Y_{1.4} = \alpha + \beta_{1}X_{1} + \beta_{2}X_{2}$

$Y_{1.4}$ = walking days in winter or summer (1 to 7 days)

α = constant

$\beta_{1\text{-}3}$ = coefficients

X_1 = demographic characteristics and objective neighborhood environments

X_2 = perceived neighborhood environments

Perceived quality of life = f (demographic characteristics and objective neighborhood environments, perceived neighborhood environments, and walking)

H5: Perceived quality of life of older adults is associated with demographic characteristics, the objective and perceived neighborhood, and walking in winter or summer.

$Y_{1.5} = \alpha + \beta_{1}X_{1} + \beta_{2}X_{2} + \beta_{3}X_{3}$

$Y_{1.5}$ = perceived quality of life
α = constant
$\beta_{1\text{-}3}$= coefficients
X_1 = demographic characteristics and objective neighborhood environments
X_2 = perceived neighborhood environments
X_3 = physical activity (walking in winter or summer)

CHAPTER V

OBSERVATION ANALYSIS AND RESULTS

Description of Observations

Housing 1

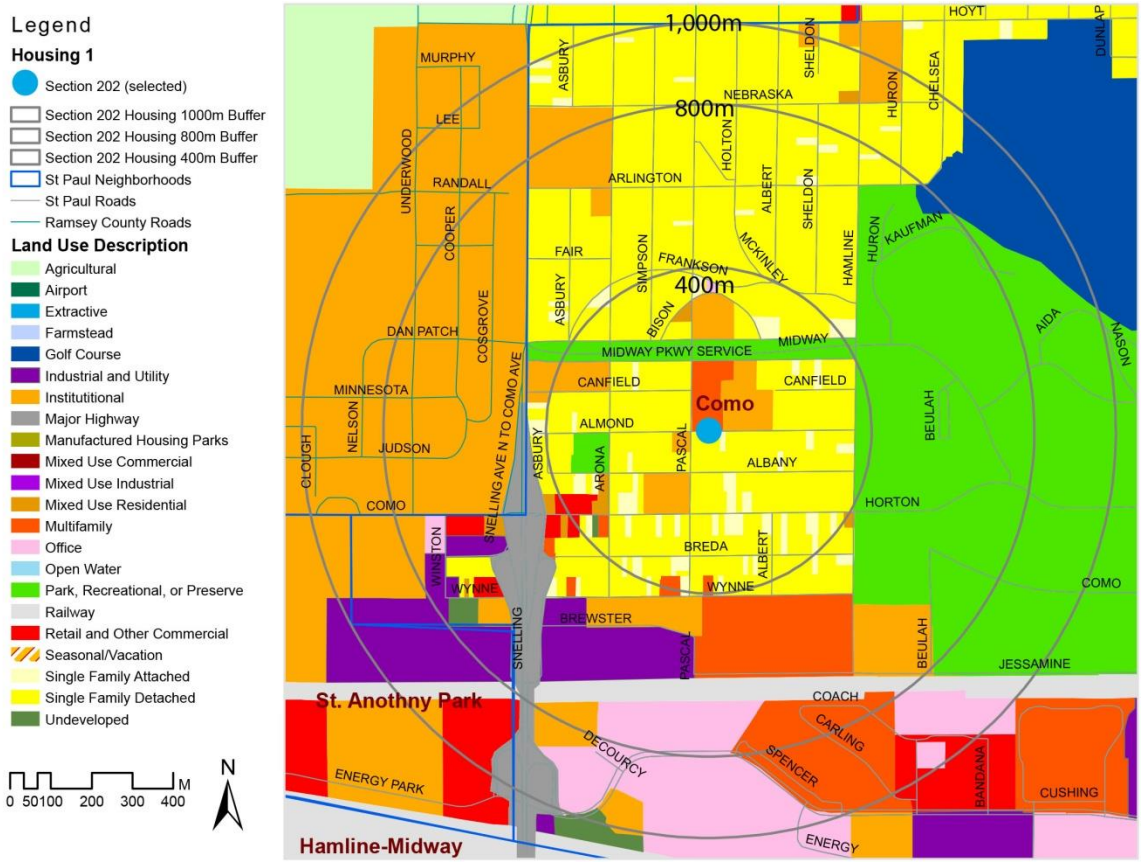

Figure 10. 2010 land use near Housing 1. Data sources came from "Data and maps: A service of Council Research & Geographic Information Services (GIS)", Twin Cities Metropolitan Council, 2013. Retrieved from http://www.metrocouncil.org/Data-and-Maps.aspx

Housing 1 is located in the Como neighborhood in St. Paul (see Figure 10) and there are a total of 105 units. Housing 1 is located in this housing complex with a café & gift shop, chapel, beauty/barber shop, other market rate rental elderly housing units, assisted living facility, and nursing home. The housing is located in the middle of a residential area. Within one quarter mile radius from the housing, there are retail stores

including delis, a coffee shop, and a Chinese grocery store. Although the majority of residents are White Americans in this housing, the only grocery store is targeting Chinese and Asian customers. The environmental quality of the area next to this housing is good with single detached houses and natural areas including a small park, parkway, and Como Park. The majority of housing in the neighborhood are single-family homes; most of the streets follow the grid system and are well connected. Most of the sidewalks are well connected. There is a bus stop with a shelter two blocks away from the housing but there is the only one bus line which runs every 30 minutes on weekdays (see Figure 16). To compensate for the limited transportation, the housing operates a bus with fee for grocery shopping. Although the neighborhood has an overall walking friendly environment, there are a couple of elements discouraging walking in the neighborhood. First of all, there are only a few of destinations (retail stores) within walking distance. Second, there are only a few street lights and the length of the blocks is too long to walk. Third, an institutional building occupying a whole block on Midway Parkway and Arona Street is vacant so it does not feel safe to walk in that area. Last, the area with retail stores has low quality buildings and there are only a few trees on the street compared to the residential area near the housing.

Housing 2

Housing 2 is located in Midway neighborhood in St. Paul (see Figure 11). There are a total of 50 units. Housing 2 is located in this housing complex with a café, church, and other market rate rental units for the elderly. Within one quarter mile radius from the housing, there are three convenience stores with no fresh vegetable and fruit and a number of other retail businesses. There are a couple of businesses negatively influencing

the quality of the neighborhood environments such as auto repair shops with low quality buildings. Moreover, the size of blocks influences walkability according to the perception of the researcher. There are big office buildings with various organizations and factory-like buildings with a large business such as a beverage distributor. Big blocks with factory-like buildings, office buildings, and big parking lots negatively influence walkability.

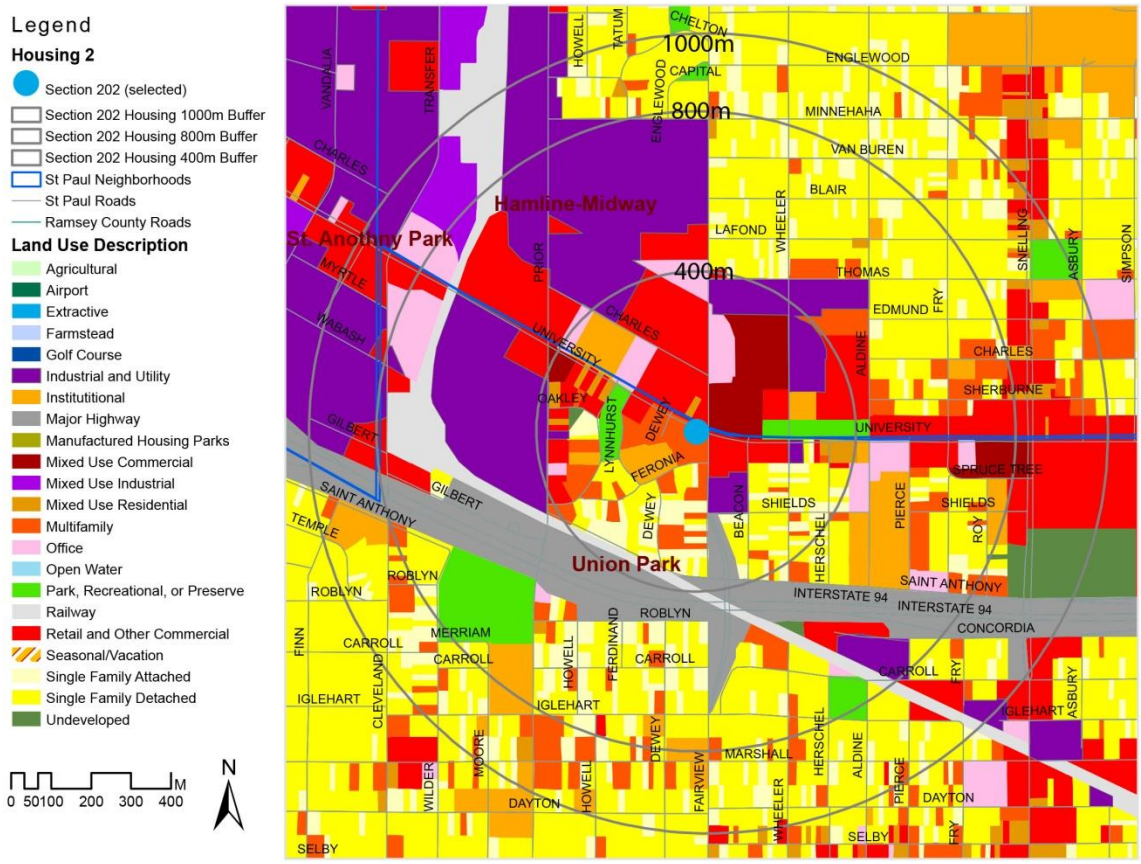

Figure 11. 2010 land use near Housing 2. Data Sources came from "Data and maps: A service of Council Research & Geographic Information Services (GIS)", Twin Cities Metropolitan Council, 2013. Retrieved from http://www.metrocouncil.org/Data-and-Maps.aspx

The environmental quality of the area next to the housing is comparatively good with a small park and single detached houses. The majority of housing types are single-family homes in the neighborhood; most of the streets follow the grid system and are well connected. Most of the sidewalks are continuous except for the area with factory-like

buildings on the large blocks. Stops for public transportation are very close (see Figure 16). Directly in front of the housing, there are bus stops and a light-rail stop but there is no shelter for the bus stop right in front of the housing. Although there are a number of destinations in the neighborhood, low quality buildings and unoccupied buildings promote less walking in the area. There are very few buildings with window displays in the area. Interior oriented buildings without display windows promote less walking because the buildings are less inviting for pedestrians and offering few good street views.

Housing 3

Housing 3 is located in the Union Park neighborhood in St. Paul and there are a total of 49 units in the housing (see Figure 12). There are no amenities in the housing. The housing is located in the middle of a commercial and retail area. Within one quarter mile radius from the housing, there are a number of institutions and retail stores including a grocery store. A clinic is located right in front of the housing. In the same block with Housing 3, a big grocery store is located selling fresh fruits and vegetables. Within one quarter mile radius from Housing 3, there are a few residential buildings. The majority of land uses are retail stores with large parking lots, institutions, highways, and vacant or large undeveloped lots within one quarter mile radius. Although there is a park near Housing 3, it does not feel that the park is approachable since the elderly residents need to cross the highway through less walkable streets according to the observation of the researcher. There is a bus stop with a shelter in the block of the housing and there are frequent bus lines within the service area (see Figure 16). Moreover, there is a light rail line under construction. Thus, the researcher could not observe any residents using Metro

Mobility in the housing, which is an offered public transit for the disabled and the elderly. The elderly residents might use general public transportation rather than Metro Mobility.

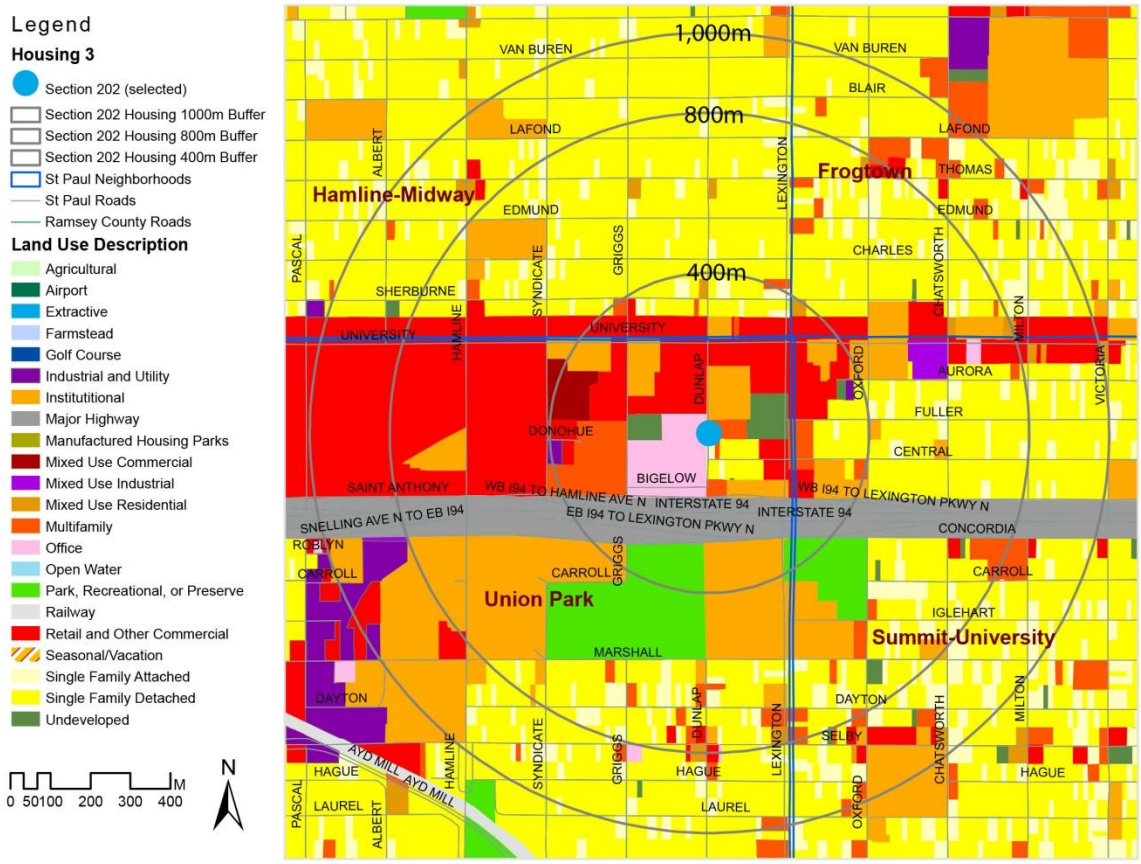

Figure 12. 2010 land use near Housing 3. Data sources came from "Data and maps: A service of Council Research & Geographic Information Services (GIS)", Twin Cities Metropolitan Council, 2013. Retrieved from http://www.metrocouncil.org/Data-and-Maps.aspx

Although there are a lot of destinations in the neighborhood, there are a couple of elements that discourage walking. First of all, the lengths of the blocks are too long to walk easily. Second, the buildings are oriented toward the interior. In other words, there are only a few display windows on buildings and the windows are mostly covered with blinds. Third, it seems like that the large buildings behind large parking lot are perceived as not safe from traffic and crime, and therefore as not attractive for walking. Last, the

area with retail stores has low quality buildings and there are only a few trees on the street compared to the residential area near the housing.

Housing 4

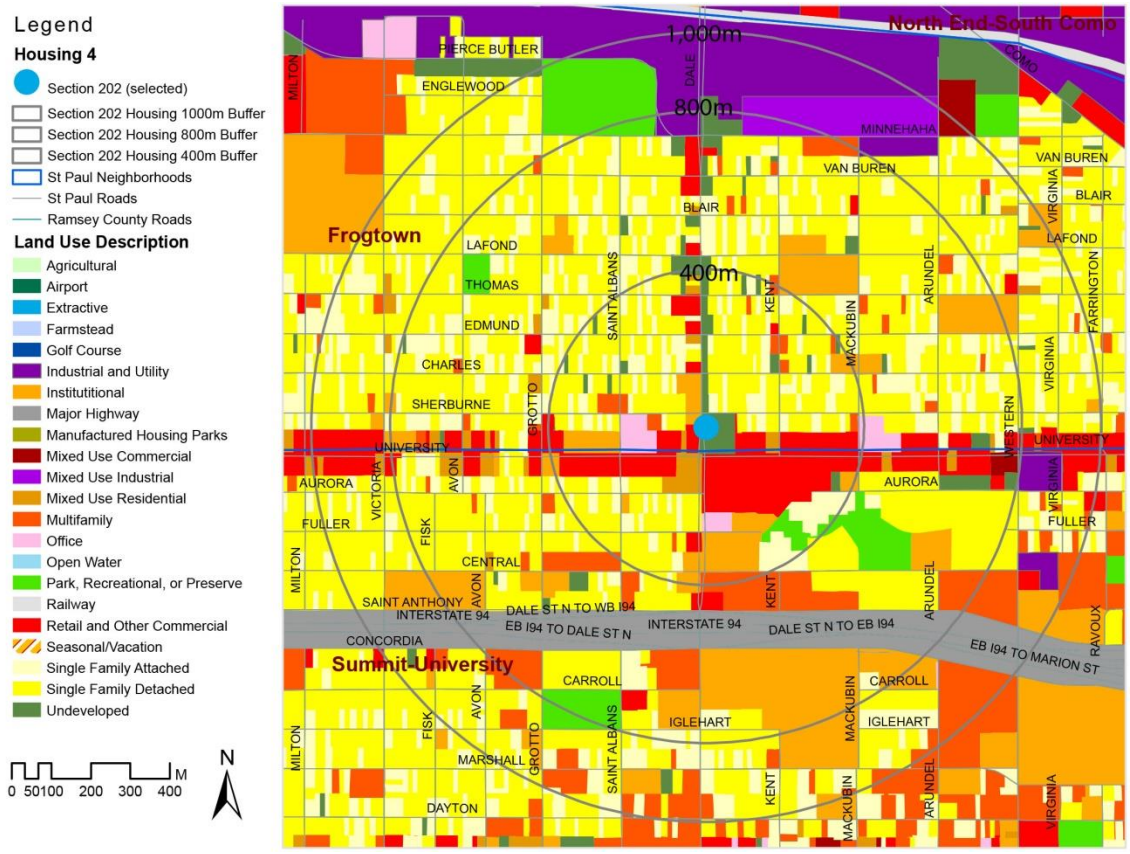

Figure 13. 2010 land use near Housing 4. Data sources came from "Data and maps: A service of Council Research & Geographic Information Services (GIS)", Twin Cities Metropolitan Council, 2013. Retrieved from http://www.metrocouncil.org/Data-and-Maps.aspx

Housing 4 is located in Frogtown neighborhood in St. Paul and there are a total of 49 units in the housing (see Figure 13). There are no amenities in the housing but the housing building was developed for mixed use with retail stores on the ground level. The housing is located in the middle of a commercial and retail area. Within one quarter mile radius from the housing, there are a number of retail stores including two large Asian grocery stores. Within one quarter mile radius from Housing 4, the majority of land uses

are residential with mostly single attached houses except for University Avenue and Dale Avenue with retail stores. The housing is approachable to public transportation stops. There are bus stops with a shelter, running buses in high frequency, and light rail stops under construction (see Figure 16). Thus, the researcher did not observe any residents using Metro Mobility in the housing. The elderly residents likely use general public transportation rather than Metro Mobility. Although there is a park within one quarter mile from Housing 4, the quality of the walking route is not good; the residents need to pass by large parking lots.

Although there are a lot of destinations in the neighborhood, there are a couple of elements discouraging walking in the neighborhood. First of all, the pedestrians face large parking lots. Second, the buildings are oriented toward inside with only a few display windows on buildings or windows are mostly covered with blinds. Third, the area with retail stores has low quality buildings and there are only a few trees on the street compared to the residential area near the housing. Fourth, the quality of houses is not attractive or not good, and the gardens in front of houses are not cultivated well. Thus, it was difficult to judge whether the houses are occupied by residents or vacant. In addition, there is a burnt-out house in the residential area. In this study, most of residential areas are well maintained in this study, but the residential area in this neighborhood was the lowest quality. Fifth, a man who appeared to have mental health problems was roaming in the area so women walking alone might feel unsafe in the area. Last, according to the data from the City of St. Paul, the neighborhood has the highest number of vacant buildings. The vacant buildings are also related to poor quality of the neighborhood environments.

Housing 5

Housing 5 is located in the West Side neighborhood in St. Paul (see Figure 14) and there are a total of 121 units in the housing. There are no amenities in the building but the housing is located in the elderly housing campus with a nursing home and assisted living facility. The housing is located in the middle of a residential area. Within one quarter mile radius from the housing, there are retail stores including convenience stores with no vegetables, restaurants, and a school, a library, and public and religious institutions.

The housing is close to bus stops but buses runs infrequently (see Figure 16). Although the shelter for bus stops is located in front of the housing, it is expected that using public transportation is not easy to use by the residents because of the infrequently running buses. From the experience of the researcher, transferring public transportation was not easy in winter. A bus operating by Metro Mobility was observed in front of the housing. However, the overall quality of the walking environments is good because the housing is located in the middle of a residential area and the area is well maintained by residents.

Although the neighborhood has good quality for walking, there are a couple of environmental conditions discouraging walking. First of all, the walking environments to destinations are not good in the aspect of quality and safety. For example, the closest walking path to destinations is Robert Avenue but the quality of the street is not good to walk and the street does not feel safe from crime because there are numerous vacant lots on the street. Moreover, there is no crosswalk or stop sign in some intersections so it is

not safe from traffic. Second, the quality of buildings for retail stores is not attractive for walking. Last, a couple of streets are hilly so it is expected that it is not easy to walk for the elderly residents.

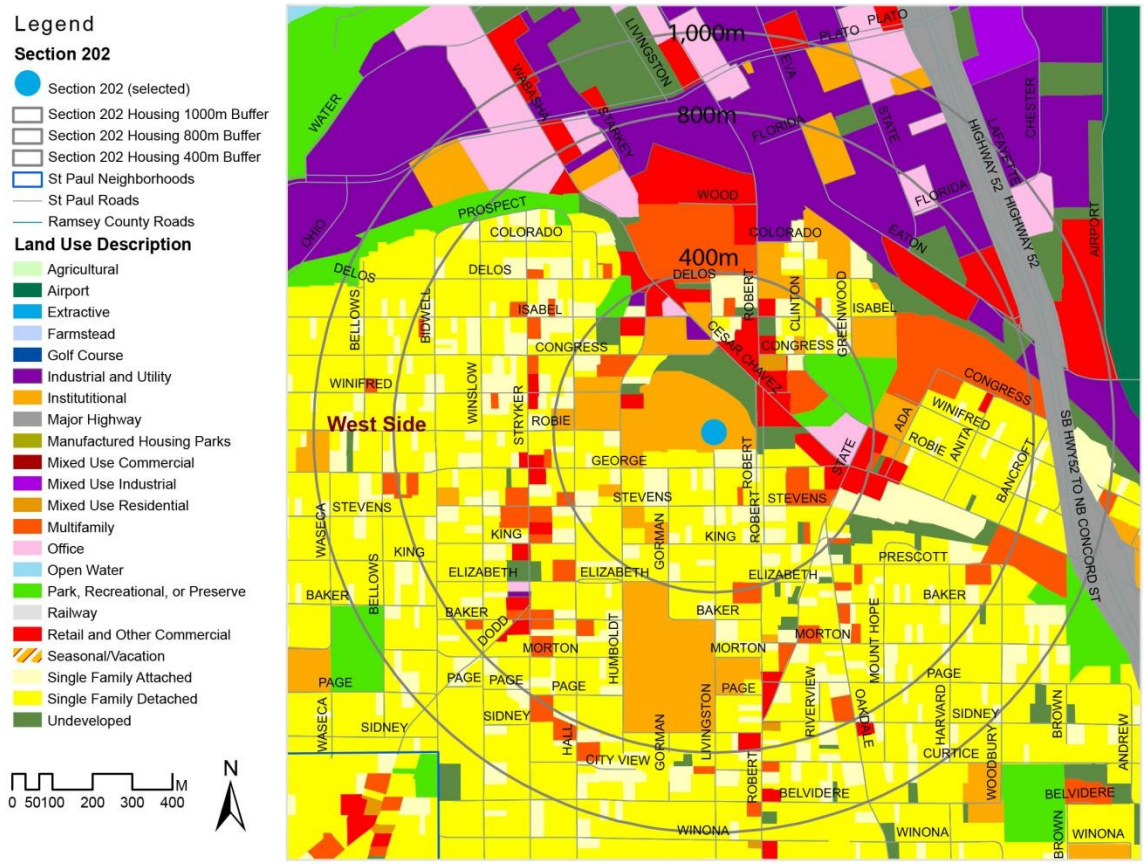

Figure 14. 2010 land use near Housing 5. Data sources came from "Data and maps: A service of Council Research & Geographic Information Services (GIS)", Twin Cities Metropolitan Council, 2013. Retrieved from http://www.metrocouncil.org/Data-and-Maps.aspx

Housing 6

Housing 6 is located in the Greater East Side neighborhood in St. Paul (see Figure 15) and has a total of 43 units. Within one quarter mile radius from the housing, there are no grocery stores or other retail businesses. Only schools and public institutions are located within the radius buffer. The majority of housing types in the neighborhood is single family attached housing or multi-family homes. The single-family homes are

located in the area south of Housing 6. In addition, there are vacant lots near Housing 6 and the areas have no continuous sidewalks so the researcher felt that the areas with the undeveloped land are less safe than other residential areas.

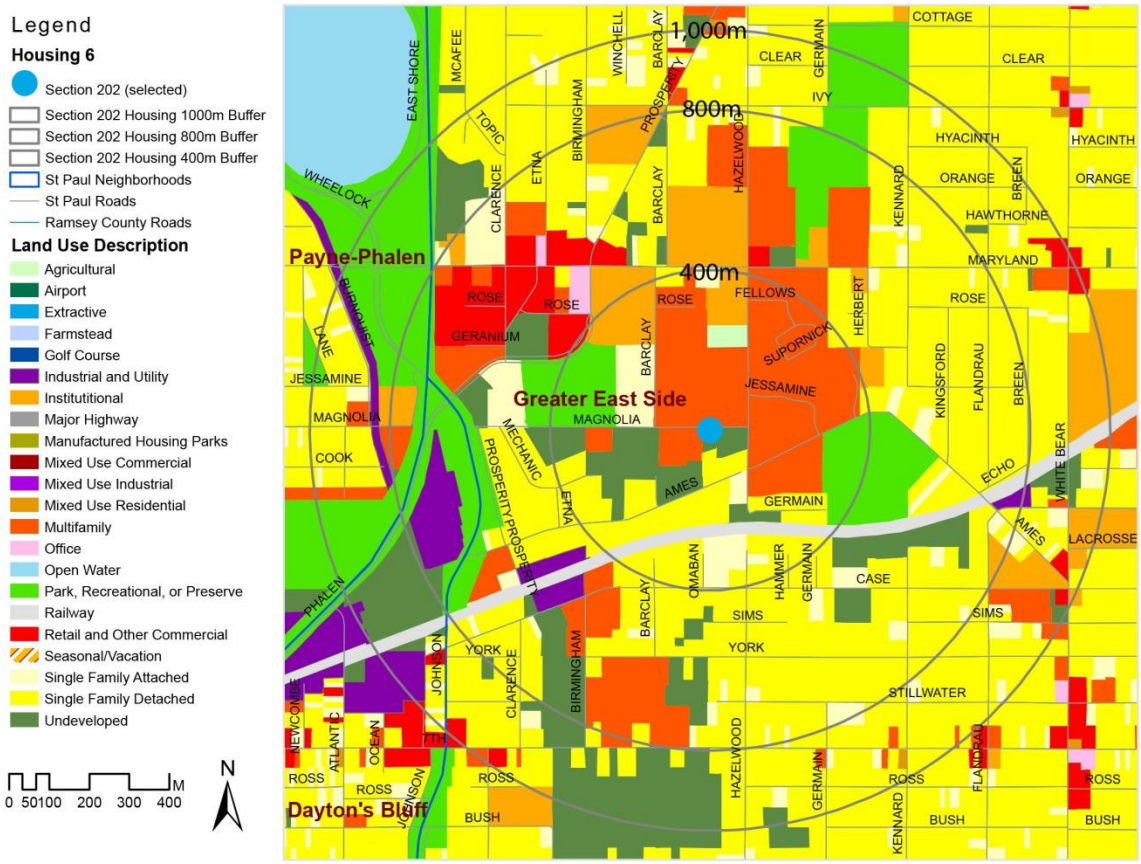

Figure 15. 2010 land use near Housing 6. Data sources came from "Data and maps: A service of Council Research & Geographic Information Services (GIS)", Twin Cities Metropolitan Council, 2013. Retrieved from http://www.metrocouncil.org/Data-and-Maps.aspx

A majority of the streets do not follow the grid system and have dead ends near Housing 6. Furthermore, a number of sidewalks are discontinuous. One-sided sidewalks are located on a majority of the streets even in the residential areas. Moreover, a majority of developed housing units are single family attached and multi-family so the street blocks are bigger than other neighborhoods which are observed by the researcher in this study.

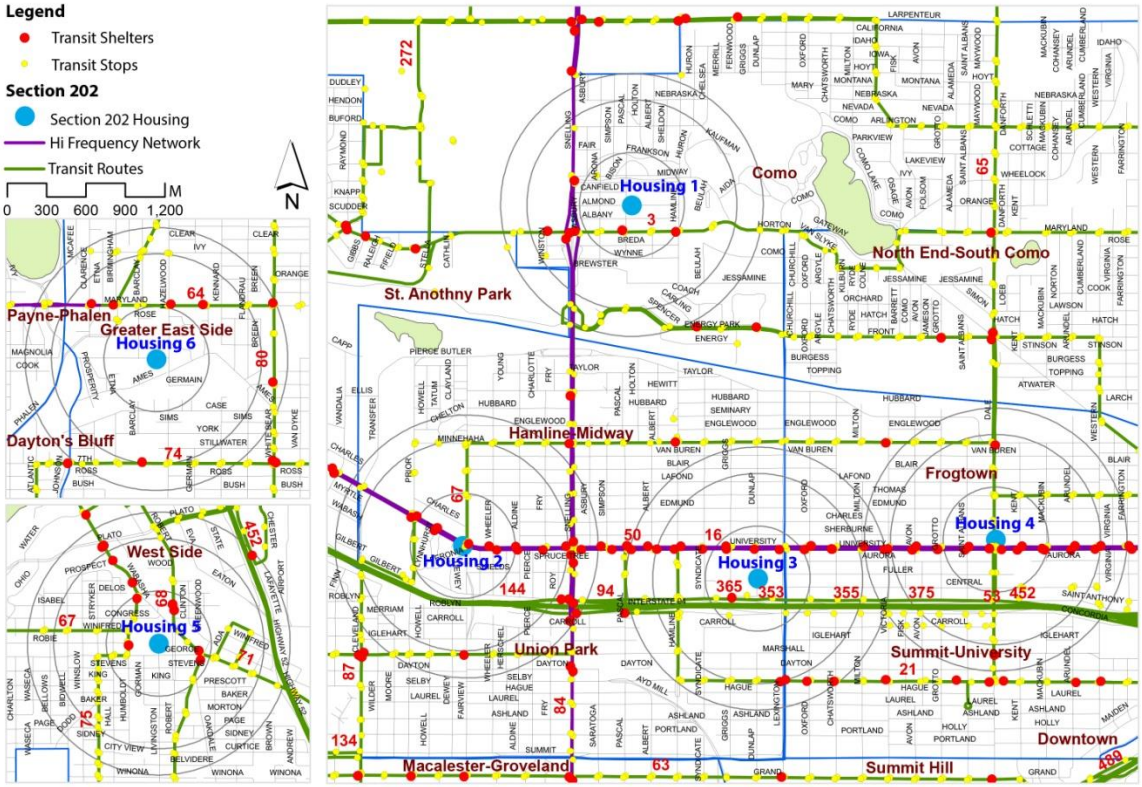

Figure 16. Transit routes and stops. Data sources came from "Data and maps: A service of Council Research & Geographic Information Services (GIS)", Twin Cities Metropolitan Council, 2013. Retrieved from http://www.metrocouncil.org/Data-and-Maps.aspx

Moreover, stops for public transportation are not close to Housing 6 (see Figure 16). The closest bus stop takes about 7 minutes (0.4miles) by walking from the housing according to Google Map. Even though linear distances between Housing 6 and destinations are relatively short, it seems that walking is not easy since the actual walking distances to potential destinations are 0.4 miles or further. The researcher observed that a man was traversing an undeveloped land area following with a small path crossing a railroad. It seems that the small path, which was naturally developed by human behaviors, could be dangerous and difficult to use, especially in winter. It is likely that the residents are more dependent on automobile in the neighborhood because more parked vehicles were observed in this neighborhood than in other neighborhoods.

GIS Analysis of Observation

Destinations

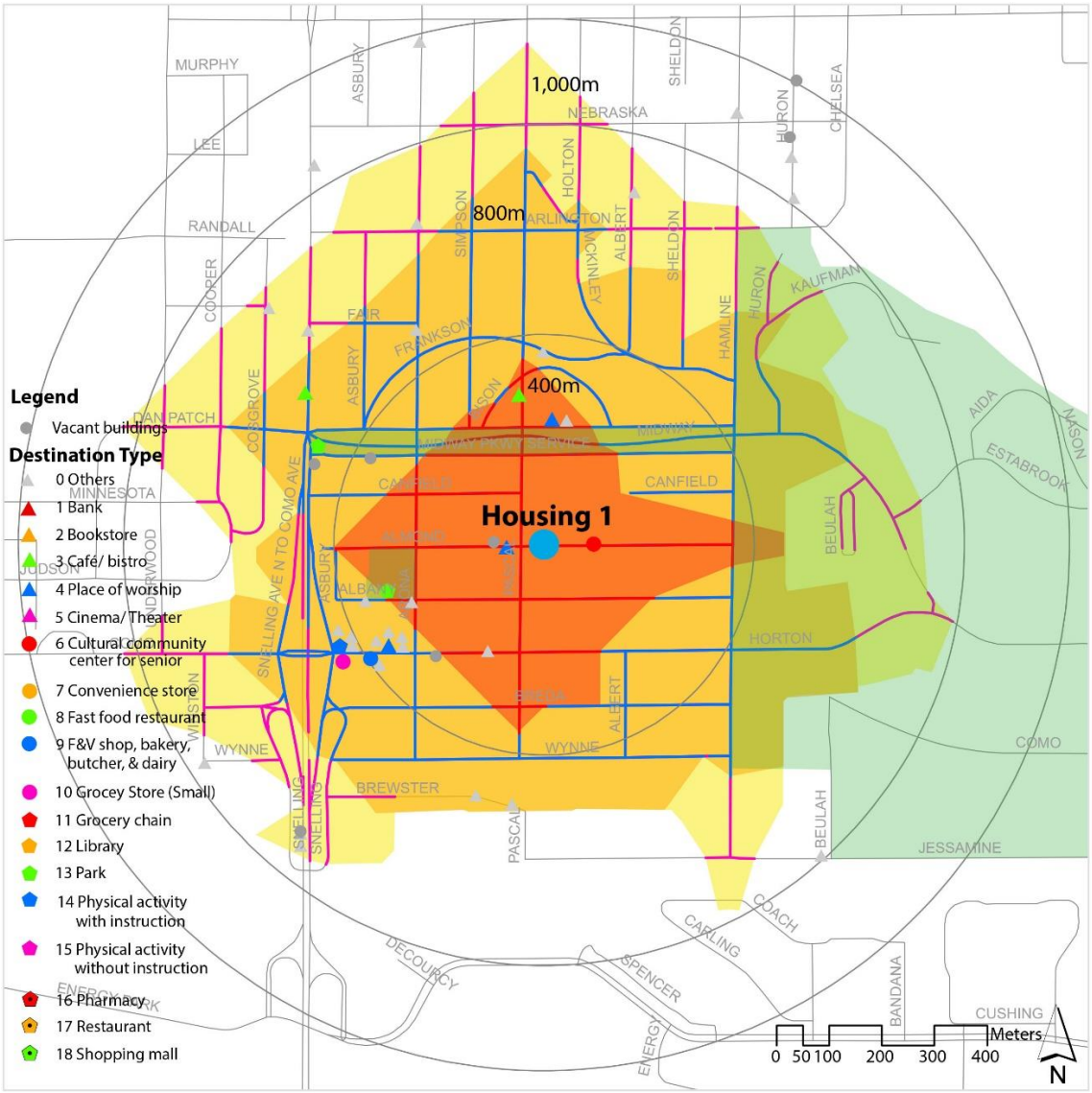

Figure 17. Destinations near Housing 1 within airline buffers and network buffers. Some data sources came from Google Maps.

To understand how the elderly residents can actually walk on the basis of street network systems, 400, 800, and 1,000 m ABs and 400, 800, and 1,000 m NBs are compared in each housing property. Moreover, the number of destinations are input on tables by destination types. According to Gauvin, Richard, Kestens, Shatenstein, Daniel,

Moore, Mercille, and Payette (2012), the following destinations are more likely to be considered supporting walking for older adults: 1) bank; 2) bookstore; 3) café/bistro; 4) place of worship including churches and other religious facilties; 5) cinema/theater; 6) cultural community center for senior; 7) convenience store; 8) fast food restaurant; 9) food and vegetable shop, bakery, butcher and dairy; 10) small grocery store; 11) grocery chain; 12) library; 13) park; 14) physical activity with and without insturction; 15) pharmacy; 16) restaurant; and 17) shopping mall. Thus, the destinations are categorized on the basis of Gauvin and collegues' classification.

Figure 17 shows the locations of destinations by type within 400, 800, and 1,000 m ABs and 400, 800, and 1,000 m NBs near Housing 1. Compared to airline buffers, the coverable areas are greatly reduced in network buffers. In particular, the residents can access less areas without grid network systems.

Types and numbers of destinations in Housing 1 within airline buffers and network buffers were also compared in Table 11. The total number of destinations supporting walking was less in the network buffers. Near Housing 1, a total of eleven destinations, that support walking, were located including a café/bistro; places of worship; a cultural community center for seniors; fruit and vegetable shops, a bakery, butcher and dairy shops; a small grocery store; parks; and a fitness center with instructions for physical activities within the 800 m NB but there are no destinations between the 800 m and 1,000 m NBs. Most distinctive characteristics related to destinations are that there are no grocery stores within the 400 m NB in Housing 1. Moreover, the grocery store which is located between the 400 m and 800 m NBs is targeting Asians although the majority of elderly residents are non-Asian. It is likely that the elderly residents do not visit the

grocery store frequently to buy food. Thus, usability of retail stores needs to be considered for walkability. The closest destination is a place of worship (73 m) and furthest destination is a café (719 m) among the destinations supporting walking (see Figure 17). As the distances to destinations are further from Housing 1, most of them are industrials and offices. Although there are the fewest destinations supporting walking within the 1,000 m NB from Housing 1 among six selected neighborhoods, the destinations are located near the neighborhood.

Table 11

Types and Numbers of Destinations in Housing 1 within Airline Buffers (ABs) and Network Buffers (NBs). Some data sources came from Google Maps.

Housing 1	400 m AB	800 m AB	1,000 m AB	400 m NB	800 m NB	1,000 m NB
Total	19	36	41	9	28	34
0 Others	10	25	30	3	17	23
Subtotal of destinations (1 to 18) for walking	**9**	**11**	**11**	**6**	**11**	**11**
1 Bank	0	0	0	0	0	0
2 Book Store	0	0	0	0	0	0
3 Café/ Bistro	1	2	2	1	2	2
4 Place of Worship	3	3	3	2	3	3
5 Cinema/ Theater	0	0	0	0	0	0
6 Cultural Community Center for Senior	1	1	1	1	1	1
7 Convenience Store	0	0	0	0	0	0
8 Fast Food Restaurant	0	0	0	0	0	0
9 Food & Vegetable Shop, Bakery, Butcher, & Dairy	1	1	1	0	1	1
10 Small Grocery Store	1	1	1	0	1	1
11 Grocery Store (Chain)	0	0	0	0	0	0
12 Library	0	0	0	0	0	0
13 Park	2	2	2	2	2	2
14 Physical Activity with Instruction	0	1	1	0	1	1
15 Physical Activity without Instruction	0	0	0	0	0	0
16 Pharmacy	0	0	0	0	0	0
17 Restaurant	0	0	0	0	0	0
18 Shopping Mall	0	0	0	0	0	0

Figure 18 shows the locations of destinations by type within 400, 800, and 1,000 m ABs and 400, 800, and 1,000 m NBs near Housing 2. As seen in Figure 18, large blocks with industrial purpose are less accessible by walking because there are few destinations which are promoting walking. Although Housing 2 is located near commercial areas, the size of the block for commercial use is large so the number of desitinations supporting walking is not as many as the total number of destinations.

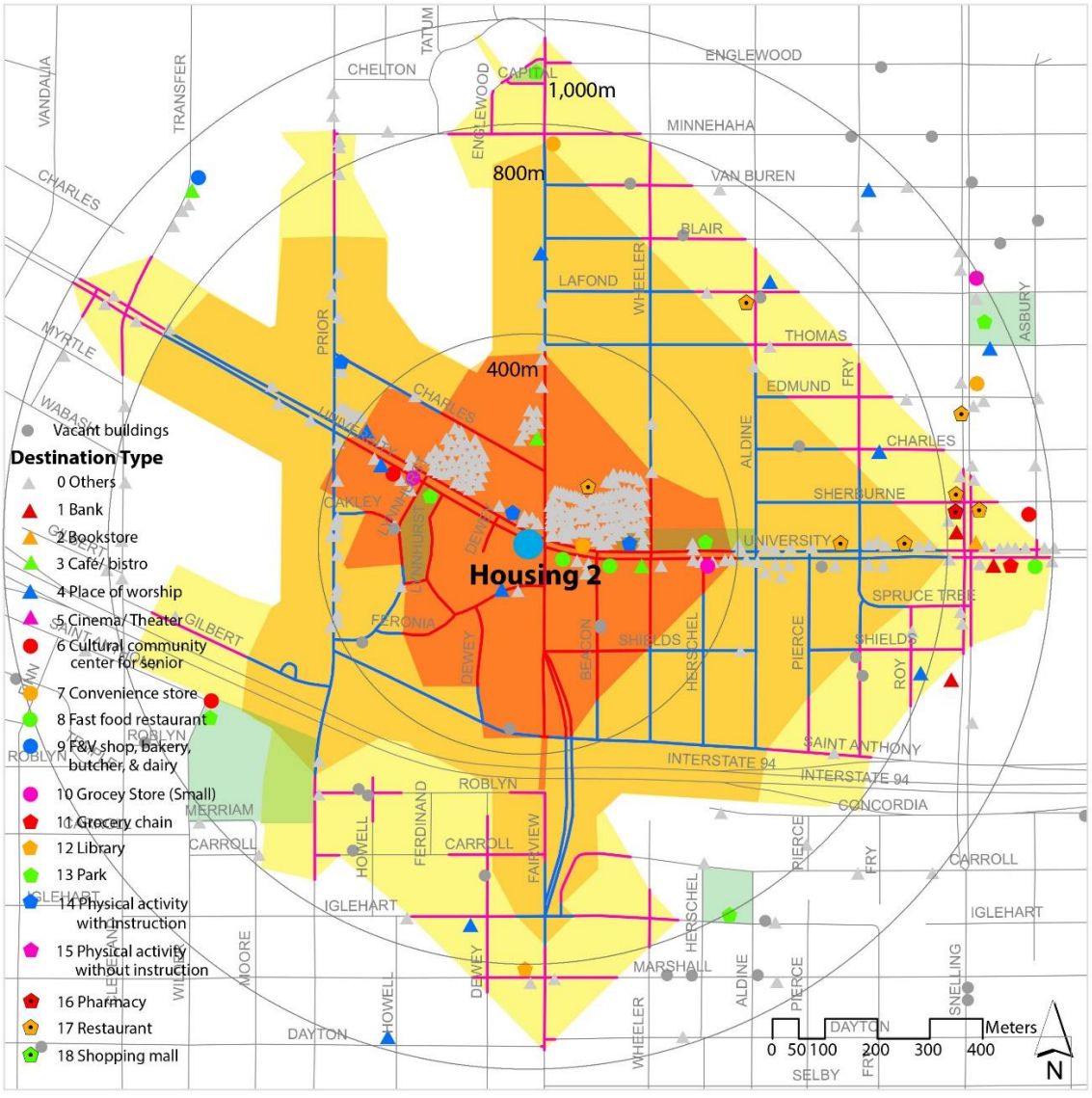

Figure 18. Destinations near Housing 2 within airline buffers and network buffers. Some data sources came from Google Maps.

Within the 400 m NB near Housing 2, a total of 16 destinations for older adults are located including cafés/bistros, places of worship, cultural community centers for seniors, convenience stores, fast food restaurants, small grocery stores, parks, facilities with for physical activity with instruction, and restaurants. Within the 1,000 m NB, there are no theaters; food and vegetable shops, bakeries, butchers and dairies; facilites for physical activity without instruction, and shopping malls among 37 destinations encouraging walking (see Figure 18).

Table 12

Types and Numbers of Destinations in Housing 2 within Airline Buffers and Network Buffers. Some data sources from Google Maps.

Housing 2	400 m AB	800 m AB	1,000 m AB	400 m NB	800 m NB	1,000 m NB
Total	223	298	375	205	269	316
0 Others	207	269	325	189	248	279
Subtotal of destinations (1 to 18) for walking	**16**	**29**	**50**	**16**	**21**	**37**
1 Bank	0	0	3	0	0	2
2 Book Store	0	0	1	0	0	1
3 Café/ Bistro	2	2	3	2	2	2
4 Place of Worship	3	8	11	3	4	8
5 Cinema/ Theater	0	0	0	0	0	0
6 Cultural Community Center for Senior	1	2	3	1	1	1
7 Convenience Store	1	2	3	1	1	2
8 Fast Food Restaurant	2	2	3	2	2	3
9 Food & Vegetable Shop, Bakery, Butcher, & Dairy	0	0	1	0	0	0
10 Small Grocery Store	2	2	3	2	2	2
11 Grocery Store (Chain)	0	0	1	0	0	1
12 Library	0	0	1	0	0	1
13 Park	2	4	6	2	3	4
14 Physical Activity with Instruction	2	3	3	2	3	3
15 Physical Activity without Instruction	0	0	0	0	0	0
16 Pharmacy	0	0	1	0	0	1
17 Restaurant	1	4	7	1	3	6
18 Shopping Mall	0	0	0	0	0	0

The closest destination is a fast food restaurant (72 m) and the furthest destinations are banks, book stores, grocery chains, libraries, and pharmacies which do not have any alternative destinations within the 800 m NB. The nearest ones are located in 899, 863, 916, 898, and 909 m (see Table 12).

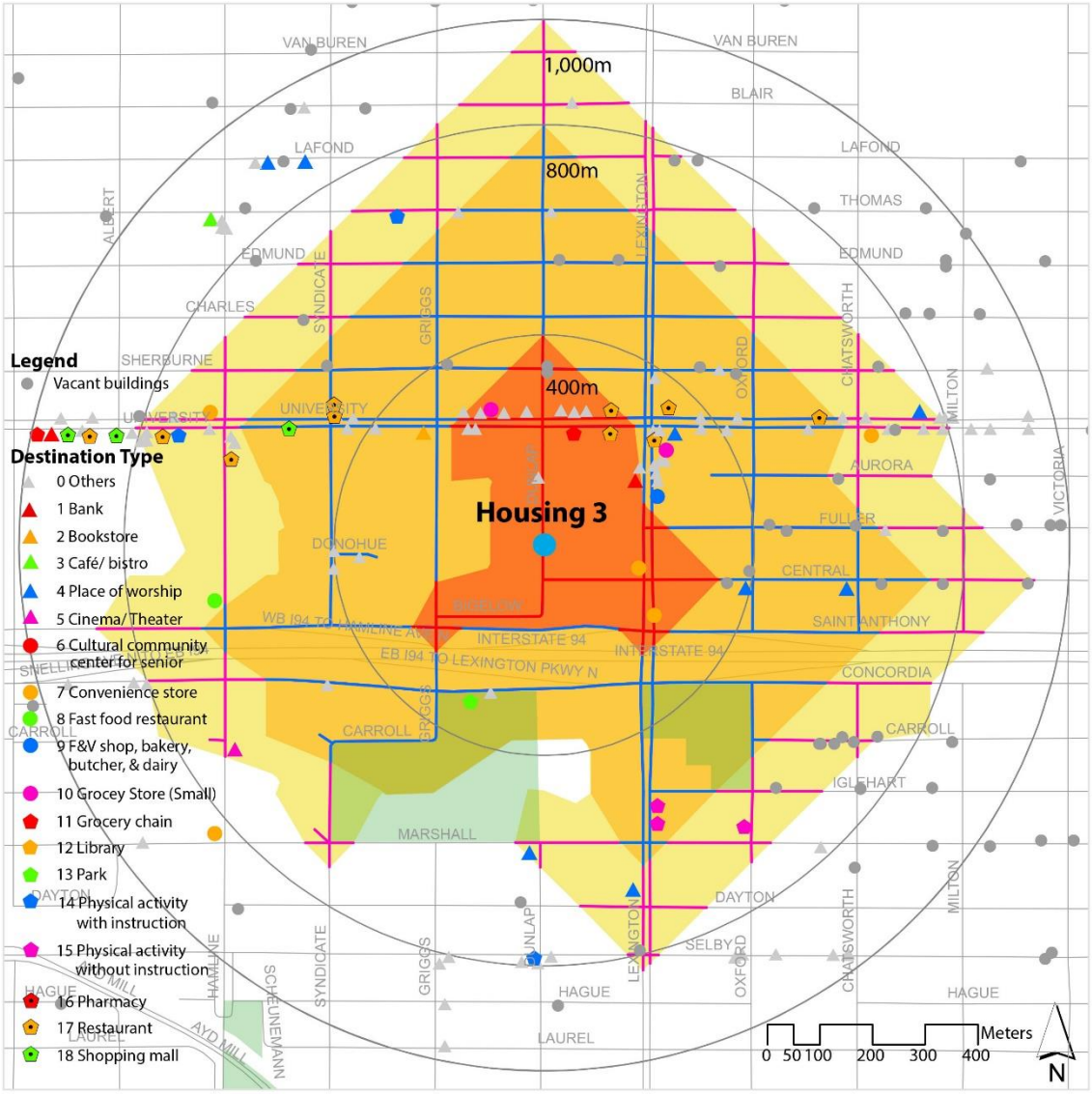

Figure 19. Destinations near Housing 3 within airline buffers and network buffers. Some data sources came from Google Maps.

The network buffer maps were drawn on the basis of roads which are accessible by cars. However, there are a couple of streets which are only accessible by pedestrians.

In particular, Housing 3 is located near highways and crossable roads are far from the Housing. Thus, an existing street containing a bridge which is only for pedestrian walking was added to the map because the bridge expands walkable areas near Housing 3 (see Figure 19).

Table 13

Types and Numbers of Destinations in Housing 3 within Airline Buffers and Network Buffers. Some data sources came from Google Maps.

Housing 3	400 m AB	800 m AB	1,000 m AB	400 m NB	800 m NB	1,000 m NB
Total	43	96	156	16	63	89
0 Others	27	59	102	10	40	54
Subtotal of destinations (1 to 18) for walking	**16**	**37**	**54**	**6**	**23**	**35**
1 Bank	1	1	3	0	1	1
2 Book Store	1	1	1	0	1	1
3 Café/ Bistro	0	0	1	0	0	0
4 Place of Worship	2	7	10	0	3	6
5 Cinema/ Theater		1	1	0	0	1
6 Cultural Community Center for Senior	0	0	0	0	0	0
7 Convenience Store	2	4	6	2	2	4
8 Fast Food Restaurant	0	1	2	0	0	1
9 Food & Vegetable Shop, Bakery, Butcher, & Dairy	1	1	1	0	1	1
10 Small Grocery Store	2	2	2	1	2	2
11 Grocery Store (Chain)	1	1	3	1	1	1
12 Library	0	0	0	0	0	0
13 Park	2	2	2	0	2	2
14 Physical Activity with Instruction	0	3	3	0	0	2
15 Physical Activity without Instruction	0	3	3	0	2	3
16 Pharmacy	0	0	0	0	0	0
17 Restaurant	4	9	13	2	7	9
18 Shopping Mall	0	1	3	0	1	1

Within the 400 m NB near Housing 3, a total of 6 destinations are located including convenience stores, small grocery stores, grocery chains, and restaurants. Within the 1,000 m NB, there are theaters; food and vegetable shops, bakeries, butchers

and dairies; facilites for physical activity without instruction; and shopping malls among 35 destinations encouraging walking (see Table 13). The closest destination is a small grocery store (278 m) and the furthest destination is a theater (982 m). There are no destinations such as a cinema/theater, a fast food restaurant, and facilties for physical activity with instruction within the 800 m NB but those are located within the 1,000 m NB near Housing 3. Compared to the total number of destinations supporting walking, which is 35, there are only six destinations within the 400 m NB near Housing 3. It is probably caused by the size of the blocks near Housing 3. Although there are lots for retail and commercial use near the housing, the size of the lots are large and the buildings can accommodate large retail stores rather than small retail stores which positively influence walking. Moreover, a small number of intersections which are caused by the size of the lots near Housing 3 can reduce the area which is accessible by walking.

As seen in Figure 20, the residents can cover the widest area by walking in the neighborhood near Housing 4 among the six selected neighborhoods. The reason is that the street network system is closest to a grid system and the distances between intersections are shortest among the six housing neighborhoods. Housing 4 has the greatest number of destinations promoting walking among the six neighborhoods and the destinations are evenly distributed in the neighborhood (see Table 14). There are 24 destinations among 49 destinations which are supporting walking within the 400 m NB. The available destinations are banks, cafés/bistros, places of worship, a cultural community center for seniors, a convenience store, a fast food restaurant, small grocery stores, grocery chains, a library, a facility for physical activity with instruction, and restaurants within the 400 m NB. Additional destinations beyond the 400 m NB are

cinemas or theaters; food and vegetable shops, bakery, butcher shops, and dairies; and parks. Interestingly, there are the greatest number of places for worship totalling ten and the highest number of grocery stores totalling eight among the six selected neighborhoods. Moreover, the majority of grocery stores are located within the 400 m NB.

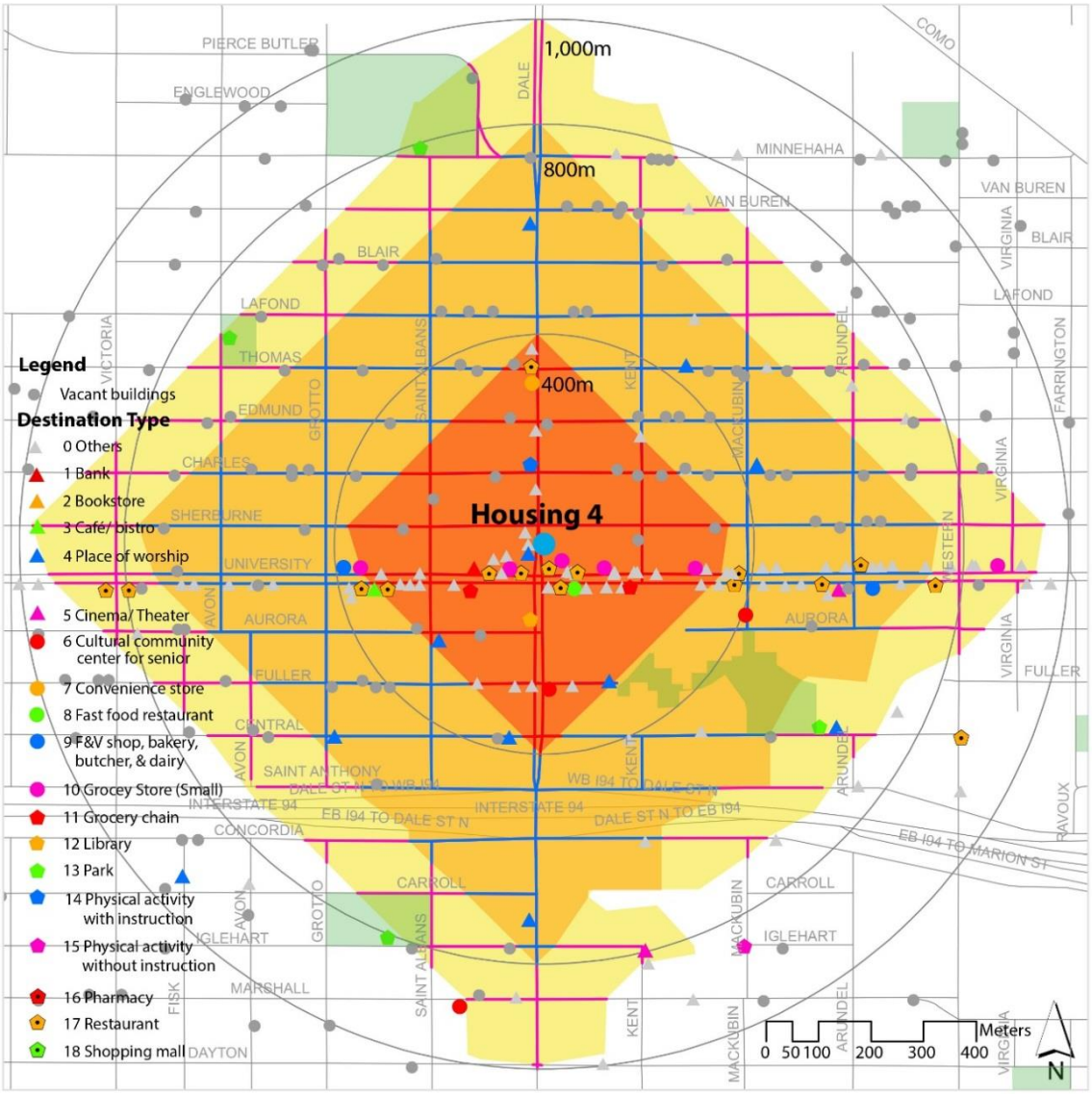

Figure 20. Destinations near Housing 4 within airline buffers and network buffers. Some data sources came from Google Maps.

Table 14

Types and Numbers of Destinations in Housing 4 within Airline Buffers and Network Buffers. Some data sources came from Google Maps.

Housing 4	400 m AB	800 m AB	1,000 m AB	400 m NB	800 m NB	1,000 m NB
Total	77	131	151	64	111	131
0 Others	46	82	96	40	71	82
Subtotal of destinations (1 to 18) for walking	**31**	**49**	**55**	**24**	**40**	**49**
1 Bank	1	1	1	1	1	1
2 Book Store	0	0	0	0	0	0
3 Café/ Bistro	1	1	1	1	1	1
4 Place of Worship	5	12	13	3	9	10
5 Cinema/ Theater	0	2	2	0	1	2
6 Cultural Community Center for Senior	1	2	3	1	2	2
7 Convenience Store	1	1	1	1	1	1
8 Fast Food Restaurant	1	1	1	1	1	1
9 Food & Vegetable Shop, Bakery, Butcher, & Dairy	1	2	2	0	2	2
10 Small Grocery Store	5	5	6	4	5	6
11 Grocery Store (Chain)	2	2	2	2	2	2
12 Library	1	1	1	1	1	1
13 Park	1	4	4	0	1	4
14 Physical Activity with Instruction	1	1	1	1	1	1
15 Physical Activity without Instruction	0	0	1	0	0	0
16 Pharmacy	0	0	0	0	0	0
17 Restaurant	10	14	16	8	12	15
18 Shopping Mall	0	0	0	0	0	0

The closest destinations are two restaurants and a grocery store, which are located in the same building with Housing 4, at distances of 90, 98 and 85 m. Among the existing destinations within the 1,000 m NB, a park is the furthest at a distance of 552 m in the neighborhood. This means that most of the available types of destinations are walkable within less than 600 m and it is likely that the residents can arrive at most of the destinations within only 7 to 8 minutes by walking. Moreover, there are additional individual types of destinations greater than 600 m near Housing 4.

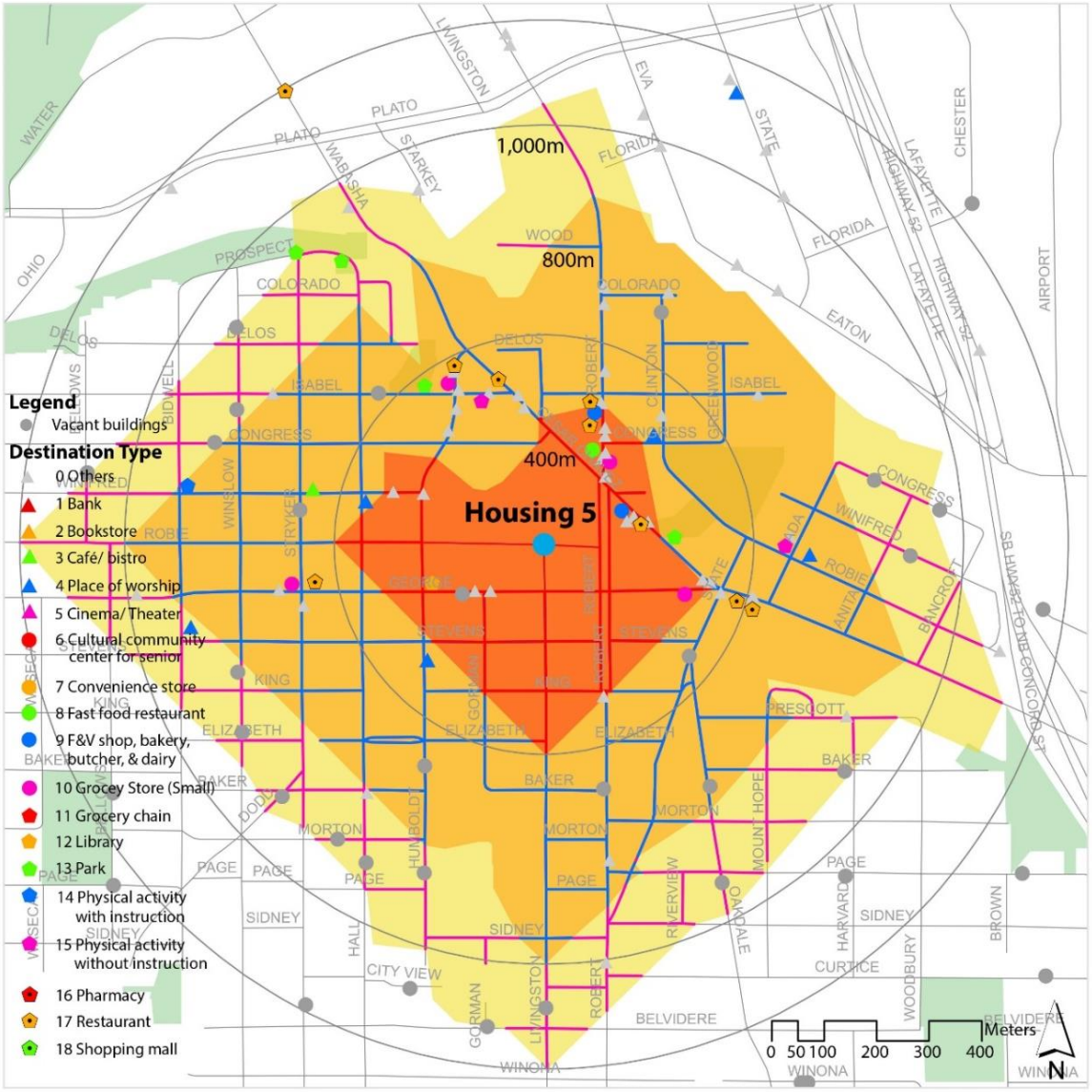

Figure 21. Destinations near Housing 5 within airline buffers and network buffers. Some data sources came from Google Maps.

As seen in Figure 21, Housing 5 is located in the middle of a senior housing campus. Thus, three extended street lines which match pedestrians' walking paths were digitized to measure the exact distances from the housing entrance to destinations although the streets are not approachable by cars.

Table 15

Types and Numbers of Destinations in Housing 5 within Airline Buffers and Network Buffers. Some data sources came from Google Maps.

Housing 5	400 m AB	800 m AB	1,000 m AB	400 m NB	800 m NB	1,000 m NB
Total	46	80	94	23	64	75
0 Others	27	51	62	14	38	46
Subtotal of destinations (1 to 18) for walking	**19**	**29**	**32**	**9**	**26**	**29**
1 Bank	0	0	0	0	0	0
2 Book Store	0	0	0	0	0	0
3 Café/ Bistro	0	1	1	0	1	1
4 Place of Worship	3	5	6	0	4	5
5 Cinema/ Theater	0	0	0	0	0	0
6 Cultural Community Center for Senior	0	0	0	0	0	0
7 Convenience Store	0	0	0	0	0	0
8 Fast Food Restaurant	0	0	0	1	1	1
9 Food & Vegetable Shop, Bakery, Butcher, & Daily	2	2	2	2	2	2
10 Small Grocery Store	3	4	4	2	4	4
11 Grocery Store (Chain)	0	0	0	0	0	0
12 Library	1	1	1	1	1	1
13 Park	2	4	5	0	2	4
14 Physical Activity with Instruction	0	1	1	0	1	1
15 Physical Activity without Instruction	1	2	2	0	2	2
16 Pharmacy	0	0	0	0	0	0
17 Restaurant	7	9	10	3	8	8
18 Shopping Mall	0	0	0	0	0	0

Only nine destinations supporting walking are approachable near Housing 5 within the 400 m NB although there are 19 destinations within the 400 m AB (see Table 15). The reasons are that the street system does not follow a grid, the housing campus occupies a large lot which is bigger than one block, and there is an undeveloped land right next to the campus. The nine destinations are classified into the followings: a fast food restaurant; a food and vegetable shop, a bakery, a butcher shop, and a dairy; small grocery stores; a library; and restaurants. In addition to these destinations, 20 more

destinations exist within the 1,000 m NB. This means that a total of 29 destinations encouranging walking are available within the 1,000 m NB. The additional destination types are cafés and bistros; places of workship; parks; and facilties for physical activities with and without instruction.

The nearest destination type is a small grocery store which is 287 m away from Housing 5. However, the quality of the closest route to arrive in the destination is not good and does not feel safe from the researcher's perception. Therefore, it was not certain whether the residents will choose the closest route or not. The furthest destination type is a café/bistro but banks, book stores, cinema/theaters, cultural community centers for seniors, convenience stores, grocery chains, and pharmacies are not available within the 1,000 m NB. The majority of destinations are located in retail and commercial land use lots which are dominant usage in the area but one or two destinations such as a coffee shop are located in the middle of single-family and multi-family housing areas. Thus, the destination is inviting to pedestrians for the purpose of recreational walking in the neighborhood.

Housing 6 is located in the neighborhood where the street is not well connected with dead ends and a circular shape and where the sizes of blocks are large. Thus, the areas that can be covered by walking are restricted with the 1,000 m NB. Not surprisingly, the coverable area by walking is smallest among the six selected neighborhoods. Moreover, most of the land uses near the neighborhood in Housing 6 are for single-family and multi-family housing and undeveloped lands rather than for retail and commercial stores. Thus, it is difficult to arrive at the destinations excluding a park by

walking near Housing 6 (see Figure 22). In particular, public transportation stops are also located beyond 5 minute walking (400 m) in the neighborhood.

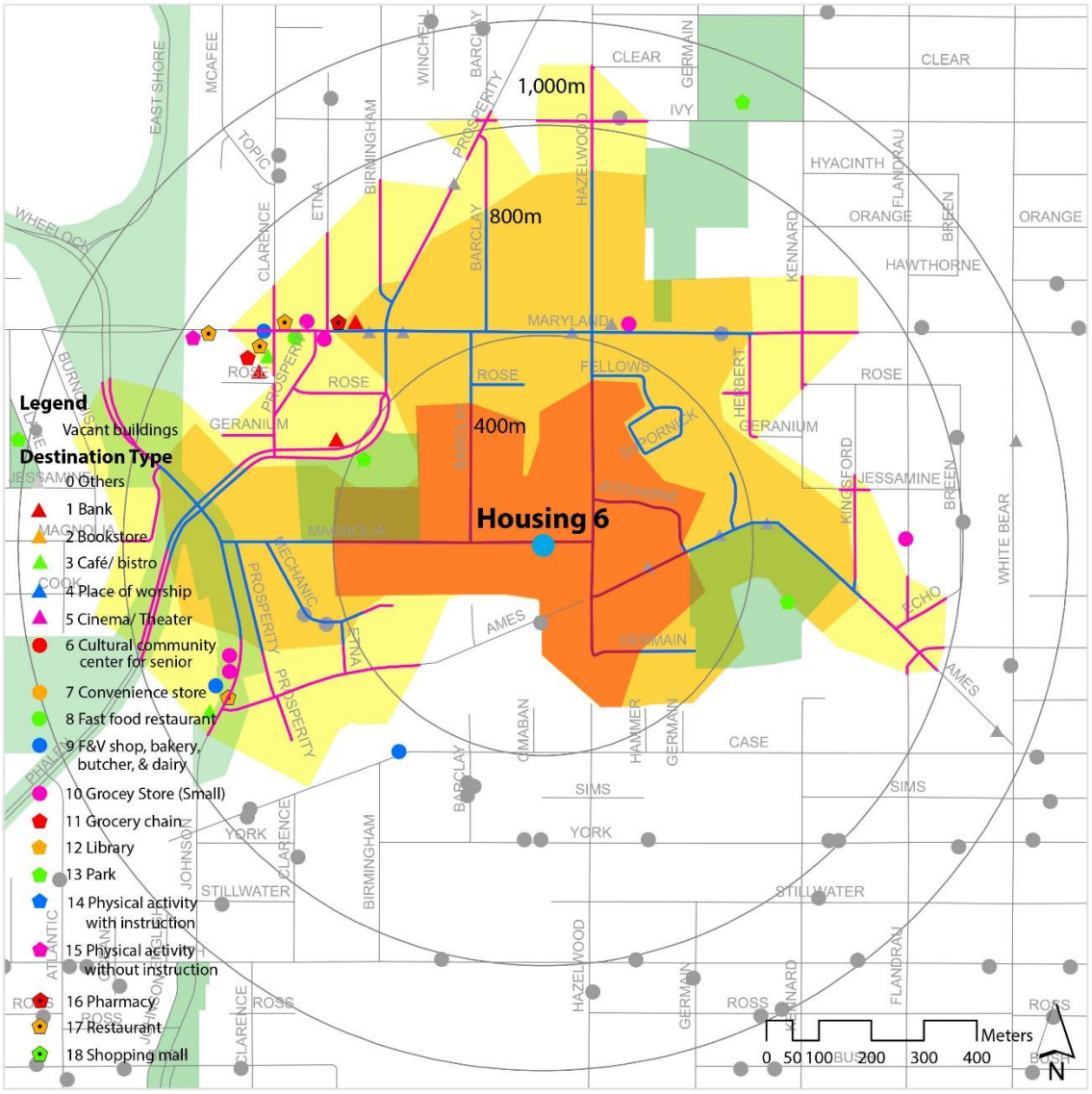

Figure 22. Destinations near Housing 6 within airline buffers and network buffers. Some data sources came from Google Maps.

Within the 400 m NB as well as the 400 m AB, there are no available destinations excluding parks (see Table 16). There are six destinations available, which are supporting walking, including a bank, four parks, and a pharmacy within the 800 m NB although there are 25 walkable destinations including banks; cafés/bistros; a fast food restaurant;

food and vegetable shops, bakeries, butcher shops, and dairies; small grocery stores; a grocery chain; parks, a facility for physical activity without instruction; a pharmacy; and restaurants within the 800 m AB. The dramatically different number of destinations shows how the street network system is important for walking, especially for the elderly, to destinations.

Table 16

Types and Numbers of Destinations in Housing 6 within Airline Buffers and Network Buffers. Some data sources came from Google Maps.

Housing 6	400 m AB	800 m AB	1,000 m AB	400 m NB	800 m NB	1,000 m NB
Total	4	33	36	2	13	28
0 Others	2	8	10	1	7	7
Subtotal of destinations (1 to 18) for walking	**2**	**25**	**26**	**1**	**6**	**21**
1 Bank	0	3	3	0	1	3
2 Book Store	0	0	0	0	0	0
3 Café/ Bistro	0	2	2	0	0	2
4 Place of Worship	0	0	0	0	0	0
5 Cinema/ Theater	0	0	0	0	0	0
6 Cultural Community Center for Senior	0	0	0	0	0	0
7 Convenience Store	0	0	0	0	0	0
8 Fast Food Restaurant	0	1	1	0	0	1
9 Food & Vegetable Shop, Bakery, Butcher, & Daily	0	3	3	0	0	2
10 Small Grocery Store	0	5	5	0	0	4
11 Grocery Store (Chain)	0	1	1	0	0	1
12 Library	0	0	0	0	0	0
13 Park	2	4	5	1	4	4
14 Physical Activity with Instruction	0	0	0	0	0	0
15 Physical Activity without Instruction	0	1	1	0	0	0
16 Pharmacy	0	1	1	0	1	1
17 Restaurant	0	4	4	0	0	3
18 Shopping Mall	0	0	0	0	0	0

The distance to the closest destination, a park, is 399 m. The furthest destination types which are closest from Housing 6 are cafés or bistros (922 m), a fast food restaurant

(872 m), food and vegetable shops (922 m), a small grocery store (852 m), a grocery chain (963 m) and a restaurant (879 m). The most distinctive characteristic is that there are no grocery stores, cafés, and restaurants which are most influencing destinations for walking within the 800 m NB. This housing is located more than 400 m from the closest bus stop. This means that the elderly residents have to walk to buy simple snacks and to carry heavy bags after grocery shopping more than ten minutes or more than five minutes after taking a bus which usually runs every 30 minutes. Thus, it was observed that the elderly residents frequently used Metro Mobility services compared to the residents in the other housing properties. It is also likely that the elderly residents do not usually walk to arrive at their destinations.

Vacant Buildings, Crimes, and Traffic Accidents

In the six neighborhoods with Section 202 HUD-subsidized housing, there are at least four or more vacant buildings and the number of vacant housing was different in each neighborhood. Table 17 and Figure 23 show the number and location of vacant buildings within a 1,000 m NB from each of the housing properties. Housing 4 has the highest number of vacant buildings totaling 94 and Housing 6 has the lowest number of vacant buildings totaling 4 within a 1,000 m NB although there are 34 vacant buildings within the 1,000 m AB in the neighborhood. The reason for this is that the walkable area has shrunken because of the street network system.

The overall neighborhood environment quality in the most residential areas was attractive with well-maintained buildings and well-cultivated gardens although there are some vacant houses. However, the overall neighborhood environment quality in Housing 4 was not good especially in the residential area. The buildings were not well maintained

and there were very few cultivated plants in the gardens so it was really difficult to distinguish whether the houses were occupied by residents or not. A house was also partially burnt and left in the neighborhood. Housing 1 is located in the Como neighborhood which has the second lowest number of vacant buildings within the 1,000 m NB.

However, a commercial building (a residential institution) which occupies a whole block is vacant and boarded up with a sign indicating the building is vacant. Thus, the researcher felt that walking alone is unsafe on this block. From the perspective of the researcher, the number of vacant buildings is associated with the perception of safety but the size and the quality of vacant buildings is also important for the safety perception.

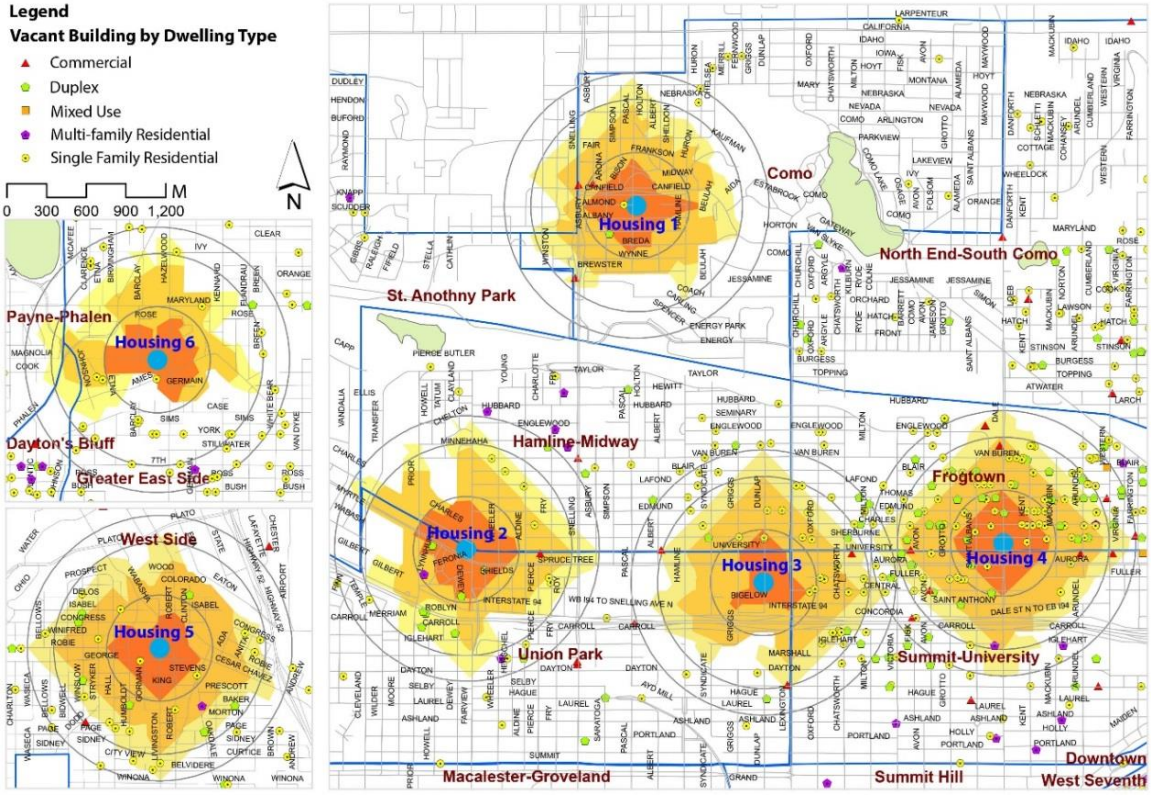

Figure 23. Locations of vacant buildings by dwelling types. Data sources came from "Vacant buildings", St Paul Minnesota, 2013. Retrieved from http://www.stpaul.gov/index.aspx?nid=1090 on February 6th, 2013.

Table 17

The Number of Vacant Buildings by Dwelling Types within 400, 800, and 1,000 m Network Buffer. Data sources came from "Vacant buildings", St Paul Minnesota, 2013. Retrieved from http://www.stpaul.gov/index.aspx?nid=1090 on February 6th, 2013.

		400 m NB	800 m NB	1000 m NB
Housing 1	Total	**1**	**4**	**5**
	Single-family residential	1	1	1
	Multi-family residential	0	0	0
	Mixed use	0	0	0
	Duplex	0	1	1
	Commercial	0	2	3
Housing 2	Total	**4**	**7**	**16**
	Single-family residential	2	3	8
	Multi-family residential	0	1	1
	Mixed use	0	0	0
	Duplex	2	2	6
	Commercial	0	1	1
Housing 3	Total	**2**	**15**	**31**
	Single-family residential	2	13	25
	Multi-family residential	0	0	0
	Mixed use	0	1	1
	Duplex	0	1	3
	Commercial	0	0	2
Housing 4	Total	**12**	**62**	**94**
	Single-family residential	9	41	56
	Multi-family residential	0	0	3
	Mixed use	0	0	0
	Duplex	3	18	29
	Commercial	0	3	6
Housing 5	Total	**1**	**8**	**24**
	Single-family residential	1	5	16
	Multi-family residential	0	1	1
	Mixed use	0	0	0
	Duplex	0	2	7
	Commercial	0	0	0
Housing 6	Total	**0**	**3**	**4**
	Single-family residential	0	3	4
	Multi-family residential	0	0	0
	Mixed use	0	0	0
	Duplex	0	0	0
	Commercial	0	0	0

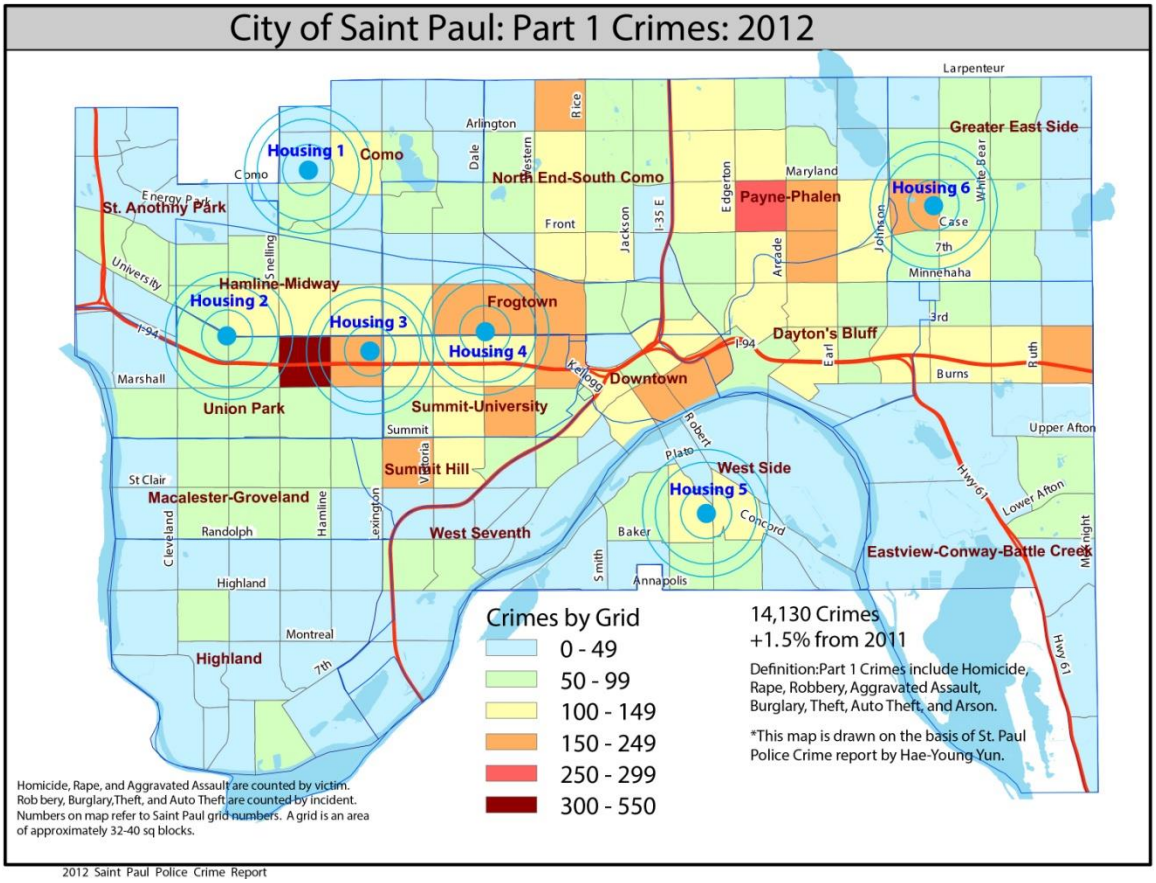

Figure 24. 2012 Part 1 Crimes by police grid in St. Paul. Adapted from "2012 City of St Paul Police Crime Report" St Paul Minnesota, 2012, p. 37. Retrieved from http://www.stpaul.gov/DocumentCenter/View/66068.

Figure 24 shows the number of Part 1 Crimes including homicide, rape, robbery, aggravated assault, burglary, theft, auto theft, and arson by police grid in 2012. The average crimes by police grid are 70 in 2012 in St. Paul (see Table 18). Overall, Section 202 housing properties are located in high crime areas except Housing 1. Housing 1 is located in the police district with the lowest number of crimes with a total of 41 Part 1 Crimes. Housing 3, 4, and 6 are located in the police grid with 150 to 249 Part 1 Crimes (see Figure 24). The individual crimes by Housing 3, 4, and 6 are 174, 228, and 178 (see Table 18). Among these three housing properties, Housing 3 is adjacent to the police grid with the number of highest crimes totaling 550 in St. Paul, which is within a walkable distance.

Table 18

Part 1 Crimes by Police Grid in St. Paul 2012. Data sources came from "2012 City of St Paul Police Crime Report" St Paul Minnesota, 2012, p. 58-63. Retrieved from http://www.stpaul.gov/DocumentCenter/View/66068.

	St. Paul average	Housing 1	Housing 2	Housing 3	Housing 4	Housing 5	Housing 6
Part 1 Crimes	70	41	94	174	228	126	178

According to the data about car accident calls in 2012, the areas near University Avenue and Arcade Avenue had the highest and second highest traffic accident calls and there were three Section 202 housing properties including Housing 2, 3, and 4 on University Avenue (see Figure 25). Housing 2 is located in the area with the highest car accident calls. Housing 1 is located in the second lowest area with traffic accident calls.

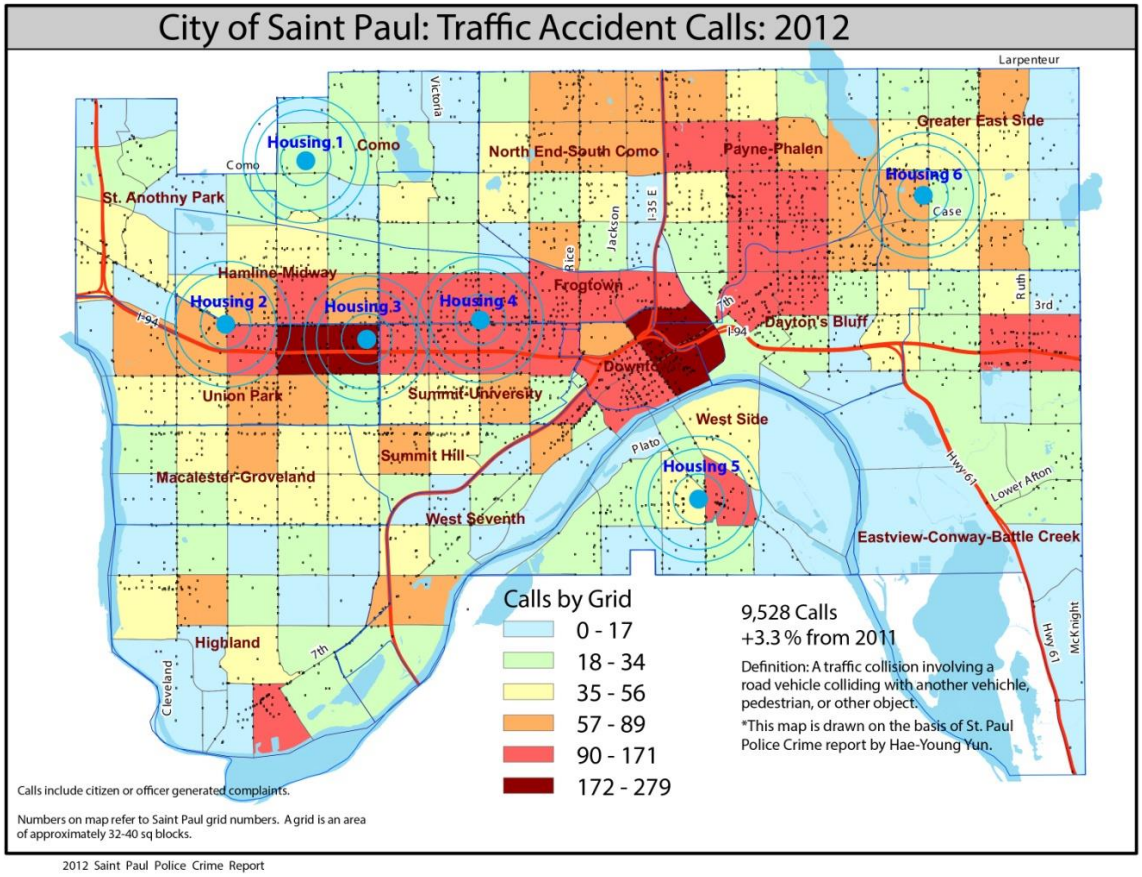

Figure 25. 2012 traffic accident calls. Adapted from "2012 City of St Paul Police Crime Report" St Paul Minnesota, 2012, p. 50. Retrieved from http://www.stpaul.gov/DocumentCenter/View/66068.

This tendency is also confirmed by the data about car accidents in the intersections. The car accidents in intersections within the 1,000 m NB from Housing 3 were highest totaling 412 car accidents among six selected Section 202 housing properties (see Figure 26). Housing 4 and 2 had the second and third highest car accidents in intersections which are located within the two 1,000 m NBs from the housing properties. On the other hand, there were no car accidents in the intersections within the two 1,000 m NBs from Housing 1 and Housing 5. It is more likely that the car accidents in intersections are associated with safety from traffic for pedestrians.

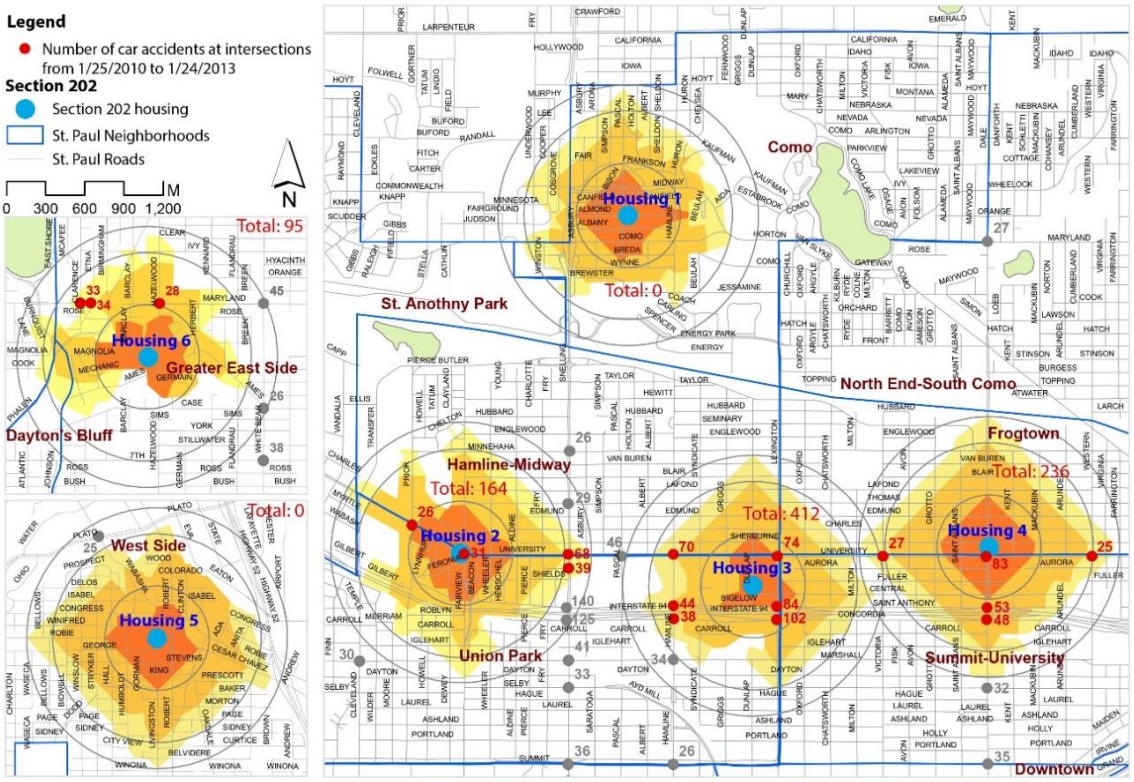

Figure 26. The number of car accidents at intersections from 1/25/2010 to 1/24/2013 in St. Paul. Data sources came from City of St. Paul, Minnesota, 2012.

The most distinctive changes between network buffers and airline buffers are generated in Housing 2 and 3 (see Table 19). There were 164 car accidents within the 1,000 m NB in Housing 2, which have the third highest number of accidents in

intersections, but there were 458 car accidents within the 1,000 m AB in Housing 3, which have the number of the highest accidents among 6 selected neighborhoods. Considering car accidents beyond the 1,000 m NB is important in Housing 2 because there are two intersections with the first and second highest car accidents totaling 140 and 125 within the 1,000 m AB in Housing 2. The car accidents are dramatically increased compared within the 400 m NB and within the 400 m AB totaling 84 and 260. This is because there is the intersection with the third highest car accidents with a total of 102 near Housing 3.

Table 19

The comparison of number of car accidents at intersections within network buffers and airline buffers from 1/25/2010 to 1/24/2013 in St. Paul. Data sources came from City of St. Paul, Minnesota, 2012.

	Housing 1	Housing 2	Housing 3	Housing 4	Housing 5	Housing 6
400 m NB	0	**31**	***84***	83	0	0
800 m NB	0	**57**	**304**	184	0	28
1,000 m NB	0	***164***	**412**	236	0	95
400 m AB	0	**31**	***260***	83	0	0
800 m AB	0	**57**	**412**	184	0	95
1,000 m AB	0	***458***	**446**	236	25	166

Connectivity

Figure 27. The method for counting intersections.

The number of intersections varies according to the airline buffers. To calculate connectivity, three way intersections and four way intersections were included. However,

the L-shaped curved streets were excluded. In addition, one intersection also excluded among two intersections for connectivity if two streets met at two different intersections (see Figure 27). All intersections are numbered by GIS within 400, 800, and 1,000 m ABs. To calculate connectivity, airline buffers were utilized instead of network buffers because the density of intersections should be calculated based on the same areas. The housing with the lowest connectivity within the 400 m AB was Housing 6 which has 11 intersections. On the other hand, Housing 5 has the highest connectivity with 41 intersections within the 400 m AB. Overall, Housing 5 has the highest connectivity and Housing 6 has the lowest connectivity within all buffers (see Table 20).

Table 20

The Number of Intersections within 400, 800, and 1,000 m Airline Buffers. The Number within the Parentheses is the Order of Connectivity among Six Housing Properties.

	Housing 1	Housing 2	Housing 3	Housing 4	Housing 5	Housing 6
400 m AB	29(2)	24(3)	15(5)	22(4)	41(1)	11(6)
800 m AB	90(3)	89(4)	76(5)	97(2)	139(1)	66(6)
1,000 m AB	119(5)	156(2)	127(4)	149(3)	187(1)	113(6)

However, the order of the connectivity changes according to buffers in Housing 1, 2, 3, and 4. For example, Housing 1 has the second highest connectivity within the 400 m AB but it has the second lowest connectivity within the 1,000 m AB. The elderly are likely to walk less distance than younger adults. According to the findings from Nagell and colleagues (2008), the relationship between retail stores and walking time was greatly related within a 5 minute walk (400 m distance) among elders. Thus, it seems like that the connectivity and destinations within a 400 m AB are more important than wider buffers.

Pedestrian Environmental Quality Index (PEQI) Data

To observe the same areas, 400 m airline buffers were used. On the basis of PEQI observation, the walkability scores of individual segments were input in GIS. The scores for intersections and streets are classified into the following: 0 to 20 (environment not suitable for pedestrians); 21 to 40 (poor pedestrian conditions exist); 41 to 60 (basic pedestrian conditions exist); 61 to 80 (reasonable pedestrian conditions exist); and 81 to 100 (ideal pedestrian conditions exist). As seen in Table 21, Housing 2 and 6 have the lowest average scores at intersections, which are between 0 and 20. Near Housing 6, there are no major traffic streets so there are stop signs only at one to two intersections and no crosswalks at all intersections. Near Housing 2, intersections on Fairview Avenue are not safe because there are few stop signs and crosswalks.

Housing 1, 3, 4, 5 have the average scores at the intersections within the 400 m ABs between 21 and 40 which mean poor pedestrian conditions. This means that overall intersections are not safe from traffic to cross streets. In particular, there are a lot of intersections with major traffics which are not safe at intersections. The researcher marked the intersections with red circles (see Figure 28). In these intersections, the residents need to be careful crossing the streets because cars run fast without stopping at the intersections in the neighborhoods near Housing 1, 2, 3, 4, and 5. In particular, a couple of destinations are accessible as crossing the red circular marked intersections near Housing 5. It was perceived as unsafe when the researcher tried to cross the intersections. This means that the number of destinations and the safety perception in the neighborhoods are important for walkable neighborhoods.

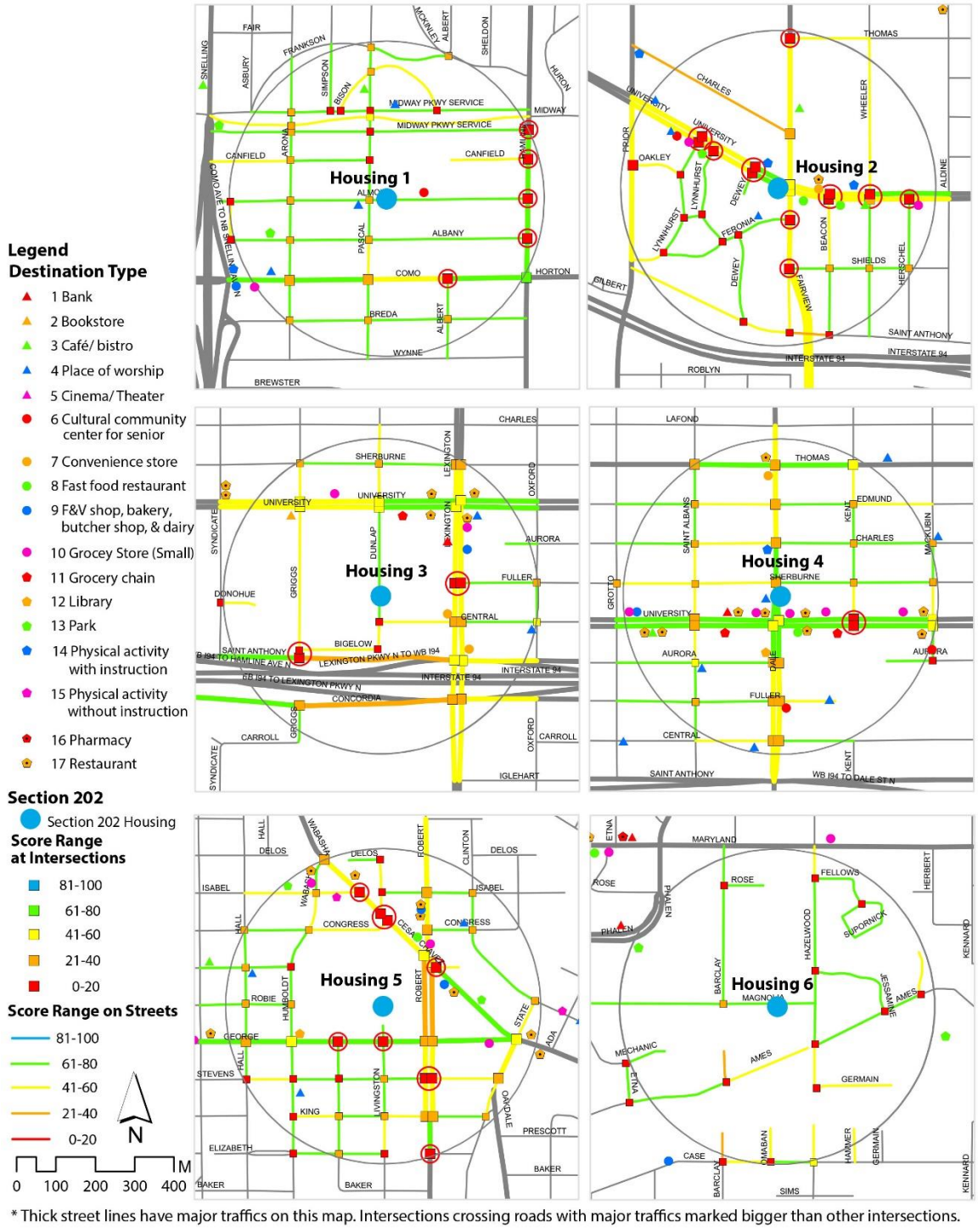

Figure 28. PEQI data and destinations within the 400 m ABs in the selected neighborhoods

Table 21

PEQI data within 400 m Airline Buffers in the Selected Neighborhoods

	Housing 1	Housing 2	Housing 3	Housing 4	Housing 5	Housing 6
Average scores at intersections	25	18	30	34	24	14
Average scores on streets	65	59	55	61	61	58

Table 21 shows the average scores on streets among six selected neighborhoods. Housing 2, 3, and 6 are scored between 41 and 60 which means that the streets have basic pedestrian conditions. Housing 1, 4, and 5 are scored between 61 and 80 which means that the overall streets have reasonable pedestrian conditions. However, the scores are not significantly different in all selected neighborhoods. Surprisingly, neighborhoods with more residential areas have higher scores on the average PEQI scores. It is explained that residential areas have better quality than industrial and retail/commercial areas so it positively influenced the perception of the researcher. However, the differences are not huge because there are fewer destinations in the residential areas. Although Housing 4 has a wide range of a residential area and a great number of destinations (see Figure 20), it is interpreted that the poor quality of housing and abandoned buildings negatively influenced neighborhood walkability. To be more specific, a couple of streets are scored between 41 and 60 in the neighborhood near Housing 4 although overall streets in residential areas are scored between 61and 80 in the other neighborhoods (see Figure 28). The PEQI scores show how the destinations on each street are walkable for the residents. Seen in Figure 28, most of the destinations are located on streets scored more than 61 or pedestrians pass on streets scored 61 or more. However, the elderly residents in Housing 5 have to walk on the street with a score between 21 and 40 to access a couple of destinations. Otherwise, they have to walk further distances on streets with better

environment qualities. According to the researcher's observations, the street segments have very narrow sidewalks under two feet, uneven sidewalk surfaces, and aesthetically unpleasing scenery.

Overall, it was difficult to judge whether a specific neighborhood is walkable or not because a neighborhood has high scores in some fields but low scores in other fields including destinations, public transit, connectivity, the number of vacant buildings, safety from crime, safety form traffic, and PEQI scores. For instance, the neighborhood near Housing 4 is positive in the fields of destinations, public transit, and connectivity for walkability but it is negative in the fields of vacant buildings, and safety from crimes. It was also difficult to judge neighborhood walkability with safety from traffic and PEQI scores. Thus, these scores were input as variables for quantitative analysis to analyze how the scores are associated with walking behaviors and quality of life among low-income older adults.

CHAPTER VI

QUANTITATIVE ANALYSIS AND RESULTS

In this chapter, the results of the quantitative data analysis are presented in two parts. First of all, the results of the descriptive data analysis are presented. Subsequently, the results of bivariate analysis, logistic regression analysis, and multiple regression analysis are illustrated. This study aims to predict the quality of life and walking behaviors among low-income elders living in HUD-subsidized housing. The key components of the empirical model are shown in Figure 9. In addition to the variables from the survey questionnaire, the variables related to objective neighborhood environments were added. The variables include the following: PEQI scores on streets within 400 m ABs; PEQI scores at intersections within 400 m ABs; Part 1 Crimes occurred by police grid; car accident calls by police grid; car accidents at intersections within 400 m NBs; connectivity (the number of intersections) within 400 m ABs; the number of vacant buildings within 400 m NBs; and destinations within 400 m NBs. To simplify the complex variables into the relationship between demographic characteristics, objective neighborhood environments, perceived neighborhood environments, walking behaviors, and quality of life, the individual variables from the survey questionnaire were tied into indices.

Descriptive Data Analysis

The demographic characteristics of the elderly respondents are illustrated in Table 22 and Table 23. The elderly respondents participated from six HUD-subsidized housing properties in St. Paul, MN. The total sample of potential respondents was 156 but only

132 returned survey questionnaires were used for the analysis. The cases with more than eight missing variables or the respondents aged less than 65 years old were dropped in this study (see Table 5).

Exogenous Variables: Demographic Characteristics

Table 22 and Table 23 present the demographic characteristics of respondents including age, race, sex, education, living arrangement, car ownership, self-rated health status, and disability. There are a total of 132 responded survey questionnaires but the responded survey questionnaires are varied by the type of questions answered. The ages of the survey participants are various from 65 to 100 years old, with a standard deviation of 7.981 and a mean age of 74.95 years old. The ages were classified into three groups including 65 to 74 years old, 75 to 85 years old, and 85 years old or over but ages were used as a continuous variable for the regression models. More than half of the respondents, 53.8% were in the group aged in 65 to 74 years old.

With regard to race and ethnicity, almost half of the respondents (60 elders) are White, Non-Hispanic (45.5%). Surprisingly, one tenth of respondents are Native Americans and the percentage is greatly high compared to the percentage of Native Americans among total population (0.7%) in St. Paul, MN (U.S. Census Bureau, 2010). The analysis shows that the majority of residents in one of the housing study sites (Housing 6) are Native Americans and they showed the highest participation rate in this study as 12 out of 21 Native Americans (57.1%) responded. It is likely that they are more interested in walkability in their neighborhood because their neighborhood environments are less walkable.

Table 22

Percentage Distribution of Demographic Characteristics (Part 1)

Characteristics	Category	Frequency	Percent
Age	65 to 74 years	71	53.8
	75 to 84 years	35	26.5
	85 years or over	18	13.6
	Missing	8	6.1
	Total	132	100.0
Race	White	60	45.5
	Black or Asian	36	27.3
	Hispanic, Native American, or two or more races	29	22.0
	Missing	7	5.3
	Total	132	100.0
Sex	Male	28	21.2
	Female	91	68.9
	Missing	13	9.8
	Total	132	100.0
Education	Less than college or other	75	56.8
	Some college or more	54	40.9
	Missing	3	2.3
	Total	132	100.0
Living arrangement	Living alone	117	88.6
	Living with spouse or others	14	10.6
	Missing	1	0.8
	Total	132	100.0
Car ownership	No car	90	68.2
	I own a car	41	31.1
	Missing	1	0.8
	Total	132	100.0
Self-rated health	Very poor	0	0
	Poor	14	10.6
	Average	61	46.2
	Good	49	37.1
	Excellent	6	4.5
	Missing	2	1.5
	Total	132	100.0
Disability	None	37	28.5
	1 to 6	93	70.0
	Missing	2	1.5
	Total	132	100.0

More than two thirds (91 elders; 68.9%) participants are female. More than half (56.8%) of respondents' education levels are high school graduate including General Educational Development (G.E.D.) or less than high school. A total of 40.9% of respondents' education levels were some college, bachelor's degree, or graduate or professional degree. Almost nine tenths of respondents (88.6%) reported that they live

alone in their current housing and one tenth of respondents (10.6%) reported that they live with their spouse or others.

More than two thirds of the elderly respondents (68.2%) marked that they do not own a car. It was reported that no one is in very poor health condition and more than 40% of respondents marked that their health conditions are good or excellent. Less than 30% of respondents have no disabilities including poor balance, reduced mobility, poor vision, hearing loss, using a cane or walker, and using a wheelchair.

Table 23

Percentage Distribution of Demographic Characteristics (Part 2: Detailed Disabilities)

Characteristics	Category	Frequency	Percent
Poor balance	No	89	67.4
	Yes	41	31.1
	Missing	2	1.5
	Total	132	100.0
Reduced mobility	No	92	69.7
	Yes	38	28.8
	Missing	2	1.5
	Total	132	100.0
Poor vision	No	103	78.0
	Yes	27	20.5
	Missing	2	1.5
	Total	132	100.0
Hearing loss	No	97	73.5
	Yes	33	25.0
	Missing	2	1.5
	Total	132	100.0
Use cane or walker	No	70	53.0
	Yes	60	45.5
	Missing	2	1.5
	Total	132	100.0
Use wheelchair	No	120	90.9
	Yes	10	7.6
	Missing	2	1.5
	Total	132	100.0

Endogenous Variables

Perceived neighborhood environments

Table 24

Percentage Distribution of Neighborhood Environments Supporting Accessibility (Part 1)

Characteristics	Category	Frequency	Percent
Places for grocery shopping	Strongly disagree	49	37.1
	Somewhat disagree	12	9.1
	Neither agree nor disagree	10	7.6
	Somewhat agree	11	8.3
	Strongly Agree	48	36.4
	Missing	2	1.5
	Total	132	100.0
Places where I can buy snacks or drinks such as convenience stores or mobile food vendors	Strongly disagree	34	25.8
	Somewhat disagree	12	9.1
	Neither agree nor disagree	20	15.2
	Somewhat agree	15	11.4
	Strongly Agree	50	37.9
	Missing	1	0.8
	Total	132	100.0
Restaurants or coffee shops I like	Strongly disagree	40	30.3
	Somewhat disagree	11	8.3
	Neither agree nor disagree	24	18.2
	Somewhat agree	15	11.4
	Strongly Agree	35	26.5
	Missing	7	5.3
	Total	132	100.0
Retail stores such as clothing, beauty shops and other stores selling what I want	Strongly disagree	65	49.2
	Somewhat disagree	10	7.6
	Neither agree nor disagree	12	9.1
	Somewhat agree	13	9.8
	Strongly Agree	31	23.5
	Missing	1	0.8
	Total	132	100.0
Public institutions such as a post office, police station, or courthouse	Strongly disagree	69	52.3
	Somewhat disagree	15	11.4
	Neither agree nor disagree	19	14.4
	Somewhat agree	14	10.6
	Strongly Agree	12	9.1
	Missing	3	2.3
	Total	132	100.0
Health related facilities such as a hospital, clinic and pharmacy	Strongly disagree	55	41.7
	Somewhat disagree	12	9.1
	Neither agree nor disagree	21	15.9
	Somewhat agree	16	12.1
	Strongly Agree	23	17.4
	Missing	5	3.8
	Total	132	100.0

Table 25

Percentage Distribution of Neighborhood Environments Supporting Accessibility (Part 2)

Characteristics	Category	Frequency	Percent
Preferred recreational facilities such as a museum, auditorium, concert hall, or theater	Strongly disagree	75	56.8
	Somewhat disagree	18	13.6
	Neither agree nor disagree	17	12.9
	Somewhat agree	9	6.8
	Strongly Agree	7	5.3
	Missing	6	4.5
	Total	132	100.0
Natural areas such as a park, river, lake, or forest	Strongly disagree	38	28.8
	Somewhat disagree	15	11.4
	Neither agree nor disagree	22	16.7
	Somewhat agree	21	15.9
	Strongly Agree	30	22.7
	Missing	6	4.5
	Total	132	100.0

Table 24 and Table 25 show the perception of the accessible destinations by respondents. More than 40% of respondents (44.7% or 46.1%) agreed or disagreed that the place for grocery shopping is located within walkable distances as their perceptions but more respondents (almost 50%) perceived that convenient stores or vendors are located within their walkable distances. Almost 40% of the respondents perceived that there are restaurants and coffee shops within walkable distances in the neighborhoods. However, fewer respondents (33%) perceived that there are retail stores such as clothing, beauty shops and other stores selling what the respondents want. Only 20% of respondents agreed or somewhat agreed that public institutions such as a post office, police station, or courthouse are within walkable distances. Only 12% of the respondents perceived that preferred recreational facilities such as a museum, auditorium, concert hall, or theater are the least walkable in their neighborhoods. Of the respondents, 38% marked that it is easy for them to walk from home to natural areas such as a park, river, lake, or forest and 40% of the respondents strongly or somewhat disagreed with this.

Table 26

Percentage Distribution of Neighborhood Environments Supporting Safety from Traffic and Crime

Characteristics	Category	Frequency	Percent
Too much traffic and too many cars passing by too fast	Strongly disagree	25	18.9
	Somewhat disagree	12	9.1
	Neither agree nor disagree	37	28.0
	Somewhat agree	18	13.6
	Strongly agree	35	26.5
	Missing	5	3.8
	Total	132	100.0
Enough crosswalks	Strongly disagree	15	11.4
	Somewhat disagree	9	6.8
	Neither agree nor disagree	27	20.5
	Somewhat agree	28	21.2
	Strongly Agree	53	40.2
	Total	132	100.0
Enough traffic signals at crosswalks or intersections, and enough time to cross the streets	Strongly disagree	21	15.9
	Somewhat disagree	11	8.3
	Neither agree nor disagree	24	18.2
	Somewhat agree	26	19.7
	Strongly Agree	48	36.4
	Missing	2	1.5
	Total	132	100.0
Many barriers preventing walking	Strongly disagree	46	34.8
	Somewhat disagree	13	9.8
	Neither agree nor disagree	28	21.2
	Somewhat agree	20	15.2
	Strongly Agree	20	15.2
	Missing	5	3.8
	Total	132	100.0
Stray dogs, gangs, or strangers	Strongly disagree	52	39.4
	Somewhat disagree	19	14.4
	Neither agree nor disagree	24	18.2
	Somewhat agree	13	9.8
	Strongly Agree	17	12.9
	Missing	7	5.3
	Total	132	100.0
Enough lighting	Strongly disagree	19	14.4
	Somewhat disagree	14	10.6
	Neither agree nor disagree	23	17.4
	Somewhat agree	27	20.5
	Strongly Agree	45	34.1
	Missing	4	3.0
	Total	132	100.0
Safety during the day	Strongly disagree	11	8.3
	Somewhat disagree	9	6.8
	Neither agree nor disagree	20	15.2
	Somewhat agree	28	21.2
	Strongly Agree	58	43.9
	Missing	6	4.5
	Total	132	100.0

As shown in Table 26, 22.7% of the elderly respondents pointed out that there are stray dogs, gangs, or strangers in the neighborhoods where they are living. Among 132 respondents, 54.6% indicated that there is enough lighting in their neighborhoods. Of the total respondents, 65.1% perceived that there are many barriers preventing walking.

Table 27

Percentage Distribution of Neighborhood Environments Supporting Comfort and Convenience

Characteristics	Category	Frequency	Percent
Continuous sidewalks on most of the streets in my neighborhood	Strongly disagree	15	11.4
	Somewhat disagree	8	6.1
	Neither agree nor disagree	15	11.4
	Somewhat agree	26	19.7
	Strongly Agree	63	47.7
	Missing	5	3.8
	Total	132	100.0
Well maintained sidewalks which are paved and level surfaced, and not cracked	Strongly disagree	16	12.1
	Somewhat disagree	23	17.4
	Neither agree nor disagree	17	12.9
	Somewhat agree	30	22.7
	Strongly Agree	42	31.8
	Missing	4	3.0
	Total	132	100.0
Benches and other places to rest along the streets	Strongly disagree	41	31.1
	Somewhat disagree	19	14.4
	Neither agree nor disagree	26	19.7
	Somewhat agree	16	12.1
	Strongly Agree	26	19.7
	Missing	4	3.0
	Total	132	100.0
Enough trees along most of the streets	Strongly disagree	23	17.4
	Somewhat disagree	11	8.3
	Neither agree nor disagree	25	18.9
	Somewhat agree	27	20.5
	Strongly Agree	42	31.8
	Missing	4	3.0
	Total	132	100.0
Public transit stops such as bus or light rail	Strongly disagree	22	16.7
	Somewhat disagree	7	5.3
	Neither agree nor disagree	17	12.9
	Somewhat agree	18	13.6
	Strongly Agree	64	48.5
	Missing	4	3.0
	Total	132	100.0

Table 27 shows the response rates which are associated with neighborhood environments supporting comfort and convenience for walking. Of the respondents, 67.4% pointed out that sidewalks are continuous on most of the streets in their neighborhoods. Among the respondents, 54.5% indicated that there are well-maintained sidewalks which are paved and level surfaced, and not cracked in their neighborhoods. Of the responded older adults, 31.8% perceived that there are benches and other places to rest along the streets. Among the responded seniors, 51.3% indicated that there are enough trees along most of the streets and 62.1% pointed out it is easy to walk from home to public transit stops such as bus or light rail.

Table 28

Percentage Distribution of Neighborhood Environments Supporting Attractiveness

Characteristics	Category	Frequency	Percent
Attractive and well-maintained buildings, homes or gardens	Strongly disagree	18	13.6
	Somewhat disagree	15	11.4
	Neither agree nor disagree	31	23.5
	Somewhat agree	25	18.9
	Strongly Agree	36	27.3
	Missing	7	5.3
	Total	132	100.0
Beautiful natural areas	Strongly disagree	26	19.7
	Somewhat disagree	19	14.4
	Neither agree nor disagree	28	21.2
	Somewhat agree	21	15.9
	Strongly Agree	33	25.0
	Missing	5	3.8
	Total	132	100.0
Abandoned houses, vacant lots, or graffiti on buildings, signs, or walls	Strongly disagree	53	40.2
	Somewhat disagree	27	20.5
	Neither agree nor disagree	28	21.2
	Somewhat agree	3	2.3
	Strongly Agree	15	11.4
	Missing	6	4.5
	Total	132	100.0
Abandoned cars, litter, trash, broken glass, or discarded items	Strongly disagree	67	50.8
	Somewhat disagree	25	18.9
	Neither agree nor disagree	16	12.1
	Somewhat agree	7	5.3
	Strongly Agree	12	9.1
	Missing	5	3.8
	Total	132	100.0

Table 28 indicates the number and rate of respondents supporting the attractiveness in neighborhood environments. Of older adults, 46.2% responded that there are many buildings, homes or gardens which are attractive and well maintained in their neighborhoods. Among the respondents, 40.9% of them perceived that there is much beautiful nature such as flowers, trees, forests, birds and bugs and there are many green spaces including parks, open fields, wooded areas forests greenbelts within their neighborhoods. On the other hand, 13.7% of the respondents pointed out that there are abandoned houses, vacant lots, or graffiti on buildings, signs, or walls in their neighborhoods which are walkable and 14.4% of the respondents perceived that there are abandoned cars, litter, trash, broken glass, or discarded items and the evidence of drug-related usage.

Walking in winter and summer

Table 29

Percentage Description of Walking in Winter and Summer

Characteristics	Category	Frequency	Percent
Walking days per week in winter	I do not walk or I cannot walk	56	42.4
	1day	14	10.6
	2days	14	10.6
	3days	6	4.5
	4days	4	3.0
	5days	14	10.6
	6days	5	3.8
Mean=2.08	7days	12	9.1
	Missing	7	5.3
	Total	132	100.0
Walking days per week in summer	I do not walk or I cannot walk	32	24.2
	1 day	11	8.3
	2 days	10	7.6
	3 days	14	10.6
	4 days	6	4.5
	5 days	12	9.1
	6 days	8	6.1
	7 days	28	21.2
Mean=3.31	Missing	11	8.3
	Total	132	100.0

As seen in Table 29, 42.4% of the respondents indicated that they had not walked more than 10 minutes in the past seven days with a mean of 2.08. This question was answered in winter season in Minnesota because the survey questionnaires were collected between March and early May. The walking days are evenly distributed from one to seven days for the rest of the respondents. Of the respondents, 24.2% pointed out that they did not walk more than 10 minutes a week in summer and the number of the respondents walking for 7 days have increased from 12 to 28. The mean of walking days in summer is 3.31.

To know whether walking days in winter and summer are the same, paired sample t-test was performed. As shown in Table 30 and Table 31, mean in walking days in summer (3.3123) is higher than mean in walking days in winter (2.0816) at the level of .000. Thus, both of walking days in winter and summer were used in regression models.

Table 30

Mean and Standard Deviation for Walking Days in Winter and Summer

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Walking days in winter	2.0816	132	2.41687	.21036
	Walking days in summer	3.3123	132	2.62703	.22865

Table 31

Paired T-Test Result for Walking Days in Winter and Summer

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Walking days in winter – Walking days in summer)	-1.23071	2.13619	.18593	-1.59853	-.86289	-6.619	131	.000

Dependent variable: Quality of life

Table 32 shows the percentage of quality of life. According to the table, 75.0% of the respondents indicated that their quality of life is good or very good and only 4.5% indicated that their quality of life is poor or very poor with a mean of 3.9.

Table 32

Percentage Description of Quality of Life

Characteristics	Category	Frequency	Percent
Quality of life	Very poor	2	1.5
	Poor	4	3.0
	Neither poor nor good	20	15.2
	Good	76	57.6
	Very good	23	17.4
	Missing	7	5.3
Mean=3.9	Total	132	100.0

Statistical Analysis

Mean Differences between Quality of Life, Walking in Winter and Summer by Housing Location

It was hypothesized that quality of life, walking days in winter, and walking days in summer are different by the locations of housing sites. Table 33 shows the mean differences in quality of life, waking days in winter, and walking days in summer by housing locations. Table 34 shows the test of homogeneity of variances for quality of life, walking days in winter, and walking days in summer. All p-values are higher than 0.5 (0. 904 for quality of life, 0.772 for walking days in winter, and 0.054 for walking days in summer) so the researcher was able to conclude, contrary to Hypothesis 1, that the variances among six housing groups for quality of life and walking days in winter are the same.

Table 33

Mean and Standard Deviation for Quality of Life and Walking Days in Winter and Summer

			Quality of life		Walking days in winter		Walking days in summer	
		N	Mean	SD	Mean	SD	Mean	SD
Housing	1	23	4.0000	.85280	1.9565	2.36409	4.1124	2.34240
	2	17	3.8184	.63476	2.2417	2.58625	4.1937	3.08081
	3	22	4.1244	.77714	1.8835	2.39791	2.3847	2.32071
	4	24	3.7917	.65801	1.8008	2.26573	2.0661	2.20905
	5	25	3.7530	.82890	2.4400	2.39931	3.8117	2.59498
	6	21	3.9958	.77483	2.1905	2.74989	3.5238	2.76801
	Total	132	3.9120	.76184	2.0816	2.41687	3.3123	2.62703

Table 34

Test of homogeneity of variances for quality of life and walking days in winter and summer

	Levene Statistic	df1	df2	Sig.
Quality of life	.314	5	126	.904
Walking days in winter	.504	5	126	.772
Walking days in summer	2.239	5	126	.054

Table 35

Results of the ANOVA Analysis of Older Adults' Quality of Life, Walking Days in Winter and Summer by Housing Locations

		Sum of Squares	df	Mean Square	F	Sig.
Quality of life	Between Groups	2.447	5	.489	.838	.525
	Within Groups	73.585	126	.584		
	Total	76.032	131			
Walking days in winter	Between Groups	7.012	5	1.402	.233	.947
	Within Groups	758.194	126	6.017		
	Total	765.206	131			
Walking days in summer	Between Groups	91.310	5	18.262	2.831	.019
	Within Groups	812.761	126	6.450		
	Total	904.071	131			

However, the result of walking days in summer was different. According to ANOVA test in Table 35, there is no difference between groups for quality of life and walking days in winter because of the p-value is higher than .05 as .525 for quality of life and .947 for walking days in winter. However, at least, one group is different from other

groups for walking days in summer at the level of .019. To confirm which group is different from other groups, a post hoc test was performed with Scheffé method. However, there is the only subset group is generated with Scheffé method (see Table 36 and Appendix A). This result does not match ANOVA test. Thus, the researcher cannot conclude that the mean of at least one group is statistically different from the mean of the other groups. However, if the housing locations are combined into three groups, the mean difference in walking days in summer is clear. On the basis of the order in Table 36, two groups are combined into three groups: Group 1 (Housing 1 and Housing 2), Group 2 (Housing 3 and Housing 4), and Group 3 (Housing 5 and Housing 6). After making three groups, ANOVA test was performed.

Table 36

Homogeneous Subsets for Walking Days in Summer

Scheffe[a,,b]

		Subset for alpha = 0.05
Housing ID	N	1
4	24	2.0661
3	22	2.3847
6	21	3.5238
5	25	3.8117
1	23	4.1124
2	17	4.1937
Sig.		.188

Note. Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 21.657.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 37

ANOVA for Walking Days in Summer for Combined Groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	89.134	2	44.567	7.055	.001
Within Groups	814.937	129	6.317		
Total	904.071	131			

As shown in Table 37, the mean in at least one group is statistically different at the level of .01. According to post hoc test with Scheffé, the mean in Group 2 is different from Group 1 and Group 3 (see Table 38). The mean of Group 2 was 2.22 with 2.24 SD. The means of Group 1 and Group 3 were 4.15 (2.64 SD) and 3.68 (2.65). The mean in Group 1 and Group 2 was not statistically different.

Table 38

Multiple Comparisons of Walking Days in Summer for Combined Groups

(I) Recode Housing	(J) Recode Housing	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Lower Bound
Group 1	Group 2	1.92850*	.54338	.002	.5828	.5828
	Group 3	.46668	.54338	.692	-.8790	-.8790
Group 2	Group 1	-1.92850*	.54338	.002	-3.2742	-3.2742
	Group 3	-1.46182*	.52409	.023	-2.7597	-2.7597
Group 3	Group 1	-.46668	.54338	.692	-1.8123	-1.8123
	Group 2	1.46182*	.52409	.023	.1640	.1640

Note. The mean difference is significant at the 0.05 level./ Scheffe

Findings from Principal Component Analysis

A Principal Component Analysis (PCA) was performed to decrease the number of variables for the perceived neighborhood environments. The factor analysis was performed after dividing two parts such as perceived accessibility (destinations) and perceived neighborhood environments (safety, comfort and convenience, and attractiveness). The factor analysis for perceived accessibility included eight variables and the analysis for perceived neighborhood environments included 15 variables.

Table 39

KMO and Bartlett's Test for Accessibility (Destinations)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.839
Bartlett's Test of Sphericity	Approx. Chi-Square	428.693
	df	28
	Sig.	.000

From the analysis, two components were extracted from accessibility. The KMO and Bartlett's test result for the variables for perceived accessibility showed 0.839 and the p-value was smaller than 0.01 (p=.000). Two generated factors for perceived accessibility explained 67.26% of the total variances. Moreover, there was no factor with a value less than 0.4. Therefore, all variables in each factor were considered appropriate (see Table 39 and Table 40).

Table 40

Pattern Matrix[a] for Accessibility (Destinations and Public Transit Stops)

	In my neighborhood,	Component	
		1	2
Utilitarian destinations	1. It is easy for me to walk from home to places where I can buy snacks or drinks such as convenience stores or mobile food vendors.	.935	
	2. It is easy for me to walk from home to places for grocery shopping.	.914	
	3. It is easy for me to walk from home to restaurants or coffee shops I like.	.812	
	4. It is easy for me to walk from home to retail stores such as clothing, beauty shops and other stores selling what I want.	.693	
	5. It is easy for me to walk from home to health related facilities such as a hospital, clinic and pharmacy.	.530	
Recreational destinations	6. It is easy for me to walk from home to natural areas such as a park, river, lake, or forest.		.923
	7. It is easy for me to walk from home to preferred recreational facilities such as a museum, auditorium, concert hall, or theater.		.717
	8. It is easy for me to walk from home to public institutions such as a post office, police station, or courthouse.		.607

Note. Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
Suppress small coefficients under 0.4
a. Rotation converged in 3 iterations.

From the analysis, four components were extracted from safety, comfort and convenience, and attractiveness. The KMO and Bartlett's test result for the variables for these analysis showed 0.740 and the p-value was smaller than 0.01 (p=.000). Four generated factors for safety, comfort and convenience, and attractiveness explained 59.55% of the total variances. Moreover, there was no factor with a value less than 0.35. Therefore, all variables in each factor were considered appropriate (see Table 41 and Table 42).

Table 41

KMO and Bartlett's Test for Safety, Comfort and Convenience, and Attractiveness

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.740
Bartlett's Test of Sphericity	Approx. Chi-Square	517.962
	df	105
	Sig.	.000

Table 42

Pattern Matrix[a] for Safety, Comfort and Convenience, and Attractiveness

		Component			
		1	2	3	4
Safety & Comfort and convenience	1. There are enough traffic signals at crosswalks or intersections, and enough time for me to cross streets.	.858			
	2. There are enough crosswalks.	.725			
	3. Public transit stops such as bus or light rail.	.682			
	4. The sidewalks are well maintained (e.g., paved, even, and not a lot of cracks).	.653			
	5. There are continuous sidewalks on most of the streets in my neighborhood.	.583			
	6. There is enough lighting.	.582			
Attractiveness & safety	7. There is much beautiful nature (e.g., flowers, trees, forests, birds and bugs) and there are lots of green spaces (e.g., parks, open fields, wooded areas forests greenbelts).		.929		
	8. There are benches and other places to rest along the streets.		.771		
	9. There are many buildings, homes or gardens which are attractive and well maintained.		.650		
	10. It is safe to walk during the day.		.392		
Unsafety	11. There is too much traffic and there are too many cars passing by too fast.			.865	
	12. There are stray dogs, gangs, or strangers.			.715	
	13. There are many barriers preventing walking.			.629	
Unattractiveness	14. There are many abandoned houses, vacant lots, or graffiti on buildings, signs, or walls.				.852
	15. There are abandoned cars, litter, trash, broken glass, or discarded items and the evidence of drug-related usage.				.829

Note. Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
Suppress small coefficients under 0.35
a. Rotation converged in 6 iterations.

Differences of Perceived Neighborhood Environments by Housing Locations

It was hypothesized that the older adults' perception on their neighborhood environments are different on the basis of housing locations. ANOVA was tested on the basis of six housing locations with PCA results but the post hoc test did not match

ANOVA test result. Thus, the housing locations categorized into Group1 (Housing 1 and Housing 2), Group2 (Housing 3 and Housing 4), and Group 3 (Housing 5 and Housing 6) with the same categories with walking days in summer. The variances in Group 1, Group 2, and Group 3 are same for each category with higher p-value than .05.

Table 43

ANOVA for Perceived Neighborhood Environments

		Sum of Squares	df	Mean Square	F	Sig.
Comfort and convenience	Between Groups	6.819	2	3.409	3.542	.032
	Within Groups	124.181	129	.963		
	Total	131.000	131			
Attractiveness	Between Groups	13.289	2	6.644	7.282	.001
	Within Groups	117.711	129	.912		
	Total	131.000	131			
Unsafety	Between Groups	10.693	2	5.347	5.733	.004
	Within Groups	120.307	129	.933		
	Total	131.000	131			
Unattractiveness	Between Groups	1.625	2	.813	.810	.447
	Within Groups	129.375	129	1.003		
	Total	131.000	131			
Utilitarian destinations	Between Groups	17.690	2	8.845	10.070	.000
	Within Groups	113.310	129	.878		
	Total	131.000	131			
Recreational destinations	Between Groups	1.050	2	.525	.521	.595
	Within Groups	129.950	129	1.007		
	Total	131.000	131			

As shown in Table 43, there are group differences in categories. The respondents' perception on comfort and convenience was significantly different on the basis of housing groups at the level of .05. Group 3 showed lower mean scores compared to Group 1. The respondents' perceptions on attractiveness, unsafety, and utilitarian destinations were significantly different on the basis of housing groups at the level of .01. In regard to attractiveness, the mean score of Group 2 is significantly lower than Group 1 and Group 3. In respect to unsafety, the mean score of Group 2 is statistically lower than

Group 1. This means that responded older adults in Housing 3 and Housing 4 perceived that their neighborhood is less safe than the older adults in Housing 1 and Housing 2. The respondents perceived utilitarian destinations on the basis of their housing locations. The respondents in Group 2 perceived that utilitarian destinations are more accessible compared to the respondents in Group 1 and Group 3.

The Relationship between Walking, Demographic Characteristics, Objective and Perceived Neighborhood Environments.

Selection of walking or non-walking in winter and summer. In these models, dependent variables are a choice to walk in winter or summer. It was hypothesized that objective neighborhood environments, demographic characteristics, and perceived neighborhood environments are directly associated with the selection of walking in winter or summer. For this study, the logistic regression analysis was performed and the results about the selection of walking in winter or summer on objective neighborhood environments, demographic characteristics such as self-rated health and disabilities, and perceived neighborhood environments were reported in Table 44.

All cases used in this analysis were 132. Among 132 respondents, 76 selected walking and 56 selected non-walking in winter and 100 chose walking and 32 chose not to walk in summer. In the model for walking in winter, chi-square is 50.584 and p-value is less than 0.5 so there is at least one meaningful variable in the model. In the model for winter, self-rated health status (p-value, .017) and unattractiveness (p-value, .002) are significantly associated with walking. Unattractiveness is negatively associated with walking in winter but self-rated health is positively associated with walking in winter.

Table 44

Logistic Analysis for Non-Walking and Walking Days in Winter and Summer

		Winter				Summer			
		B	Wald	Sig.	Exp(B)	B	Wald	Sig.	Exp(B)
Objective neighborhood environments									
Step 1[a]	PEQI scores	-2.955	3.625	.057	***.052***	-2.412	1.602	.206	.090
	PEQI scores at intersections	-.199	1.291	.256	.820	-.192	.803	.370	.826
	Crime	.059	3.260	.071	***1.061***	.035	.786	.375	1.035
	Traffic Accident Calls	-15.731	3.382	.066	***.000***	-12.955	1.549	.213	.000
	Traffic accidents at intersections within 400 m network buffers	.317	2.987	.084	***1.373***	.270	1.476	.224	1.310
	Connectivity within 400 m airline buffers	omitted	omitted	omitted	omitted	omitted	omitted	omitted	omitted
	Vacant buildings within 400 m network buffers	omitted	omitted	omitted	omitted	omitted	omitted	omitted	omitted
	Destinations within 400 m network buffers	omitted	omitted	omitted	omitted	omitted	omitted	omitted	omitted
Demographic Characteristics									
	Age	-.004	.013	.908	.996	-.010	.053	.817	.990
	Race, White	omitted	.244	.885	omitted	omitted	2.993	.224	omitted
	Race, Black or Asian	-.391	.194	.660	.676	-1.700	2.576	.108	.183
	Race, Others	-.073	.007	.935	.930	-.360	.122	.727	.698
	Sex, Male	omitted	1.917	.383	omitted	omitted	1.212	.545	omitted
	Sex, Female	-.961	.773	.379	.382	1.014	.749	.387	2.755
	Sex, Missing	-1.235	1.773	.183	.291	.232	.053	.819	1.261
	Education, Less than college	omitted	1.352	.509	omitted	omitted	.646	.724	omitted
	Education, Some college or more	29.875	.000	1.000	.000	-27.098	.000	1.000	.000
	Education, Missing	-29.295	.000	1.000	.000	-26.622	.000	1.000	.000
	Living alone	omitted	2.032	.362	omitted	omitted	.000	1.000	omitted
	Living with spouse or others	.982	.000	1.000	2.670	-2.288	.000	1.000	.101
	Living with, Missing	2.421	.000	1.000	11.260	28.822	.000	1.000	3.290E12
	Car ownership, No	omitted	4.586	.101	omitted	omitted	.249	.883	omitted
	Car ownership, Yes	.466	.000	1.000	1.593	29.678	.000	1.000	7.745E12
	Car ownership, Missing	-.736	.000	1.000	.479	29.353	.000	1.000	5.593E12
	Self-reported health	.867	5.737	.017	**2.379**	.459	1.161	.281	1.582
	Disability, No	omitted	omitted	omitted	omitted	omitted	omitted	omitted	omitted
	Disability, Yes	.350	.370	.543	1.419	.845	1.367	.242	2.327
Perceived neighborhood environments									
	Comfort and convenience	.102	.105	.746	1.108	-.481	1.664	.197	.618
	Attractiveness	.350	1.612	.204	1.419	.983	9.052	.003	**2.674**
	Unsafety	-.314	1.410	.235	.730	-.211	.492	.483	.810
	Unattractiveness	-.878	9.960	.002	**.416**	-.548	3.612	.057	***.578***
	Utilitarian destination	.391	1.364	.243	1.479	.083	.052	.820	1.087
	Recreational destination	.186	.423	.516	1.204	.228	.480	.489	1.256
	Constant	253.239	.000	1.000	9.558E109	187.518	.000	1.000	2.741E81
		-2 Log likelihood:129.365 Chi-square:50.584 P=.001				-2 Log likelihood: 99.976 Chi-square: 46.242 P=.004			

Note. Variable(s) entered on step 1: Comfort and convenience, Attractiveness, Unsafety, Unattractiveness, Utilitarian destinations, Recreational destinations.

In the model for summer, -2 Log likelihood is 99.976, Chi-square is 46.242, and p-value is 0.004. There is a statistically significant variable for walking in summer such as attractiveness in the neighborhoods. In the model for winter, there are four objective neighborhood variables, as p-vale less than .1, which are potentially associated with choosing to walk in winter. Those include PEQI scores, Part 1 Crimes, traffic accident calls, and traffic accidents at intersections within 400 m NBs. Surprisingly, PEQI scores are negatively associated with choosing walking in winter. It is interpreted that the neighborhoods with high PEQI scores have fewer destinations to walk. Moreover, the older adults tend to choose walking in winter in the neighborhoods with more traffic accidents at intersections within 400 m NBs. It is interpreted that there are more destinations to walk in the neighborhood with high volumes of traffic and traffic accidents.

Walking behaviors with walking respondents in winter or summer. After performing the logistic regression model to know the variables related to the selection of walking or non-walking in winter or summer, multiple linear regression models were performed with the cases which selected walking in winter or summer. A total of 76 cases for walking days in winter and 100 cases for walking days in summer were used in these analyses (see Table 46 and Table 48). For these analyses, stepwise methods were used. For the model examining walking days in a week in winter, living alone explained 8.0% of variability with a p-value of .013. Living alone and self-rated health status also explained 16.3% of variability with a p-value of .009 (see Table 45 and Table 46). According to Table 46, the variable, living alone was negatively associated with walking

behaviors in winter. Self-rated health status was positively associated with walking days for the respondents who walk at least more than one day a week in winter.

Table 45

Model Summary[c] of Walking Days in Winter

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.283[a]	.080	.068	2.06732	.080	6.438	1	74	.013
2	.404[b]	.163	.140	1.98529	.083	7.242	1	73	.009

Note. a. Predictors: (Constant), Living arrangement (Living alone)
b. Predictors: (Constant), Living alone, Self-rated health
c. Dependent Variable: Walking days in the last week in winter (Walking only)

Table 46

Coefficients[a] of Walking Days in Winter

Model (76 cases)		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1 [b]	(Constant)	4.940	.573		8.616	.000		
	Living alone	-1.598	.630	-.283	-2.537	.013	1.000	1.000
2 [c]	(Constant)	1.864	1.269		1.469	.146		
	Living alone	-1.628	.605	-.288	-2.692	.009	1.000	1.000
	Self-reported health	.881	.328	.288	2.691	.009	1.000	1.000

Note. a. Dependent Variable: Walking days in the last week in winter (Walking only)
b. Excluded variables: Objective neighborhood environments (PEQI scores, PEQI scores at intersection, crime, accident call number, traffic accidents at intersections within 400 m network buffers connectivity within 400 m airline buffers, vacant buildings within 400 m network buffers, and destinations within 400 m network buffers), demographic characteristics (age, sex, race, education, car ownership, self-reported health, and disability) and perceived neighborhood characteristics (comfort and convenience, attractiveness, unsafety, unattractiveness, utilitarian destinations, and recreational destinations)
c. Self-rated health status was added from b.

A total of 76 cases for walking days in winter and 100 cases for walking days in summer were used in these analyses (see Table 46 and Table 48). For these analyses, stepwise methods were used. For the model examining walking days in a week in winter, living alone explained 8.0% of variability with a p-value of .013. Living alone and self-rated health status also explained 16.3% of variability with a p-value of .009 (see Table 45 and Table 46). According to Table 46, the variable, living alone was negatively

associated with walking behaviors in winter. Self-rated health status was positively associated with walking days for the respondents who walk at least more than one day a week in winter.

Table 47

Model Summary[d] of Walking Days in Summer

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.228[a]	.052	.042	2.06478	.052	5.358	1	98	.023
2	.301[b]	.090	.072	2.03274	.039	4.114	1	97	.045
3	.367[c]	.135	.107	1.99312	.044	4.894	1	96	.029

Note. a. Predictors: (Constant), Traffic accidents at intersections within 400 m network buffers
b. Predictors: (Constant), Traffic accidents at intersections within 400 m network buffers, Self-rated health status
c. Predictors: (Constant), Traffic accidents at intersections within 400 m network buffers, Self-rated health status, Utilitarian destinations
d. Dependent Variable: Walking days in a week in summer (Walking Only)

Table 48

Coefficients[a] of Walking Days in Summer

Model (100 cases)		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1[b]	(Constant)	4.745	.262		18.122	.000		
	Traffic accidents at intersections within 400 m NBs	-.013	.006	-.228	-2.315	.023	1.000	1.000
2[c]	(Constant)	2.752	1.016		2.710	.008		
	Traffic accidents at intersections within 400 m NBs	-.012	.006	-.210	-2.163	.033	.992	1.008
	Self-rated health	.575	.283	.197	2.028	.045	.992	1.008
3[d]	(Constant)	3.160	1.013		3.120	.002		
	Traffic accidents at intersections within 400 m NBs	-.017	.006	-.303	-2.911	.004	.831	1.204
	Self-rated health	.497	.280	.170	1.774	.079	.977	1.024
	Utilitarian destinations	.494	.223	.230	2.212	.029	.832	1.202

Note. a. Dependent Variable: Walking days in a week in summer (Walking only)
b. Excluded variables: Objective neighborhood environments (PEQI scores, PEQI scores at intersection, crime, accident call number, connectivity within 400 m airline buffers, vacant buildings within 400 m network buffers, and destinations within 400 m network buffers), demographic characteristics (age, sex, race, education, living arrangement, car ownership, self-rated health, and disability) and perceived neighborhood characteristics (comfort and convenience, attractiveness, unsafety, unattractiveness, utilitarian destinations, and recreational destinations)
c. Self-rated health status was added from b.
d. Self-rated health status and utilitarian destinations were added from b.

For the model in walking days in a week in summer, traffic accidents at intersections within 400 m NBs explained 5.2% of variability in the p-value of .023 and traffic accidents at intersections within 400 m NBs and self-rated health status explained 7.2% of variability in p-value of .045. Moreover, traffic accidents at intersections within 400 m NBs, self-rated health status, utilitarian destinations explained 13.5% of variance with a p-value of .029 (see Table 47 and Table 48). According to Table 48, traffic accidents at intersections within 400 m NBs were negatively associated. Self-rated health status and utilitarian destinations are positively associated with walking days for the respondents who walk at least more than one day a week in summer. These showed the statistical significance at the level of .01 (traffic accidents at intersection within 400 m NBs), .10 (self-rated health status), and .05 (utilitarian destinations). Self-rated health is a significant variable predicting walking behaviors in winter and summer. However, self-rated health functioned as a less significant variable in summer at the statistically significant level of 0.10 if the variable was simultaneously entered with the variables such as traffic accidents at intersections within 400 m NBs and utilitarian destinations. Therefore, it is interpreted that older adults tend to walk more if their neighborhood environments are safe from traffic and there are a lot of perceived utilitarian destinations regardless of their health status.

Quality of Life: The Relationship between Quality of Life, Walking, Demographic Characteristics, Objective and Perceived Neighborhood Environments.

The dependent variable in this multiple linear regression model was quality of life. It was hypothesized that quality of life is associated with demographic characteristics, objective and perceived neighborhood environments and walking in winter or summer.

For these analyses, stepwise methods were used to enter variables. Two different models were developed to evaluate how walking days in winter or summer are differently related to quality of life. On the basis of this regression analysis, there is no difference between walking days in winter and walking days in summer influencing on quality of life because the only influential variable for quality of life was self-rated health.

Table 49

Model Summary[b] for Quality of Life

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.438[a]	.192	.186	.68737	.192	30.924	1	130	.000

Note. a. Predictors: (Constant), Self-rated health
b. Dependent Variable: Quality of life

Table 50

Coefficients[a] for Quality of Life

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.376	.283		8.410	.000		
	Self-rated health	.457	.082	.438	5.561	.000	1.000	1.000

Note. a. Dependent Variable: Quality of life

Table 49 showed that F-test result is statistically significant at the level of .001 so self-rated health status explained quality of life in 19.2% of the variances with F value of 30.924. The standardized correlation coefficient is .438 at the level of .001(see Table 50). There are no other variables related to quality of life except for self-rated health status so multicollinearity is not considered in this model.

Bivariate Analysis: The Correlations between Quality of Life, Walking Days in Winter and Summer, and Objective Neighborhood Environments.

Table 51

Correlations between Quality of Life, Walking Days in Winter, Walking Days in Summer, and Objective Neighborhood Environments.

		QOL	WD in winter	WD in summer	PEQI scores	PEQI scores at ITS	Crime	TA calls	TA at ITS within 400 m NB	Connectivity within 400 m AB	VB within 400 m NB	Des within 400 m NB
Quality of life	Pearson Correlation	1	**.210***	.080	-.071	-.010	-.016	.048	.027	-.116	-.080	-.115
	Sig.		**.016**	.364	420	.907	.855	.582	.758	.184	.364	.187
Walking days in winter	Pearson Correlation		1	**.644****	.002	-.064	-.031	-.045	-.069	.051	-.054	-.032
	Sig.			**.000**	.979	.466	.720	.612	.430	.565	.537	.713
Walking days in summer	Pearson Correlation			1	.142	**-.233****	**-.273****	**-.264****	**-.283****	.142	**-.212***	-.141
	Sig.				.104	**.007**	**.002**	**.002**	**.001**	.105	**.015**	.107
PEQI scores	Pearson Correlation				1	.080	**-.557****	**-.835****	**-.486****	**.606****	.091	**.181***
	Sig.					.359	**.000**	**.000**	**.000**	**.000**	.300	**.038**
PEQI scores at intersections	Pearson Correlation					1	**.364****	**.397****	**.747****	.132	**.668****	**.591****
	Sig.						**.000**	**.000**	**.000**	.131	**.000**	**.000**
Crime	Pearson Correlation						1	**.790****	**.658****	**-.472****	**.587****	**.384****
	Sig.							**.000**	**.000**	**.000**	**.000**	**.000**
TA calls	Pearson Correlation							1	**.872****	**-.631****	**.430****	**.278****
	Sig.								**.000**	**.000**	**.000**	**.001**
TA at ITS within 400 m NB	Pearson Correlation								1	**-.422****	**.701****	**.575****
	Sig.									**.000**	**.000**	**.000**
Connectivity within 400 m AB	Pearson Correlation									1	-.090	.166
	Sig.										.303	.056
VB within 400 m NB	Pearson Correlation										1	**.938****
	Sig.											**.000**
Des within 400 m NB	Pearson Correlation											1
	Sig.											

Note. *. Correlation is significant at the 0.05 level (2-tailed). / **. Correlation is significant at the 0.01 level (2-tailed). N=132

Table 52

Correlations between Quality of Life (QOL), Walking Days (WD) in Winter and Summer, and Perceived Neighborhood Environments (Destinations)

		QOL	WD in Winter	WD in Summer	1	2	3	4	5	6	7	8
QOL	Pearson Correlation	1	**.210***	.080	**.209***	.118	-.027	.077	.072	.033	.014	.049
	Sig.		**.016**	.364	**.016**	.178	.759	.379	.412	.710	.876	.578
WD in winter	Pearson Correlation		1	**.644****	**.228****	**.239****	**.202***	**.179***	**.211***	**.241****	.132	.138
	Sig.			**.000**	**.009**	**.006**	**.020**	**.040**	**.015**	**.005**	.131	.115
WD in summer	Pearson Correlation			1	.149	.068	.137	.110	.051	**.340****	.056	.125
	Sig.				.089	.441	.118	.209	.560	**.000**	.526	.152
1	Pearson Correlation				1	**.714****	**.626****	**.569****	**.484****	.098	**.281****	**.446****
	Sig.					**.000**	**.000**	**.000**	**.000**	.265	**.001**	**.000**
2	Pearson Correlation					1	**.546****	**.559****	**.572****	.080	**.325****	**.385****
	Sig.						**.000**	**.000**	**.000**	.361	**.000**	**.000**
3	Pearson Correlation						1	**.607****	**.479****	.137	**.351****	**.419****
	Sig.							**.000**	**.000**	.118	**.000**	**.000**
4	Pearson Correlation							1	**.544****	**.194***	**.427****	**.678****
	Sig.								**.000**	**.026**	**.000**	**.000**
5	Pearson Correlation								1	**.285****	**.493****	**.536****
	Sig.									**.001**	**.000**	**.000**
6	Pearson Correlation									1	**.347****	**.357****
	Sig.										**.000**	**.000**
7	Pearson Correlation										1	**.537****
	Sig.											**.000**
8	Pearson Correlation											1
	Sig.											

Note. *. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
N=132

1. It is easy for me to walk from home to places where I can buy snacks or drinks such as convenience stores or mobile food vendors in my neighborhood.
2. It is easy for me to walk from home to places for grocery shopping in my neighborhood.
3. It is easy for me to walk from home to restaurants or coffee shops I like in my neighborhood.
4. It is easy for me to walk from home to retail stores such as clothing, beauty shops and other stores selling what I want in my neighborhood.
5. It is easy for me to walk from home to health related facilities such as a hospital, clinic and pharmacy in my neighborhood.
6. It is easy for me to walk from home to natural areas such as a park, river, lake, or forest in my neighborhood.
7. It is easy for me to walk from home to preferred recreational facilities such as a museum, auditorium, concert hall, or theater in my neighborhood.
8. It is easy for me to walk from home to public institutions such as a post office, police station, or courthouse in my neighborhood.

Table 53

Correlations between Quality of Life, Walking Days in Winter and Summer, and Perceived Neighborhood Environments (Safety from Traffic and Crime, Attractiveness, and Comfort and Convenience)

		QOL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
QOL	Pearson Correlation	1	**.210***	.080	.075	**.186***	-.016	.081	.130	.050	.039	.051	.066	.026	-.123	-.077	-.063	**-.195***	-.101
	Sig.		**.016**	.364	.390	**.033**	.857	.354	.139	.572	.654	.558	.453	.770	.161	.377	.476	**.025**	.251
1	Pearson Correlation		1	**.644****	.102	.116	***.162***	-.001	.126	.140	.132	.023	.127	**.325****	-.013	-.049	.021	**-.198***	-.063
	Sig.			**.000**	.244	.185	***.063***	.991	.149	.110	.131	.794	.147	**.000**	.884	.581	.815	**.023**	.473
2	Pearson Correlation			1	.050	***.145***	.057	-.003	***.146***	.011	**.363****	.116	**.195***	**.355****	-.082	-.108	-.077	**-.200***	-.067
	Sig.				.567	***.097***	.516	.975	***.094***	.902	**.000**	.184	**.025**	**.000**	.351	.218	.378	**.022**	.448
3	Pearson Correlation				1	**.481****	**.393****	**.527****	**.378****	**.403****	.108	**.320****	**.191***	**.364****	**.253****	.017	-.008	-.108	-.045
	Sig.					**.000**	**.000**	**.000**	**.000**	**.000**	.216	**.000**	**.028**	**.000**	**.003**	.843	.929	.217	.611
4	Pearson Correlation					1	**.310****	**.401****	**.419****	**.318****	**.208***	**.188***	**.356****	**.338****	-.002	-.080	-.122	***-.159***	-.114
	Sig.						**.000**	**.000**	**.000**	**.000**	**.017**	**.031**	**.000**	**.000**	.985	.361	.163	***.069***	.192
5	Pearson Correlation						1	**.215***	**.301****	**.322****	.081	.053	.086	**.271****	***.161***	.007	.020	-.130	-.127
	Sig.							**.013**	**.000**	**.000**	.358	.545	.329	**.002**	***.065***	.938	.818	.138	.147
6	Pearson Correlation							1	**.306****	.140	**.240****	**.356****	**.204***	**.296****	.019	-.023	-.078	.070	.000
	Sig.								**.000**	.110	**.006**	**.000**	**.019**	**.001**	.825	.795	.371	.423	.997
7	Pearson Correlation								1	**.343****	**.218***	**.221***	**.268****	**.410****	.060	-.108	-.095	***-.171***	**-.229****
	Sig.									**.000**	**.012**	**.011**	**.002**	**.000**	.497	.219	.279	***.050***	**.008**
8	Pearson Correlation									1	***.164***	**.270****	**.245****	**.171***	.094	-.079	-.039	-.084	-.010
	Sig.										***.060***	**.002**	**.005**	**.050**	.283	.367	.658	.341	.906
9	Pearson Correlation										1	**.532****	**.472****	**.376****	-.047	.003	-.035	-.110	-.070
	Sig.											**.000**	**.000**	**.000**	.596	.971	.691	.211	.422
10	Pearson Correlation											1	**.332****	**.225****	**.182***	.109	-.044	.044	.056
	Sig.												**.000**	**.009**	**.037**	.213	.619	.618	.524

11	Pearson Correlation												1	**.415****	***-.165***	**-.266****	***-.156***	**-.268****	-.102
	Sig.													**.000**	***.058***	**.002**	***.074***	**.002**	.243
12	Pearson Correlation													1	.035	-.142	***-.149***	**-.293****	**-.228****
	Sig.														.687	.105	***.089***	**.001**	**.009**
13	Pearson Correlation														1	**.476****	**.330****	.084	.131
	Sig.															**.000**	**.000**	.341	.135
14	Pearson Correlation															1	**.361****	**.363****	**.363****
	Sig.																**.000**	**.000**	**.000**
15	Pearson Correlation																1	**.344****	**.200***
	Sig.																	**.000**	**.021**
16	Pearson Correlation																	1	**.617****
	Sig.																		**.000**
17	Pearson Correlation																		1
	Sig.																		

Note. N= 132 / *. Correlation is significant at the 0.05 level (2-tailed). / **. Correlation is significant at the 0.01 level (2-tailed).
Italic letters. Correlation is significant at the 0.1 level (2-tailed).

1. Walking days in the last week (winter)
2. Walking days in a week in summer
3. There are enough traffic signals at crosswalks or intersections, and enough time for me to cross streets.
4. There are enough crosswalks.
5. It is easy for me to walk from home to public transit stops such as bus or light rail.
6. The sidewalks are well maintained (e.g., paved, even, and not a lot of cracks).
7. There are continuous sidewalks on most of the streets in my neighborhood.
8. There is enough lighting.
9. There is much beautiful nature (e.g., flowers, trees, forests, birds and bugs) and there are lots of green spaces (e.g., parks, open fields, wooded areas forests greenbelts).
10. There are benches and other places to rest along the streets.
11. There are many buildings, homes or gardens which are attractive and well maintained.
12. It is safe to walk during the day.
13. There is too much traffic and there are too many cars passing by too fast.
14. There are stray dogs, gangs, or strangers.
15. There are many barriers preventing walking.
16. There are many abandoned houses, vacant lots, or graffiti on buildings, signs, or walls.
17. There are abandoned cars, litter, trash, broken glass, or discarded items and the evidence of drug-related usage.

Table 51 illustrates unadjusted bivariate analysis outcomes to evaluate the correlations between quality of life, walking days in winter or summer, and objective neighborhood environments. Any variables for objective neighborhood environments were not significantly related to older adults' quality of life and walking in the regression analysis. On the basis of Table 51, quality of life is only associated with walking days in winter as .210 of correlation at the level of .05 but it is not related to walking days in summer and other objective neighborhood environments. Walking days in winter is only related to walking days in summer with .644 correlation at the level of .001 but walking days in summer are negatively associated with objective neighborhood environments including average PEQI scores at intersections, Part 1 Crimes, traffic accident calls, the number of traffic accidents at the intersections within the 400 m NBs, and the number of vacant buildings within the 400 m NBs. However, destinations within the 400 m NBs and connectivity within the 400 m ABs are not associated with walking days in summer.

Table 52 shows unadjusted bivariate analysis resulted to evaluate the correlations between quality of life, walking days in winter or summer, and perceived neighborhood environments, especially for destinations. Quality of life has statistically significant relationship with the easiness to walk to the places where the respondents can buy snacks or drinks such as convenience stores or mobile food vendors with the correlation of .210 at the significance level of .05. Moreover, walking days in winter is significantly associated with five types of destinations including convenience stores or mobile food vendors; restaurants or coffee shops the respondents liked; retail stores such as clothing; beauty shops and other stores selling what older adults wanted; health related facilities such as a hospital, clinic and pharmacy; and natural areas such as parks, rivers, lakes, or

forests in the neighborhoods. It is interpreted that walking days in winter is associated with utilitarian walking to the destinations rather than recreational walking.

Table 53 summarized the unadjusted bivariate analysis outcomes to evaluate the correlations between quality of life, walking days in winter or summer, and perceived neighborhood environments including safety from traffic and crime, attractiveness, and comfort and convenience. From the results, quality of life was related to the perception of enough crosswalks in the neighborhood (correlation coefficients, r=.186 at the .05 level) and the perception of many abandoned houses, vacant lots, or graffiti on buildings, signs, or walls (correlation coefficients, r=-.195 at the .05 level).

Walking days in winter was significantly and positively related to safety to walk during the day (correlation coefficients, r=.325 at the .001 level) and negatively associated with many barriers preventing walking (correlation coefficients, r=.198 at the .05 level). The easiness of walking to public transit stops was associated with walking days in winter (correlation coefficients, r=.162 at the .1 level).

Walking days in summer were positively correlated to attractiveness and safety perceptions in the neighborhoods. Beautiful nature such as flowers, trees, forests, birds and bugs and lots of green spaces such as parks, open fields, wooded areas forests greenbelts (correlation coefficients, r=.363 at the .001 level), attractive and well maintained many buildings, homes or gardens (correlation coefficients, r=.195 at the .05 level), and perceived safety during the day were significantly associated with walking days in summer (correlation coefficients, r=.355 at the .05 level). The perception of many abandoned houses, vacant lots, or graffiti on buildings, signs, or walls (correlation

coefficients, r=-.200 at the .05 level) was negatively related to walking days in summer. Enough crosswalks (correlation coefficients, r=.145) and continuous sidewalks on most of the streets in the respondent's neighborhoods (correlation coefficients, r=.146) were also positively related to walking days in summer at the .1 level).

In summary, among the demographic characteristics self-rated health status was the most significant variable predicting the perception of quality of life and walking days in winter and summer. Although perceived neighborhood environments were not statistically significant variables anticipating quality of life, objective and perceived neighborhood environments were statistically significant variables predicting walking behaviors. However, the specific variables influencing walking days in winter or summer were different in these models. Overall, self-rated health, living arrangements (living alone), destinations, attractiveness and unattractiveness, objective neighborhood environment characteristics which are related to safety from traffic and crime were significantly associated with walking behaviors although the significant variables were different on the basis of the models.

CHAPTER VII

CONCLUSION AND IMPLICATION

The purpose of this study was to analyze the relationships between quality of life, walking, objective and perceived neighborhood environments, and demographic characteristics. Most previous studies about the elderly have focused on the relationship between quality of life and housing environments rather than the relationship between quality of life and neighborhood environments although neighborhood environments were also an important factor for older adults. Moreover, previous studies have concentrated on walking in neighborhood environments and health rather than walking behaviors in neighborhood environments and quality of life, especially for low-income older adults.

It is important to know which factors in neighborhood environments influence walking and quality of life for the low-income elderly living in Section 202 housing properties because understanding walking behaviors and quality of life for low-income older adults is beneficial to policy makers and housing developers seeking to provide better neighborhood environments and quality of life for older adults. Moreover, walking in neighborhood environments contributes to public health through preventing mobility loss (Simonsick, Volpato, Balfour, & Fried, 2005).

Summary of Findings

In order to examine the relationships identified, regarding quality of life, walking, objective and perceived neighborhood environments, and demographic characteristics for the elderly, five hypotheses were examined.

The first hypothesis was that quality of life, walking in winter and walking in summer are different by housing locations. The researcher found that walking behaviors of low-income older adults were significantly different by housing locations in summer although quality of life and walking days in winter did not differ by the housing locations (Appendix F.b). Group 2 (Housing 3 and Housing 4) showed the lowest walking days in summer by respondents. The findings reported in this study indicated that the objective neighborhood environments of the group of the housing developments vary considerably as shown in Table 54. Sum of Part 1 Crime, vacant buildings within the 400 m NBs, and traffic accidents at intersections within the 400 m NBs were the distinctively highest in Group 2. In regard to attractiveness, there is no park within the 400 m NB in Group 2 as shown in Figure 22 and Figure 23. Moreover, the neighborhoods with Group 2 are not attractive with a lot of vacant lots and buildings and occupied houses are not well maintained. Thus, the study findings indicated that objective neighborhood environments including crime, vacant buildings, and traffic accidents influenced older adults' walking behaviors in summer.

Table 54

Objective Neighborhood Environment Scores

	Group 1	**Group 2**	**Group 3**
Sum of Destinations	**22(6+16)**	**30(6+24)**	**10(9+1)**
Sum of Connectivity	**53(29+24)**	**37(15+22)**	**52(41+11)**
Sum of Part 1 Crime	**135(41+94)**	**402(174+228)**	**304(126+178)**
Sum of vacant buildings within 400 m NB	**5(1+4)**	**14(2+12)**	**1(1+0)**
Sum of traffic accidents at intersections within 400 m NB	**31(0+31)**	**167(84+83)**	**0(0+0)**
PEQI	**65+59**	**55+61**	**61+58**
PEQI at intersections	**25+18**	**30+34**	**24+14**

The second hypothesis was that perceived neighborhood environments are different by housing locations. Among six variables about perceived neighborhood

environments after performing PCA, there were no group differences in perceived unattractiveness and perceived recreational destinations. However, there were group differences in the perceptions of comfort and convenience, attractiveness, poor safety, and utilitarian destinations. The perceptions of attractiveness, poor safety, and utilitarian destinations were statistically different in Group 2. Perceived attractiveness was lowest, perceived poor safety was highest, and perceived utilitarian destinations were highest among three groups (Appendix F.c). Moreover, the means of perceived comfort and convenience statistically differed by groups. The mean of comfort and convenience is lowest in Group 3 (Housing 5 and Housing 6).

The researcher expected that the perception of low safety levels would be directly associated with objective built environments factors. Moreover, it was expected that perceived attractiveness is related to vacant buildings because the number of vacant buildings are highest and perceived attractiveness was lowest. The study found that these relations may be associated with the lowest walking days in summer.

The third hypothesis was that the selection of walking or non-walking in winter and summer is related to demographic characteristics and objective and perceived neighborhood environments. Logistic analyses were performed to identify the selection of walking behaviors in winter and summer. In winter, self-rated health status was positively associated with a walking selection while perceived unattractiveness was negatively associated with a walking selection. In summer, the only significant perceived variables related to walking behavior were attractiveness or unattractiveness of the environment (Appendix F.d). Surprisingly, self-rated health was not associated with the

selection of walking in summer but attractiveness and unattractiveness among perceived neighborhood environment variables were statistically significant. The perception of attractiveness was positively associated and the perception of unattractiveness was negatively associated with walking choices in summer. Objective neighborhood environment variables are not associated with walking choices in winter and summer in logistic regression analyses.

The fourth hypothesis was that walking behaviors in winter and summer are associated with demographic characteristics and objective and perceived neighborhood environments. Two analytical methods were used to examine these associations such as multiple linear regression analysis and bivariate analysis.

Multiple linear regression models were performed to understand which variables are associated with walking behaviors among the respondents who selected walking. In winter, objective and perceived neighborhood environments were not associated with walking behaviors among the respondents who selected walking. Only demographic characteristics were associated with walking in winter. The respondents who live alone tend to walk less. However, self-rated health was positively associated with walking behaviors in winter. Among the respondents who selected walking in summer, traffic accidents at intersections (objective neighborhood environment) were negatively related to walking behaviors in summer (Appendix F.d). In addition, the respondents, who perceived that utilitarian destinations (perceived neighborhood environments) are more easily accessible, were likely to walk more in summer. Self-rated health (demographic characteristics) was also positively related to walking behaviors in summer but the

significance level was at .10. Therefore, the objective and perceived neighborhood environments are significant factors encouraging walking behaviors in summer.

To explore which specific variables are associated with walking behaviors in winter and summer, bivariate analysis was performed. Bivariate analyses only targeted objective and perceived neighborhood environments without Principal Component Analysis (PCA). Walking behaviors in winter were mainly associated with utilitarian destinations including convenience stores, grocery stores, restaurants or coffee shops, retail stores, and health facilities. Moreover, natural areas, closeness of transit stops, and safety during the day were positively related to walking in winter. However, the perception of abandoned buildings and vacant lots was negatively associated with walking in winter.

In summer, objective neighborhood environment variables including PEQI scores at intersections, Part 1 Crimes, traffic accident calls, traffic accidents at intersections, and vacant buildings within the 400 m NBs were negatively associated with walking. The perception of abandoned buildings and vacant lots was also negatively associated with walking in summer. However, the perceived neighborhood environments such as attractiveness and safety from traffic and crime were positively associated with walking in summer. The specific variables include natural areas, enough crosswalks, continuous sidewalks, beautiful nature, beautiful buildings and gardens, and safety during the day. On the basis of bivariate analysis, walking behaviors in winter were related to accessibility to destinations but walking behaviors in summer were associated with safety and attractiveness. Thus, it is expected that the main walking purpose in winter was

utilitarian walking because of harsh weather but the primary walking purpose in summer was recreational walking.

The last hypothesis was that quality of life is associated with demographic characteristics, objective and perceived neighborhood environments, and walking behaviors in winter or summer. On the basis of multiple regression analysis, the only important variable for quality of life was self-rated health. However, the variables about perceived neighborhood environments, including accessibility to convenience stores or mobile food vendors and safety from traffic (enough crosswalks), were positively related with quality of life in bivariate analysis. Perceived unattractiveness such as abandoned buildings and vacant lots was negatively associated with quality of life. In addition, walking days in winter was positively associated with quality of life. Thus, the findings indicated that safe and attractive walking environments to utilitarian destinations such as convenience stores may be associated with quality of life among low-income older adults, especially in winter.

Through this study, the most important variable is self-rated health for quality of life and winter walking behaviors although self-rated health was not statistically significant for walking behaviors in summer. Objective and perceived neighborhood environments related to attractiveness and safety from traffic and crime were also important variables predicting walking behaviors.

Discussion

Quality of life did not differ by housing locations and the most significant variable for quality of life was self-rated health in this study. Accessibility to destinations

was not significant for quality of life. These findings confirmed findings from previous studies. According to a previous study, quality of life for older adults differs by urban and suburban areas but there were no geographical differences after controlling socioeconomic characteristics (Patterson and Chapman, 2004). Similar to the findings of this study, self-rated health status was an important predictor but accessibility to destinations was not a significant predictor for quality of life for older adults.

In this study, the perception of neighborhood environments is not directly related to quality of life although accessibility to convenience stores, enough crosswalks, and abandoned buildings and vacant lots were positively or negatively associated with quality of life in bivariate analysis. Previous studies revealed that quality of life was associated with neighborhood environments related to accessibility to destinations or neighborhood physical features when social cohesion or neighborhood satisfaction functioned as a mediator (Rogers, Halstead, Gardner, & Carlson, 2011; Sirgy & Cornwell, 2002). This study also revealed that more walking days in winter were associated with quality of life in bivariate analysis confirming findings of a previous study that more walking and higher health status is associated with higher quality of life (Sugiyama, Thompson, & Alves, 2009).

Objective neighborhood environments were associated with walking behaviors. Some findings were congruent with previous studies but other findings were not. An objective measurement for good accessibility to retail stores such as grocery stores is positively related to walking behaviors in previous studies (Lin and Moudon, 2010) but the sum of destinations cannot guarantee more walking in the neighborhoods.

Nevertheless, previous studies found that a number of different types of objectively measured destinations are associated with walking behaviors (Gauvin et al., 2012; Tilt et al., 2007). The neighborhood environments with Group 2 have the highest number of destinations within the 400 m NBs but the older respondents walked least in the neighborhoods. The highest number of Part 1 Crimes, car accidents at intersections, and vacant buildings within the 400 m NBs were also identified in Group 2. The number of vacant buildings was related with unattractiveness in the neighborhood on the basis of the researcher' observations. This finding is consistent to previous studies that the objectively measured attractiveness or unattractiveness is positively or negatively associated with walking behaviors (Giles-Corti, Broomhall, Knuiman, Collins, Douglas, Ng, Lange, & Donavan, 2005; Michael, Beard, Choi, Farquhar, & Carlson, 2006; Pikora et al., 2006). These study findings confirmed the previous studies that the areas with good accessibility to destinations were more associated with traffic accidents as discouraging walking behaviors of older adults (Lee, Zegras, & Ben-Joseph, 2013; Miranda-Morenoa, Morency, & El-Geneidy, 2011; McGinn et al., 2007; Moudon, Lin, Jiao, Hurvitz, & Reeves, 2011). Although the relationship between objectively measured crime and walking did not clearly reveal in this study, previous research showed that objectively measured crime was negatively associated with walking (McDonald, 2008). This means that older adults tend to walk more in safer neighborhoods from traffic and crime.

This study also revealed that the variables about perceived neighborhood environments, including attractiveness, unattractiveness, and accessibility to utilitarian destinations, were significant variables to predict walking behaviors which were encouraged or discouraged. Previous studies confirmed that perceived accessibility to

destinations was associated with walking behaviors (King, Brack, Belle, Killingsworth, Fenton, & Kriska, 2003; Lee & Moudon, 2008, Tilt et al., 2007). Perceived accessibility to utilitarian destinations, especially convenience stores, was important. This finding was congruent to a previous study (Lee & Moudon, 2008).

As this study revealed, the positive perception of attractiveness in the neighborhoods was positively associated with walking and the perception of unattractiveness discouraged walking behaviors in previous studies (Ball et al., 2001; Humpel, Owen, Iverson, Leslie, & Bauman, 2004). However, the perceived unattractiveness was not statistically associated with walking behaviors in a previous study (Michael et al., 2006).

In this study, the relationship between safety and walking behaviors was emphasized less although attractiveness or unattractiveness was considered as significant variables for walking behaviors. However, there were a couple of variables which were used as confounding variables for safety and attractiveness compared to a previous study (Alfonzo, Boarnet, Day, Mcmillan, & Anderson, 2008). Safety was the most significant factor associated with walking in a previous study and the safety was measured by street lighting, rundown buildings, vacant buildings, abandoned buildings, graffiti, windows toward the streets, and undesirable land uses. Attractiveness was only measured by street trees and street furniture. However, vacant buildings, abandoned buildings, and graffiti were categorized into attractiveness or unattractiveness rather than safety in this study and the variables about attractiveness and unattractiveness were important variables for walking behaviors in winter and summer in this study. Thus, the findings about

attractiveness and unattractiveness can be interpreted as perceived safety in the neighborhood. When the researcher observed the neighborhood environments, the researcher also perceived that neighborhoods were safer if there were less vacant and abandoned buildings, well-maintained gardens and beautiful streets with trees.

Demographic characteristics such as living arrangements (living alone) and self-rated health status were also significant variable associated with walking behaviors in this study. Unlike the finding that living arrangements (living alone) is negatively associated with walking in this study, previous studies did not find a statistically significant relationship between living arrangement (living alone) and walking behaviors (Patterson and Chapman, 2004). However, another previous study found research participants, especially women tended to walk less for recreation or exercise if there is no company to walk with (Ball, Bauman, Leslie, & Owen, 2001). This study finding can be interpreted that the older respondents who live alone have less chances to have companions to walk with in this study so they are less likely to walk. Self-rated health was an important factor predicting walking behaviors of older adults and this result is in accordance with previous literature (Ruopilla & Ruuskanen, 1995). Although self-rated health is a good predictor for walking, this variable is usually confounded by other variables. Most of previous literature has found that regular walking behaviors drew better health outcomes in the neighborhood environments that were higher quality (Buman, Hekler, Haskell, Pruitt, Conway, Cain, Sallis, Saelens, Frank, & King, 2010; Simonsick, Guralnik, Volpato, Balfour, & Fried, 2005).

Implication for Housing Developers, Urban Designers and Policy Makers

Although self-rated health status was the most important factor expecting quality of life, walking and neighborhood environments are indirectly associated with quality of life among low-income older adults. Regular walking behaviors are a statistically important factor maintaining health and preventing worse health according to previous studies (Buman et al., 2010; Simonsick et al., 2005). Less walking of older adults' health living in Group 2 may get worse compared to the other groups. Thus, their worse health status influences quality of life in the future. Walking behaviors are encouraged by neighborhood environments. Although there was no significant relationship between quality of life and walking in this study, accessibility to utilitarian destinations and walking showed a tentative association. Thus, policy makers need to make an effort to make walkable neighborhoods for older adults and to develop health promotion programs for better quality of life and better health for the low-income older adults.

In regard to neighborhood environments, one important thing which needs to be considered is the balance between neighborhood environment characteristics. Through the observations, most residential areas are comparatively attractive but have only a few destinations. However, as the number of destinations increases, the quality of neighborhood environments declined with a fewer trees and the poor quality buildings and neglected landscapes. The number of crime and traffic accidents also increased in these neighborhoods. Most of the destinations are located on the roads with high traffic volumes. Through the quantitative research method, the researcher found that the older respondents hesitate to walk in the areas with a lot of crime and traffic accidents, and

unattractiveness with a lot of vacant buildings even though there are a number of destinations within walkable distances. From the perception of the researcher during the observations, vacant buildings and unattractive neighborhood environments negatively influence the perception of safety. Although there was not a clear relationship between self-selected walking in the neighborhoods and quality of life among older adults, increased walking which is promoted by safe and attractive neighborhood environments may influence quality of life for older adults. Thus, safe and attractive environments with the appropriate destinations are important for older adults in the aspect of walking and quality of life. Thus, policy makers need to consider the ways to reduce crimes, car accidents, and vacant buildings in neighborhoods to facilitate walking behaviors of older adults in their neighborhoods. Urban designers and policy makers need to find ways to cultivate safe and attractive neighborhood environments with local residents and retail store owners through incentives and promotions. HUD Section 202 housing developers and policy makers also need to construct housing in safe and attractive neighborhoods.

Limitations and Future Research

This study has six recommendations for future research. First, it is important to investigate the relationship between self-selection and walking. It was clear that the residents in two housing properties walked less than the residents in the other housing properties although there were no statistical differences in self-rated health between groups. It is expected that they walked less because of safety concerns from traffic and crime or they do not prefer to walk but it was not clear in this research. Thus, preference of walking and safety concerns from crime and traffic need to be used as latent variables to reveal the characteristics of walking behaviors among low-income older adults.

Second, it is significant to investigate older adults' health outcomes which are related to walking behaviors in the neighborhoods. As shown in the research findings, walking behaviors are different among three groups. Thus, it is necessary to use longitudinal analysis to know the extent of voluntary walking, which is able to improve physical health or loosen physical health deterioration including body mass index, diabetes or other common illnesses among older adults, in the neighborhood environments.

Third, the emphasized neighborhood environments are different on the basis of walking purposes such as utilitarian walking and recreational walking. For utilitarian walking, short distances to destinations are significant but for the recreational walking, the presence of parks and beautiful nature are important on the basis of literature reviews. In this study, it was expected that older adults walked primarily for utilitarian purpose during the winter and they walked for recreation during the summer. However, the impact of the neighborhood environment for the two categories of walking was not clearly identified in this study.

Fourth, it is beneficial to investigate the relationship between quality of life and psychological health among low-income older adults in the neighborhood environments. Quality of life is affected by psychological health status and walking can improve psychological health status. Thus, using longitudinal analysis is necessary to explore whether more walkable neighborhoods influence quality of life among low-income older adults.

Fifth, exploring walking purpose of older adults such as utilitarian and recreational walking is important because their desired walking environments are

different. The low-income elderly's perception and motivation of their walking behaviors may be different. Thus, exploring their walking purpose, motivation, perception, and desire about their neighborhood environments through a qualitative research method is recommended.

Last, there are a wide range of studies about walking behaviors, neighborhood environments, and quality of life available in the research literature. However, there is no clear model explaining the relationship between quality of life, walking behaviors, and neighborhood environments. It is suggested that a recursive analysis similar to the following model may be a possible alternative (see Figure 29).

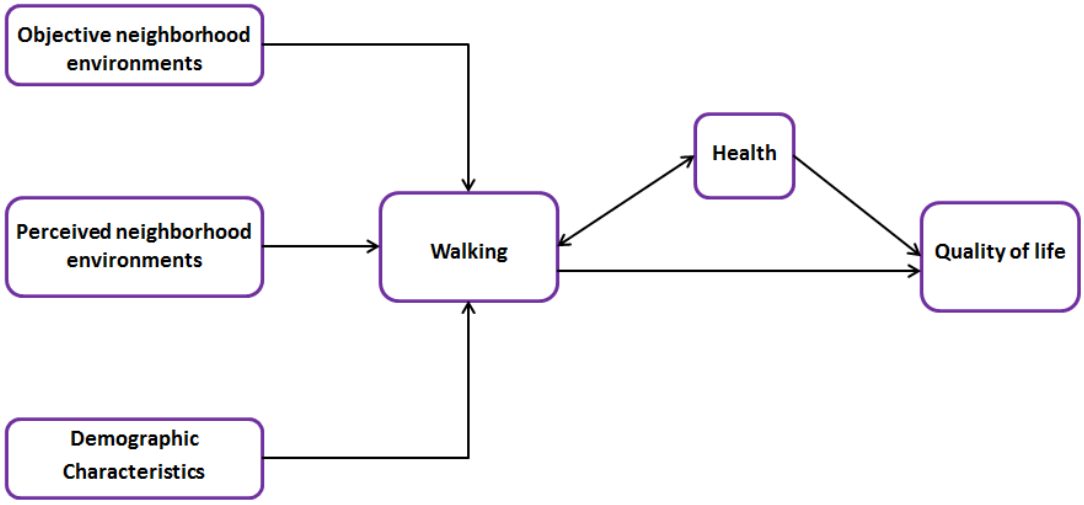

Figure 29. Path analysis for a future study

This study finding showed that healthy older adults walked more but previous study showed that the elderly who had walked regularly were likely to have better health. On the basis of the result of this study, the model for path analysis has been drawn. Self-rated health status was an important predictor about walking and quality of life and regular walking behaviors are positively associated with health status. Thus, developing a model explaining this relationship serves to help to understand quality of life and walking

behaviors of low-income older adults living independently in the neighborhoods. Moreover, understanding the relationship between quality of life, walking behaviors and neighborhood environments can help policy makers, low-income housing developers, and urban designers, enhancing quality of life and health outcomes through walking for low-income older adults in the neighborhood environments.

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Appendix A

Comparison for Walking Days in Summer by Housing Location

Scheffe

Dependent Variable	(I) Housing ID	(J) Housing ID	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Walking days in summer	1	2	-.08128	.81234	1.000	-2.8278	2.6652
		3	1.72771	.75740	.397	-.8330	4.2885
		4	2.04635	.74110	.187	-.4593	4.5520
		5	.30070	.73381	.999	-2.1803	2.7817
		6	.58860	.76656	.988	-2.0031	3.1803
	2	1	.08128	.81234	1.000	-2.6652	2.8278
		3	1.80899	.82015	.437	-.9639	4.5819
		4	2.12763	.80512	.230	-.5944	4.8497
		5	.38198	.79841	.999	-2.3174	3.0814
		6	.66988	.82862	.985	-2.1316	3.4714
	3	1	-1.72771	.75740	.397	-4.2885	.8330
		2	-1.80899	.82015	.437	-4.5819	.9639
		4	.31864	.74965	.999	-2.2159	2.8532
		5	-1.42701	.74244	.596	-3.9372	1.0832
		6	-1.13911	.77484	.825	-3.7588	1.4806
	4	1	-2.04635	.74110	.187	-4.5520	.4593
		2	-2.12763	.80512	.230	-4.8497	.5944
		3	-.31864	.74965	.999	-2.8532	2.2159
		5	-1.74565	.72580	.334	-4.1996	.7083
		6	-1.45775	.75890	.596	-4.0236	1.1081
	5	1	-.30070	.73381	.999	-2.7817	2.1803
		2	-.38198	.79841	.999	-3.0814	2.3174
		3	1.42701	.74244	.596	-1.0832	3.9372
		4	1.74565	.72580	.334	-.7083	4.1996
		6	.28790	.75179	1.000	-2.2539	2.8297
	6	1	-.58860	.76656	.988	-3.1803	2.0031
		2	-.66988	.82862	.985	-3.4714	2.1316
		3	1.13911	.77484	.825	-1.4806	3.7588
		4	1.45775	.75890	.596	-1.1081	4.0236
		5	-.28790	.75179	1.000	-2.8297	2.2539

Note. No mean differences between housing groups

Appendix B

Excluded Variables for Walking Days in the Last Week during the Winter

	Model 1			Model 2		
	Beta In	t		Beta In	t	
Objective Neighborhood Environments						
PEQI scores	.003[a]	.025	.980	-.012[b]	-.114	.910
PEQI scores at intersections	-.075[a]	-.667	.507	-.029[b]	-.265	.792
Crime	-.014[a]	-.121	.904	.030[b]	.266	.791
Traffic accident calls	-.047[a]	-.409	.684	-.019[b]	-.172	.864
Traffic accidents at intersections within 400NB	-.083[a]	-.729	.468	-.052[b]	-.472	.638
Connectivity within 400m AB	.006[a]	.051	.960	.044[b]	.398	.692
Vacant buildings with 400m NB	-.077[a]	-.674	.502	-.045[b]	-.408	.685
Demographic Characteristics						
Age	-.062[a]	-.538	.592	-.116[b]	-1.031	.306
Race, White	.080[a]	.710	.480	.071[b]	.652	.517
Race, Black or Asian	-.157[a]	-1.414	.162	-.119[b]	-1.093	.278
Sex, female	-.113[a]	-.998	.321	-.102[b]	-.939	.351
Sex, missing	.026[a]	.233	.817	.073[b]	.666	.507
Education, college or more	.108[a]	.964	.338	.050[b]	.450	.654
Education, missing	-.137[a]	-1.187	.239	-.164[b]	-1.483	.142
Living arrangement, missing	.003[a]	.030	.976	-.023[b]	-.204	.839
Car ownership, yes	.148[a]	1.311	.194	.110[b]	.999	.321
Car ownership, missing	-.164[a]	-1.435	.155	-.158[b]	-1.436	.155
Self-reported health	.288[a]	2.691	.009	-	-	-
Disability, yes	-.242[a]	-2.226	.029	-.166[b]	-1.476	.144
Perceived Neighborhood Environments						
Comfort and convenience	-.041[a]	-.360	.720	-.098[b]	-.895	.374
Attractiveness	-.070[a]	-.627	.533	-.105[b]	-.970	.335
Unsafety	.143[a]	1.276	.206	.124[b]	1.147	.255
Unattractiveness	.000[a]	.001	.999	.041[b]	.381	.705
Utilitarian destinations	.172[a]	1.487	.141	.161[b]	1.450	.151
Recreational destinations	.148[a]	1.307	.195	.132[b]	1.216	.228

Note. a. Predictors in the Model 1: (Constant), Living alone

b. Predictors in the Model 2: (Constant), Living alone, Self-reported health

c. Dependent Variable: Walking days in the last week in winter, 76 cases

Appendix C

Excluded Variables Walking Days in a Week during the Summer

	Model 1			Model 2			Model 3		
Model	Beta In	t	Sig.	Beta In	t	Sig.	Beta In	t	Sig.
Objective neighborhood environments									
PEQI scores	-.051[a]	-.446	.656	-.041[b]	-.367	.715	-.033[c]	-.297	.767
PEQI scores at intersections	-.132[a]	-.951	.344	-.098[b]	-.708	.481	-.072[c]	-.530	.598
Crime	-.115[a]	-.901	.370	-.094[b]	-.745	.458	-.122[c]	-.985	.327
Traffic accident calls	.035[a]	.178	.859	.024[b]	.122	.903	-.005[c]	-.026	.980
Connectivity within 400m AB	-.030[a]	-.273	.785	.002[b]	.019	.985	.031[c]	.293	.771
Vacant buildings with 400m NB	-.059[a]	-.417	.677	-.040[b]	-.290	.773	-.054[c]	-.392	.696
Destinations within 400m NB	.006[a]	.047	.962	.023[b]	.188	.851	.025[c]	.209	.835
Demographic Characteristics									
Age	.003[a]	.029	.977	-.045[b]	-.442	.659	-.024[c]	-.237	.813
Race, White	.063[a]	.560	.577	.047[b]	.423	.673	.130[c]	1.140	.257
Race, Black or Asian	-.111[a]	-.765	.446	-.098[b]	-.683	.497	-.158[c]	-1.110	.270
Sex, female	-.050[a]	-.509	.612	-.046[b]	-.474	.637	-.042[c]	-.437	.663
Sex, missing	.020[a]	.199	.843	.030[b]	.308	.759	.001[c]	.014	.989
Education, college or more	.117[a]	1.189	.238	.102[b]	1.052	.296	.150[c]	1.549	.125
Education, missing	.027[a]	.269	.789	.005[b]	.054	.957	-.001[c]	-.011	.991
Living arrangement, living alone	-.122[a]	-1.236	.219	-.112[b]	-1.149	.253	-.068[c]	-.690	.492
Living arrangement, missing	.115[a]	1.153	.252	.096[b]	.979	.330	.077[c]	.792	.430
Car ownership, yes	.014[a]	.137	.891	.002[b]	.023	.982	.008[c]	.083	.934
Car ownership, missing	-.017[a]	-.174	.862	-.019[b]	-.189	.851	-.025[c]	-.262	.794
Self-reported health	.197[a]	2.028	.045	-	-	-	-	-	-
Disability, yes	-.137[a]	-1.401	.164	-.082[b]	-.794	.429	-.068[c]	-.669	.505
Perceived neighborhood environments									
Comfort and convenience	.079[a]	.783	.436	.030[b]	.293	.770	-.017[c]	-.161	.873
Attractiveness	.035[a]	.341	.734	.018[b]	.180	.857	.002[c]	.018	.986
Unsafety	.042[a]	.417	.678	.029[b]	.292	.771	-.031[c]	-.303	.763
Unattractiveness	-.080[a]	-.808	.421	-.070[b]	-.715	.476	-.080[c]	-.828	.410
Utilitarian destinations	.254[a]	2.428	.017	.230[b]	2.212	.029	-	-	-
Recreational destinations	.212[a]	2.193	.031	.203[b]	2.125	.036	.122[c]	1.044	.299

Note. a. Predictors in the Model: (Constant), Traffic accidents at intersections within 400m NB
b. Predictors in the Model: (Constant), Traffic accidents at intersections within 400m NB, Self-reported health status
c. Predictors in the Model: (Constant), Traffic accidents at intersections within 400m NB, Self-reported health status, Utilitarian destinations
d. Dependent Variable: Walking days in summer (walking Only), 100 cases

Appendix D

Excluded Variables[b] for Quality of Life

Model	Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
					Tolerance	VIF	Minimum Tolerance
Objective neighborhood environments							
PEQI scores	-.086[a]	-1.097	.275	-.096	.999	1.001	.999
PEQI scores at intersections	.023[a]	.294	.769	.026	.994	1.006	.994
Crime	.032[a]	.403	.688	.035	.988	1.012	.988
Traffic accident calls	.084[a]	1.066	.289	.093	.994	1.007	.994
Traffic accidents at intersections within 400m NB	.065[a]	.826	.411	.073	.993	1.008	.993
Connectivity within 400m AB	-.126[a]	-1.602	.112	-.140	1.000	1.000	1.000
Vacant buildings with 400m NB	-.039[a]	-.492	.623	-.043	.991	1.009	.991
Destinations within 400m NB	-.083[a]	-1.044	.298	-.092	.994	1.006	.994
Demographic Characteristics							
Age	-.042[a]	-.522	.602	-.046	.966	1.035	.966
Sex, female	.073[a]	.919	.360	.081	.999	1.001	.999
Sex, missing	-.009[a]	-.108	.914	-.010	.996	1.004	.996
Race, White	.006[a]	.076	.939	.007	.993	1.007	.993
Race, Black or Asian	.100[a]	1.265	.208	.111	1.000	1.000	1.000
Education, college or more	-.013[a]	-.165	.869	-.015	.997	1.003	.997
Education, missing	-.095[a]	-1.203	.231	-.105	.992	1.008	.992
Living arrangement, living alone	-.011[a]	-.138	.890	-.012	.996	1.004	.996
Living arrangement, missing	-.024[a]	-.297	.767	-.026	.994	1.006	.994
Car ownership, yes	-.007[a]	-.082	.935	-.007	.991	1.009	.991
Car ownership, missing	.000[a]	.000	1.000	.000	1.000	1.000	1.000
Self-reported health	.047[a]	.570	.569	.050	.904	1.106	.904
Perceived Neighborhood Environments							
Comfort and convenience	.012[a]	.142	.887	.013	.943	1.060	.943
Attractiveness	.013[a]	.164	.870	.014	.980	1.020	.980
Unsafety	-.119[a]	-1.518	.131	-.132	.998	1.002	.998
Unattractiveness	-.094[a]	-1.197	.234	-.105	.997	1.003	.997
Utilitarian destinations	.082[a]	1.037	.302	.091	.995	1.005	.995
Recreational destinations	.022[a]	.284	.777	.025	1.000	1.000	1.000
Walking (Physical activity)							
Walking days in a week in summer	-.021[a]	-.255	.799	-.022	.949	1.054	.949

Note. a. Predictors in the Model: (Constant), Self-reported health
b. Dependent Variable: Quality of life

Appendix E

Multiple Comparisons for Perceived Neighborhood Environments

Scheffe

Dependent Variable	(I) Recode Housing	(J) Recode Housing	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Comfort and convenience	Group 1	Group 2	.13139023	.21211611	.826	-.3939037	.6566842
		Group 3	.53416841*	.21211611	.045	.0088744	1.0594624
	Group 2	Group 1	-.13139023	.21211611	.826	-.6566842	.3939037
		Group 3	.40277818	.20458294	.148	-.1038603	.9094167
	Group 3	Group 1	-.53416841*	.21211611	.045	-1.0594624	-.0088744
		Group 2	-.40277818	.20458294	.148	-.9094167	.1038603
Attractiveness	Group 1	Group 2	.68891090*	.20651639	.005	.1774843	1.2003375
		Group 3	.04508442	.20651639	.976	-.4663422	.5565110
	Group 2	Group 1	-.68891090*	.20651639	.005	-1.2003375	-.1774843
		Group 3	-.64382648*	.19918209	.007	-1.1370901	-.1505629
	Group 3	Group 1	-.04508442	.20651639	.976	-.5565110	.4663422
		Group 2	.64382648*	.19918209	.007	.1505629	1.1370901
Unsafety	Group 1	Group 2	-.70347910*	.20878086	.004	-1.2205135	-.1864447
		Group 3	-.43545266	.20878086	.118	-.9524871	.0815817
	Group 2	Group 1	.70347910*	.20878086	.004	.1864447	1.2205135
		Group 3	.26802644	.20136614	.415	-.2306458	.7666987
	Group 3	Group 1	.43545266	.20878086	.118	-.0815817	.9524871
		Group 2	-.26802644	.20136614	.415	-.7666987	.2306458
Unattractiveness	Group 1	Group 2	-.27551999	.21650624	.447	-.8116859	.2606459
		Group 3	-.14163215	.21650624	.808	-.6777980	.3945337
	Group 2	Group 1	.27551999	.21650624	.447	-.2606459	.8116859
		Group 3	.13388784	.20881716	.814	-.3832365	.6510121
	Group 3	Group 1	.14163215	.21650624	.808	-.3945337	.6777980
		Group 2	-.13388784	.20881716	.814	-.6510121	.3832365
Utilitarian destinations	Group 1	Group 2	-.75963417*	.20261851	.001	-1.2614079	-.2578605
		Group 3	.01596287	.20261851	.997	-.4858108	.5177366
	Group 2	Group 1	.75963417*	.20261851	.001	.2578605	1.2614079
		Group 3	.77559705*	.19542265	.001	.2916435	1.2595506
	Group 3	Group 1	-.01596287	.20261851	.997	-.5177366	.4858108
		Group 2	-.77559705*	.19542265	.001	-1.2595506	-.2916435
Recreational destinations	Group 1	Group 2	.21144406	.21698666	.623	-.3259116	.7487997
		Group 3	.16903691	.21698666	.739	-.3683187	.7063925
	Group 2	Group 1	-.21144406	.21698666	.623	-.7487997	.3259116
		Group 3	-.04240715	.20928052	.980	-.5606789	.4758646
	Group 3	Group 1	-.16903691	.21698666	.739	-.7063925	.3683187
		Group 2	.04240715	.20928052	.980	-.4758646	.5606789

Note. The mean difference is significant at the 0.05 level.

Group 1: N=40
Group 2: N=46
Group 3: N=46

Appendix F

Summary of Findings

a. Objective Neighborhood Environments and Observations

	Housing 1	Housing 2	Housing 3	Housing 4	Housing 5	Housing 6
Pictures						
Land use	Mainly residential area/ a few retail stores and a large park	Mainly residential area with large industrial and retail businesses	Mainly residential area with large and small retail businesses	Mainly residential area with small retail businesses	Mainly residential area with institutional lot and small retail businesses	Mainly residential area with parks and undeveloped land, and large retail businesses out of the 400m AB
Transportation	Bus stops with low frequency schedule within the 400m AB	Bus and light-rail stops with high frequency schedule within the 400m AB	Bus and light-rail stops with high frequency schedule within the 400m AB	Bus and light-rail stops with high frequency schedule within the 400m AB	Bus stops with low frequency schedule within the 400m AB	Bus stops with low frequency schedule out of the 400m AB
Destination for older adults within 400, 800, and 1000 m NBs	6/ 11/ 11	16/ 21/ 37	6/ 23/ 35	24/ 40/ 49	9/ 26/ 29	1/ 6/ 21
Vacant buildings within 400, 800, and 1000 m NBs	1/ 4/ 5	4/ 7/ 16	2/ 5/ 31	12/ 62/ 94	1/ 8/ 24	0/ 3/ 4
Part 1 Crimes	41	94	174	228	126	178
Traffic accidents at intersections within 400, 800, and 1000 m NBs	0/ 0/ 0	31/ 57/ 164	84/ 304/ 412	83/ 184/ 236	0/ 0/ 0	0/ 28/ 95
Connectivity within 400, 800, and 1000 m ABs	29/ 90/ 119	24/ 89/ 156	15/ 76/ 127	22/ 97/ 149	41/ 139/ 187	11/ 66/ 113
Average PEQI scores at intersections within 400m ABs	25	18	30	34	24	14
Average PEQI scores on streets within 400m ABs	65	59	55	61	61	58

Note. All photographs were taken by Hae Young Yun.

b. Summary of the Differences on Quality of Life, Walking Days in Winter and Walking days in Summer by Housing Groups (ANOVA test)

	Quality of life	Walking in winter	Walking in summer			
	No group differences (Significance level at .525)	No group differences (Significance level at .947)	**Group 2 is lowest (Significance level at .019)**			
			(I)	(J)	Mean Difference (I-J)	Sig.
Group 1 (Housing 1 & Housing 2)			Group 1	Group 2	1.92850*	.002
				Group 3	.46668	.692
Group 2 (Housing 3 & Housing 4)			Group 2	Group 1	-1.92850*	.002
				Group 3	-1.46182*	.023
Group 3 (Housing 5 & Housing 6)			Group 3	Group 1	-.46668	.692
				Group 2	1.46182*	.023

Note. The mean difference is significant at the 0.05 level./ Scheffe

c. Summary of the Differences on Perceived Neighborhood Environments by Housing Groups

	Comfort and convenience	Attractiveness	Low safety	Unattractiveness	Utilitarian destinations	Recreational destinations
Group difference	Significance level at .032 **Group 3 is lowest.**	Significance level at .001 **Group 2 is lowest.**	Significance level at .004 **Group 2 is highest.**	No group difference	Significance level at .000 **Group 2 is highest.**	No group difference

d. Summary of Quantitative Analysis for Quality of life, Walking in Winter and Walking in Summer

	Quality of life	Walking in winter	Walking in summer
Logistic analysis (walking selection)	-	**1. Self-rated health** 2. Unattractiveness	**1. Attractiveness** 2. Unattractiveness
Multiple linear regression	**1. Self-rated health**	1. Living alone **2. Self-rated health**	*1. Traffic accidents at intersections within 400m NB* **2. Self-rated health** **3. Utilitarian destinations**
Bivariate analysis	**1. Walking in winter** **2. Convenience store or mobile food vendors** **3. Enough crosswalks** 4. Abandoned buildings and vacant lots	**1. Convenience store** **2. Grocery store** **3. Restaurant or coffee shop** **4. Retail stores** **5. Health facilities** **6. Natural areas** **7. Public transit stop** **8. Safety during the day** 9. Abandoned buildings and vacant lots	**1. Natural areas** **2. Enough crosswalks** **3. Continuous sidewalks** **4. Beautiful nature** **5. Beautiful buildings and garden** **6. Safety during the day** *7. PEQI scores at intersections* *8. Part 1 Crimes* *9. Traffic accident calls* *10. Traffic accidents within 400m NBs* *11. Vacant buildings within 400m NBs* *12. Abandoned buildings and vacant lots*

Note. Bold letters mean positive relationship.
Italic letters mean the variables for objective neighborhood environments

Appendix G

Consent Form

UNIVERSITY OF MINNESOTA

Twin Cities Campus *College of Design*

Department of Design,
Housing, and Apparel
1985 Buford Ave.
240 McNeal Hall
St. Paul, MN 55108

Office: 612-624-9700
Fax: 612-624-2750

Dear Senior Residents living in HUD Section 202 housing:

You are invited to participate in research conducted by Hae-Young Yun, a doctoral student in Housing Studies at the University of Minnesota. This study explores what influences the quality of life among older adults in HUD-subsidized housing. You are invited to participate in this study because you live in HUD-subsidized housing. We ask that you read this material and ask any questions you may have before agreeing to be in the study.

Background Information:
The purpose of this study is to learn about the neighborhood experiences of older adults living in HUD-subsidized housing. The researcher would like to understand how quality of life among older adults in HUD-subsidized housing is influened by functional ability, mobility, physical activity, and neighborhood environments. If you agree with participating in this research, these are the conditions:

1. Please complete the attached survey about your quality of life and your neighborhood environment. After filling out this survey, put it in the box in the front of the manager's office. Keep this information sheet for your records. A reminder card may be placed at your door.

2. This study contains minimal risk; you may feel uncomfortable answering some of the questions, or feel that you have to participate in this study. You may skip questions that make you uncomfortable, and participation in this study is completely voluntary. In any publication of the data, we will not describe participants in a way to allow identification of individual residents.

3. There are no direct benefits to participation in this study.

Incentives:
You will have an opportunity to be entered into a drawing for $30 gift cards. If you would like to be entered in a drawing for the $30 gift cards, please write your phone number or email address on the attached card in this package.

Confidentiality:
The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify youself. Research records will be stored securely, and only researchers will have access to the records.

Voluntary Nature of the Study:
Your decision whether or not to participate will not affect your current or future relations with your apartment or the University of Minnesota. You are free not to answer any question or withdraw at any time without affecting any of those relations.

Comprehension Check:
This question is for checking up your understanding of the benefits and risks of this study. Please think about the following questions.
What is the risk of this study?
What is the benefit of participating in this study?

Contacts and Questions:
The researcher conducting this study is Hae Young Yun. If you have questions, you may contact Hae Young at (651) 403-9404 and at yunxx051@umn.edu. If you have any questions or concerns regarding this study and would like to talk to someone other than the researchers, please contact Hae Young's advisor at (612) 625-8795 and aziebart@umn.edu. Otherwise, please contact the Research Subjects Advocate Line at (612) 624-1650. You will be given a copy of this information to keep for your records.

Appendix H

Flyer

UNIVERSITY OF MINNESOTA

Twin Cities Campus *College of Design*

Department of Design,
Housing, and Apparel
1985 Buford Ave.
240 McNeal Hall
St. Paul, MN 55108

Office: 612-624-9700
Fax: 612-624-2750

Dear Senior Residents living in HUD Section 202 housing:

I am a PhD student in Housing Studies at the University of Minnesota. I am recruiting seniors aged in 65 or older in HUD-subsidized units. I am interested in understanding how your neighborhood environments influence your quality of life.

I would like to hear from you on how you are satisfied with your neighborhoods including natural, social, and built environments and how you feel about your quality of life. This research will be done with a survey questionnaire and it would take 20 to 30 minutes.

If you are interested in participating in this survey, please fill out the questionnaire which will be put in front of your door and put it in the box in front of the housing manager's office.

If you have any question or need assistance to fill out the survey, you can call me at 651-403-9494 or email me at yunxx051@umn.edu. After participating in this study, you will be entered in a drawing with $30 gift cards.

I hope you join in my study.

Thank you.

Sincerely,

Hae Young Yun

Appendix I

Survey Questionnaire for HUD Section 202 Housing

Neighborhood Survey for American Older Adults in HUD-subsidized housing

Dear Participant:

I appreciate that you agreed participate in this study. The questions in this survey regard your functional ability, mobility, physical activity, perception of neighborhood environments, and quality of life. If you answer all questions, it would be most helpful for this research. Your sincere responses are really appreciated. Please review the general information below before you start.

1. There is no wrong or right answer for each question. Most of the questions in this survey questionnaire ask you to mark only one response reflecting your own experience about you and your neighborhood. Feel free to add any comments or additional information which will help me in understanding your answers on the basis of your judgment.

2. Please let all friends and family members who live in your apartments participate in this survey.

3. Please answer all questions asked. If you do not clearly understand any questions or need help to fill out this questionnaire, please call or email me at 651-403-9404 or yunxx051@umn.edu.

4. This survey consists of 3 pages including this cover letter.

5. Once you finish this survey, please return the questionnaire to me or leave it in the box in front of the management office.

6. I really appreciate your comments and questions. Please feel free to contact me. Thank you so much.

Sincerely,
Hae Young Yun, PhD student
Housing Studies at the University of Minnesota

240 McNeal Hall
1985 Buford Ave
St. Paul, MN 55108
Telephone: 651-403-9404
E-mail: yunxx051@umn.edu

Section 1 Neighborhood Environments

Please choose the answer that best applies to your neighborhood. Check ***onlv One*** *for each question. If you cannot walk, please choose N/A. However,* ***if you can move with a walker or wheelchair*** *in your neighborhood, please* ***indicate the followings from 1 to 5****.*

Strongly disagree **Strongly agree**

1 2 3 4 5

In my neighborhood, it is easy for me to walk from home to:	**1**	***2***	**3**	**4**	**5**	**N/A**
1. Places for grocery shopping.						
2. Places where I can buy snacks or drinks such as convenience stores or mobile food vendors.						
3. Restaurants or coffee shops I like.						
4. Retail stores such as clothing, beauty shops and other stores selling what I want.						
5. Public institutions such as a post office, police station, or courthouse.						
6. Health related facilities such as a hospital, clinic and pharmacy.						
7. Preferred recreational facilities such as a museum, auditorium, concert hall, or theater.						
8. Natural areas such as a park, river, lake, or forest.						
In my neighborhood,	**1**	**2**	**3**	**4**	**5**	**N/A**
9. There is too much traffic and there are too many cars passing by too fast.						
10. There are enough crosswalks.						
11. There are enough traffic signals at crosswalks or intersections, and enough time for me to cross streets.						
12. There are many barriers preventing walking.						
13. There are stray dogs, gangs, or strangers.						
14. There is enough lighting.						
15. It is safe to walk during the day.						
16. There are continuous sidewalks on most of the streets in my neighborhood.						
17. The sidewalks are well maintained (e.g., paved, even, and not a lot of cracks).						
18. There are benches and other places to rest along the streets.						
19. There are enough trees along most of the streets.						
20. It is easy for me to walk from home to public transit stops such as bus or light rail.						
21. There are many buildings, homes or gardens which are attractive and well maintained.						
22. There are many abandoned houses, vacant lots, or graffiti on buildings, signs, or walls.						
23. There is much beautiful nature (e.g., flowers, trees, forests, birds and bugs) and there are lots of green spaces (e.g., parks, open fields, wooded areas forests greenbelts).						
24. There are abandoned cars, litter, trash, broken glass, or discarded items and the evidence of drug-related usage.						

Section 2 Quality of Life

1. How would you rate your quality of life?

1) Very poor 2) Poor 3) Neither poor nor good 4) Good 5) Very good

Section 3 Walking

*In this section, **your walking ability includes moving by walking and using a walker or wheelchair.** If you move by walking or using a walker or wheelchair, please answer the following questions.(N/A means you do not walk or cannot walk.)*

1. During the last 7 days, how many days did you walk outside for at least 10 minutes at a time in your neighborhood?
   __ 1 day __ 2 days __ 3days __ 4days __5 days __6 days __7days __N/A

2. If your walking is **limited because of the winter season**, how many days did you usually walk outside for **at least 10 minutes for a week during the summer**?
   __ 1 day __ 2 days __ 3days __ 4days __5 days __6 days __7days __N/A

Section 4 Demographic Characteristics

1. How old are you? _____ years old

2. What is your race?
   ___ White ___ Black ___ Asian ___ Hispanic
   ___ Two or more races ___ Native

3. Sex ___ Male ___ Female

4. Education
   ___ Less than high school ___ College graduate (bachelor's degree)
   ___ High school graduate ___ Graduate or professional degree
   ___ Some college, no degree ___ Other (please describe)_____

5. I am living
   ___ Alone ___ With my spouse ___ Other (please describe)_____

6. I own a car. ___ Yes ____No

7. How would you rate your general health at the present time?
   ___ Very poor ___ Poor ___ Average ___ Good ___ Excellent

8. Please check all that you have difficulty with.
   ___ I have poor balance ___ I have reduced mobility ___ I use a cane or walker
   ___ I use a wheelchair ___ I have poor vision ___ I have a hearing loss

Please give me comments if you have any. Thank you for participating in this study.

Appendix J

Follow-Up Postcard

Reminder card

(Front)

Hae-Young Yun, PhD Candidate
University of Minnesota-Twin Cities
Department of Design, Housing, and Apparel
240 McNeal Hall
1985 Buford Avenue
St. Paul, MN 55108-6136

Housing Survey for the Elders living in Carty Heights

(Back)

Dear residents in HUD Section 202 Housing

This is a friendly reminder for the survey about neighborhood walkability and quality of life for seniors. If you have not filled out the survey questionnaire yet, please fill out the survey questionnaire and then put it in the box in front of the housing manager's office. If you have already filled out the survey, please disregard this reminder.

If you would like to have a summary of the study results please return this card with your survey in the box. The card will be separated from the survey forms before we code the data to maintain confidentiality of your responses.

Name: _____

Address: _____

Appendix K

Pedestrian Environment Quality Index

PEQI: Intersection Form *(sample only- download original form from website)*

Team (names):	Date:

Intersection ID: _____

This is the intersection of : _____ (Street 1) and _____ (Street 2)

		0 directions	1 directions	2 directions	3 directions	4+ directions
1. Crosswalks						
2. Ladder crosswalks						
3. Pedestrian signals	a. WITH countdowns					
	b. NO countdowns					
4. Stop signs						
5. No Turn On Red signals/signs						
6. Curb cuts at pedestrian crossings						
7. Signal at intersection		☐ yes ☐ no → if no, skip to item 8				

Cross street ONLY with a green light or walk signal. Measure across larger street.

a. Crossing time: Measure crossing time (in seconds): _____ seconds

b. Crossing distance: Measure crossing distance (in paces): _____ paces

Length of my stride: _____ feet in my stride

8. Crosswalk scramble	☐ yes ☐ no
9. Intersection Traffic Calming Features *Indicate if any of the following are present*	Yes No ☐ ☐ pavement treatments ☐ ☐ median or middle-divider ☐ ☐ mini-circles or roundabouts ☐ ☐ speed tables, speed humps or speed bumps ☐ ☐ bike lane at intersection ☐ ☐ partial closures ☐ ☐ drains, dips or other unintentional features that slow traffic ☐ ☐ curb extensions/bulb-outs ☐ ☐ lights set in crosswalk ☐ other (explain: _____)
10. Additional signs for pedestrians	☐ yes ☐ no

PEQI: Intersection Form *(sample only- download original form from website)*

Team (names): | **Date:**

Intersection ID: _____

This is the intersection of : _____ Street 1 and _____ Street 2

		0 directions	1 directions	2 directions	3 directions	4+ directions
1. Crosswalks						
2. Ladder crosswalks						
3. Pedestrian signals	a. WITH countdowns					
	b. NO countdowns					
4. Stop signs						
5. No Turn On Red signals/signs						
6. Curb cuts at pedestrian crossings						

7. Signal at intersection ☐ yes ☐ no → if no, skip to item 8

Cross street ONLY with a green light or walk signal. Measure across larger street.

a. Crossing time: Measure crossing time (in seconds): _____ seconds

b. Crossing distance: Measure crossing distance (in paces): _____ paces

Length of my stride: _____ feet in my stride

8. Crosswalk scramble ☐ yes ☐ no

9. Intersection Traffic Calming Features

Indicate if any of the following are present

Yes	No	
☐	☐	pavement treatments
☐	☐	median or middle-divider
☐	☐	mini-circles or roundabouts
☐	☐	speed tables, speed humps or speed bumps
☐	☐	bike lane at intersection
☐	☐	partial closures
☐	☐	drains, dips or other unintentional features that slow traffic
☐	☐	curb extensions/bulb-outs
☐	☐	lights set in crosswalk
☐ other (explain: _____)		

10. Additional signs for pedestrians ☐ yes ☐ no

16. Sidewalk *surface* condition-- *An impediment is anything which poses a tripping hazard or interrupts the smooth surface of the sidewalk.* *Choose only one option from the right*	☐ **no sidewalk** ☐ **significant impediments in surface** ☐ **few impediments in surface** ☐ **no impediments in surface**
17. Large sidewalk *obstructions* *An obstruction is any object which reduces the width of the sidewalk or hangs low so that people must duck to pass under while on the sidewalk.* *Choose only one option from the right.*	☐ **no sidewalk** ☐ **permanent obstructions** ☐ **temporary obstructions** ☐ **both permanent and temporary obstructions** ☐ **no obstructions**
18. Presence of curb	☐ **yes** ☐ **no**
19. Driveway cuts *how many present*	_____ **driveway cuts**
20. Trees *Choose the one that best describes this street*	☐ **continuously lined** ☐ **a few trees; sporadically lined** ☐ **no trees**
21. Planters/gardens *public and private*	☐ **yes** ☐ **no**
22. Public seating *including bus stops*	☐ **yes** ☐ **no**
23. Presence of buffers *Indicate if any of the following are present*	**Yes No** ☐ ☐ **bike lane** ☐ ☐ **parallel street parking—not time-restricted** ☐ ☐ **parallel street parking—time-restricted** ☐ ☐ **grassy or paved margin**

Land Use	
24. Storefront/retail use *Count the number of stores*	_____ **shops or businesses of any type**
25. Public art/historical sites	☐ **yes** ☐ **no**

Safety and aesthetic qualities	
26. Illegal graffiti	☐ **Major graffiti** ☐ **Little or no graffiti**
27. Litter	☐ **yes** ☐ **no**

28. Pedestrian-scale street lighting *Choose only one option from the right.*	☐ yes, private ☐ yes, public ☐ yes, both private and public ☐ no pedestrian-scale street lighting
29. Construction Sites	☐ yes ☐ no
30. Abandoned/boarded up buildings	☐ yes ☐ no
31. Vacant Lots	☐ yes ☐ no
32. Bike rack(s) present on this street segment	☐ yes ☐ no
Perceived Walkability: Please circle the number that your team thinks best describe this street segment.	
33. Street segment is visually attractive for walking.	Strongly Agree 1 Agree 2 Disagree 3 Strongly Disagree 4
34. Street segment feels safe for walking.	Strongly Agree 1 Agree 2 Disagree 3 Strongly Disagree 4
35. Are there obvious strong odors anywhere on this street segment (e.g., vehicle exhaust, urine stench, rotting garbage, etc)?	No Odors 1 A Little Odor 2 Some Odors 3 A lot of Odors 4
36. How noisy do you find this street segment?	No Noise 1 Little Noise 2 Some Noise 3 A lot of Noise 4
37 . On a scale of 1 to 10, how walkable do you find this street segment?	Not Walkable 1 2 3 4 5 6 7 8 9 10 Very Walkable