Title
Physical Activity, Socioeconomic Status, and Perceptions of Neighborhood Safety in Older Adults

Author
Kealey, Melissa

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Physical Activity, Socioeconomic Status, and Perceptions of Neighborhood Safety in Older Adults

by
Melissa Kay Kealey

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Committee:

Professor William Satariano, Chair
Professor Alan Hubbard
Professor Andrew Scharlach

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Abstract

Background

Mobility, "the ability to move oneself [e.g., by walking, by using assistive devices, or by using transportation) within community environments that expand from one's home, to the neighborhood, and to regions beyond" (Webber, Porter et al. 2010)], is important to healthy aging. Walking, both for recreation and for transportation, has been suggested to be a particularly accessible, affordable, and safe way to be physically active. It is important to understand the barriers to and supports for walking in one's neighborhood for older adults. Neighborhood socioeconomic status and other neighborhood characteristics, such as perceived safety from crime, are associated with walking and physical activity. Health symptoms may also be important determinants of walking and physical activity for older adults.

Objectives

1. Determine to what extent objective and perceived neighborhood characteristics of older adults vary by the socioeconomic status of the neighborhood. Determine what objective neighborhood and personal characteristics are associated with perceived neighborhood safety in older adults.

2. Determine the leading health symptoms reported by older people as causing difficulty when walking outdoors.

3. Determine the different physical activities engaged in by older men and women. Determine the association between both neighborhood socioeconomic status and perceived safety from crime and physical activity.

Methods

The study titled "Environmental Correlates of Physical Activity among Older Adults: A Healthy Aging Research Network (HAN) Collaboration" (referred to in this dissertation as the "HAN Walking Study") was designed to examine how the neighborhood environment may influence physical activity and walking behavior in older adults, and how this relationship may be modified by the functional capacity of older adults. Data were collected from 884 older adults at four sites across the country, from a diversity of physical environments. Data collection included in person interviews, lower-body functional capacity testing, accelerometers, walking diaries, and secondary GIS data.

Results

1. Participants living in neighborhoods of low socioeconomic status (low SES) have objectively shorter block lengths, higher housing density, and more businesses. Participants living in low SES neighborhoods perceive that they are less safe from crime and traffic. They also perceive that their neighborhood is more densely populated with greater percentages of apartments and condominiums. Perceived crime safety is associated with both neighborhood characteristics as well as the characteristics of the people who live there.

2. Most participants report multiple barriers to walking outside. Overall, 95.5% report at least one health symptom or other barrier to walking, with a range of 0-37 and a mean of 7.9 barriers.

3. The most frequent types of activity reported by both women and men are light housework (93.0%) and shopping or running errands (93.0%), followed by walking at a normal or leisurely pace (77.7%). In a combined model, crime safety, but not neighborhood poverty or primary type of neighborhood housing, is associated with physical activity.

Conclusions

Walking is engaged in by the majority of both older men and women in this study. However, they perceive multiple barriers to walking. Neighborhood determinants of walking may be one pathway through which neighborhood socioeconomic status influences health outcomes. Perceived safety from crime is possibly an important neighborhood determinant of walking and physical activity. Further research is needed to determine how changes in neighborhoods as well as other interventions may reduce barriers and lead to increased walking behavior in older adults.

Introduction

Mobility

Mobility is increasingly recognized as being critical to the health and well-being of older adults (Webber, Porter et al. 2010). Webber and colleagues define mobility "as the ability to move oneself (e.g., by walking, by using assistive devices, or by using transportation) within community environments that expand from one's home, to the neighborhood, and to regions beyond" (Webber, Porter et al. 2010). Walking and physical activity are recognized as important components to mobility and multiple physical and mental health outcomes, as well as quality of life, in our aging population. Even as researchers call for a more comprehensive framework for understanding the many different aspects of mobility in older adults, there is a recognition of the importance at looking at personal, social, and environmental determinants of different types of mobility, such as outdoor walking and physical activity (Webber, Porter et al. 2010). McCormack and others call for the need to look at the determinants of different physical activities separately (McCormack, Giles-Corti et al. 2004), as the barriers to walking outside may be different than the barriers to other physical activities or aspects of mobility. Outdoor walking is a particularly important physical activity, as the most common place for walking is outside. Eyler et al found that 66.9% of occasional walkers and 68.5% of regular walkers age 65 and over walked on neighborhood streets, higher than the percentages that walked in shopping malls, in parks, or on walking or jogging trails (Eyler, Brownson et al. 2003). Because most walking occurs outdoors, it is important to understand what it is about outdoor environments that may encourage or discourage older adults from walking.

Despite the recognized benefits of walking and physical activity, many older adults face multiple barriers to these activities. Perceived barriers to walking in the outdoor environment have been found to be associated with lower quality of life (Rantakokko, Iwarsson et al. 2010). There is a growing recognition that place matters. Early studies looking at barriers to physical activity often asked people to report what they believed the barriers to physical activity to be. Most recent studies about the barriers to physical activity have looked at the associations between perceived and objective environmental characteristics with physical activity or walking. Shigematsu found that relationships between perceived neighborhood characteristics and walking varied by age (Shigematsu, Sallis et al. 2009). Among older adults 66 and over, walking for transportation was most strongly related to mixed land use and access to recreation facilities (Shigematsu, Sallis et al. 2009). Hall found that among older women, walking less than 10,000 steps a day was associated with less street connectivity and less safety from traffic (Hall and McAuley 2010). While it is important to look at the characteristics of neighborhoods associated with walking, knowing whether someone perceives that neighborhood characteristic as a barrier to walking or not provides additional information. Dawson (Dawson, Hillsdon et al. 2007) asked older adults in Britain about perceived barriers to walking. Significantly more women than men reported worrying about personal safety (34.6% versus 13.6%) as well as reporting that no one to walk with them was a barrier to walking (30.1% versus 12.4%). A qualitative study of minority women 40 and older found a variety of barriers to physical activity, including safety, which was mentioned in all of their focus groups (Eyler, Baker et al. 1998). Older people are rarely asked

directly about which health symptoms (e.g., back pain or fatigue) are most likely to cause them difficulty when walking outside. In addition, differences in barriers between different age groups of older adults are infrequently examined. This research should contribute to an understanding of how health symptoms affect walking, and to future studies to determine how neighborhood design can either enhance or impede walking among older people with specific health symptoms.

Physical Activity and Walking are Important Health Outcomes

"Few factors contribute as much to successful aging as having a physically active lifestyle. Regular physical activity is important for the primary and secondary prevention of many chronic diseases (e.g., coronary heart disease, non-insulin-dependent diabetes mellitus, obesity), disabling conditions (e.g., osteoporosis, arthritis), and chronic disease risk factors (e.g., high blood pressure, high cholesterol)" (CDC website(CDC 2003)).

There are multiple goals aimed at increasing physical activity in Healthy People 2020. A CDC/Health Canada evidence-based symposium in 2000 found evidence supporting a dose-response relationship between physical activity and many health outcomes, including all cause-mortality, total cardiovascular disease, coronary heart disease incidence and mortality, incidence of type 2 diabetes mellitus, and weight loss in randomized controlled trials lasting less than 16 weeks (Kesaniemi, Danforth et al. 2001). Increased physical activity may also contribute to meeting other Healthy People 2020 goals, such as reducing disparities in health outcomes experienced by different socioeconomic and race/ethnic groups. Walking, both for recreation and for transportation, has been suggested to be a particularly accessible, affordable, and safe way to be physically active. The US Physical Activity Study, a cross-sectional random-digit dial telephone survey of US adults that over-sampled a low-income population, found that among self-reported access to places to exercise, the place for physical activity most people reported having access to was neighborhood streets (64.5% of women, 68.2% of men) (Brownson, Baker et al. 2001). A small randomized control trial among middle age men and women found that physically active commuting to work improved VO2 max, maximal treadmill time, and HDL cholesterol (Vuori, Oja et al. 1994).

Environmental Determinants of Physical Activity and Walking

Research is increasingly showing that environmental characteristics of neighborhoods are associated with physical activities, especially with walking behavior (Cervero and Kockelman 1997; Diez Roux 2001; Craig, Brownson et al. 2002; Giles-Corti and Donovan 2002; De Bourdeaudhuij, Sallis et al. 2003; Giles-Corti, Macintyre et al. 2003; Leyden 2003; Saelens, Sallis et al. 2003; Saelens, Sallis et al. 2003; Fisher, Li et al. 2004; Wendel-Vos, Schuit et al. 2004; Atkinson, Sallis et al. 2005; King, Belle et al. 2005).The International Obesity Task Force identifies numerous determinants of physical activity and obesity, including the availability of leisure activity facilities, public transportation, and public safety (Kumanyika 2001). People who perceive their neighborhood to be unsafe are less likely to be physically active (MMRW 1999). Frequency of seeing others in the neighborhood has also been found to be associated with physical activity (King, Castro et al. 2000). Focus groups of US ethnic minority women over age forty found that the most commonly reported environmental barriers to physical activity were safety, availability, and cost (Eyler, Baker et al. 1998). However, there is an increasing

recognition in the field that neighborhood environmental characteristics may have different effects on different aspects of physical activity, and this may vary for different populations. Walking for transportation and walking for recreation are both thought to be influenced by the neighborhood environment. However, walking for transportation and walking for recreation have been shown to have different correlates in a variety of studies (Pikora, Giles-Corti et al. ; Saelens, Sallis et al. ; Humpel, Owen et al.). Pikora and colleagues used a Delphi expert panel to create an extensive framework of physical environmental factors hypothesized to influence walking, including characteristics of the walking surface, streets, traffic, and permeability of the street network, personal and traffic safety, aesthetics, and destinations (Pikora, Giles-Corti et al. 2003). They hypothesize that some factors may be more important to walking for transportation, such as proximity to stores, while other factors may be more important to walking for recreation, such as aesthetics (Pikora, Giles-Corti et al. 2003). In the Walkable and Bikable Communities (WBC) study, architectural visual quality and sidewalks were correlated with recreation walking only, while distances from the closest grocery store, restaurant, post office, and bank were correlated with transportation walking only (Lee 2006). In addition, there is emerging evidence that the neighborhood environmental correlates of physical activity may be different for older adults than for middle aged adults. For example, cul-de-sacs and quiet streets, which might discourage walking for transportation in middle age adults, might be the same features that encourage walking for recreation in older adults (Stanford lecture, Abby King).

Neighborhood Socioeconomic Status and Health Outcomes

Many studies have examined the relationship between neighborhood of residence (using census tract as a proxy measure) and health outcomes. Results indicate that residence in a low SES neighborhood seems to predict poor health beyond an individual's measured SES level. Various hypotheses are proposed to explain the pathways through which neighborhood might affect health. These pathways include the influence of the physical environment (e.g. environmental toxics) or the built environment (e.g. presence of stores, alcohol outlets, neighborhood housing quality, access to healthy and affordable food, recreational resources, and medical care) on community social capital, racial and ethnic segregation, social integration versus exclusion, political participation, levels of investment in the community, and neighborhood norms for health behaviors such as diet, physical activity, smoking, and drug use. In addition, previous research has shown that socioeconomic disparities exist for both physical activity outcomes and neighborhood environments. For example, supermarkets (Morland, Wing et al. 2002) and physical activity resources (Estabrooks, Lee et al. 2003) are found to be less likely to be located in the poorest neighborhoods. Studies in Alameda County have found neighborhood poverty to be associated with physical inactivity (Yen and Kaplan 1998), and self-reported neighborhood problems to be associated with overall and lower extremity functional loss in older adults (Balfour and Kaplan 2002). In addition, perceptions of neighborhoods have been found to vary by neighborhood socioeconomic status. Our understanding of these health behavior disparities is likely to be enhanced by looking at specific behaviors and contexts.

Research Gaps

While the evidence is overwhelming that neighborhood matters to health and physical activity outcomes, more research is needed that is specifically focused on older adults. Fear of

crime has been suggested to be a particularly important barrier to walking in older populations (MMRW 1999; Kumanyika 2001). In addition, there is a need to understand both how an individual's perceived environment and standard indicators of neighborhood environment are related to each other, and how each, in turn, is related to physical activity and walking behavior. There is relatively little research that has examined how these self-reported assessments and standardized indicators are correlated with each other, and with the socioeconomic characteristics of the neighborhood. In addition, research to address health disparities may benefit by a greater understanding of the pathways through which neighborhood socioeconomic status acts on health outcomes such as physical activity and walking. Insufficient attention is directed to aspects of place itself as important determinants of walking and physical activity in older adults.

Our aims in the following three papers are to:

1. Determine to what extent objective and perceived neighborhood characteristics of older adults vary by the socioeconomic status of the neighborhood. Determine what objective neighborhood and personal characteristics are associated with perceived neighborhood safety in older adults.

2. Determine the leading health symptoms reported by older people as causing difficulty when walking outdoors.

3. Determine the different physical activities engaged in by older men and women. Determine the association between both neighborhood socioeconomic status and perceived safety from crime with physical activity.

HAN Walking Study

The study entitled "Environmental Correlates of Physical Activity among Older Adults: A Healthy Aging Research Network (HAN) Collaboration" (referred to in this dissertation as the "HAN Walking Study") was designed to examine how the neighborhood environment may influence physical activity and walking behavior in older adults, and how this relationship may be modified by the functional capacity of older adults. Data were collected from 884 older adults at four sites across the country, from a diversity of physical environments.

Covariates: Standard covariates associated with physical activity were self-reported in an in person interview. These include age, gender, race, current spouse, years of schooling, income, self-reported health, whether financial resources adequately meet needs, how many friends the participant feels close to, and whether or not the participant currently drives a car or other motor vehicle or has someone who drives them on a regular basis. Depression is defined as a score of 10 or more on the short version of the CESD.

Lower-body functional capacity is measured with a modified version of the Short Physical Performance Battery (SPPB) (Guralnik and Simonsick 1993; Guralnik, Simonsick et al. 1994; Guralnik, Ferrucci et al. 1995), as described in Satariano 2010, and included walking speed, one-legged stand, full and semi-tandem stand, and chair stand. This modified SPPB, like the original version, was summarized in quartiles from poor to excellent lower-body function.

Physical activity data were collected with accelerometers, self reported interview data, and walking diaries. Physical activity was self-reported based on an adaptation of the Study of Physical Performance and Age-Related Changes in Sonomans (SPPARCS) study protocol (Tager, Hollenberg et al. 1998). Participants were asked to report whether or not they engaged in 17 physical activities, as well as "other" physical activities in a typical week. If they engaged in an activity, they were asked to report how many times per week and minutes per session they engaged in that activity. A total MET score was calculated based on the Compendium of Physical Activity 2000 update (Ainsworth, Haskell et al. 2000). A cut point of 50 METS per week was chosen to divide the participants approximately equally into high and low physical activity. Fifty METS per week is equivalent to 3000 MET-minutes per week, the cut point for "high" levels of physical activity recommended in the scoring protocol for the International Physical Activity Questionnaire (IPAQ), an instrument similar to the SPARRCS instrument (Ainsworth BE). Walking diaries were used to collect even more detailed information about walking behaviors and destinations.

Neighborhood environment data were collected both on perceptions of the environment, with items from the NEWS survey and modified WBC study questions, and objective characteristics of the environment. Measurement of the perceived neighborhood environment used questions from the abbreviated Neighborhood Environment Walkability Scale (NEWS). The NEWS is a widely used tool for measuring people's perceptions of their neighborhoods on the domains of importance to walking behavior. The NEWS has been validated, and in addition, a factor analysis of the NEWS components was used to create an abbreviated NEWS with domains of related items. The NEWS is a standard set of questions divided into subscales. This analysis used an abbreviated scoring scheme developed by Saelens and colleagues (Saelens, Sallis et al. 2003; Cerin, Saelens et al. 2006; Adams, Ryan et al. 2009; Cerin, Conway et al. 2009) for each of the subscales, using a 4-point scale from 1 (*strongly disagree*) to 4 (*strongly agree*). Results for each subscale were summed, and then totals were divided into quartiles. The algorithm used to divide into quartiles sometimes results in less than four categories when more than a quarter of participants reported the same score. In the case of crime safety, more than a quarter of the participants reported the same highest possible score for crime safety, resulting in three instead of four categories of perceived crime safety.

Objective neighborhood environment: Previous literature, as well as "Environment and Physical Activity: GIS Protocols" edited by Ann Forsyth (Forsyth 2005) were used as references for the measurement of neighborhood variables in GIS, such as neighborhood socioeconomic status as measured in the census, median block size, median street length, and housing density.

Home addresses were collected from study participants and geocoded with GIS. The first round of geocoding was done using ESRI Business Analyst 9.2. For the second round of geocoding, ArcInfo 9.3 was employed to take advantage of improvements to the base map. Geocoding provided both a point location and a census tract for each participant. Data sources included 2000 U.S. Census data from the SF3 files for census tract housing unit density and percent of households below poverty, and RAND Center for Population Health and Health Disparities (CPHHD) database for census tract median block length. The CPHHD median block length data for 2000 were supplemented with 1990 data when 2000 data were missing, after validating that when both 1990 and 2000 median block length data were available, they were

usually identical. A count of destinations was obtained within a 400 meter radius (approximately a quarter of a mile) of each participant's address, a commonly used distance which has been found to be inclusive of the majority of walking trips. Business data was from ESRI Business Analyst, which contained data from InfoUSA for businesses listed on January 1, 2006. Businesses were categorized according to North American Industry Classification System (NAICS) codes in order to select which businesses were possible retail walking destinations, and summed to create a count of the number of retail businesses within the 400 meter buffer.

The HAN Walking Study is an extremely rich data source in which to examine how specific behaviors are associated with different aspects and measurements of neighborhood context in older adults, and how these relationships may be related to health disparities. The following three papers make use of that data to examine how neighborhood perceptions vary in neighborhoods of different SES, how both individual characteristics and objective neighborhood characteristics influence perceptions of neighborhood, what physical symptoms and environmental barriers people perceive to be barriers to walking, and how physical activity behavior is correlated with both objective and perceived neighborhood characteristics. Frequently in epidemiological research, self-reported perceptions are viewed as inferior to objectively measured variables. When examining something as complex as walking behavior, however, looking at perceived barriers and perceived neighborhood attributes may contribute information beyond what can be objectively measured. Together, the following three analyses illuminate different components of the pathways between neighborhoods and physical activity and walking outcomes.

Human Subjects

Human subjects approval was obtained for the HAN Walking Study from each of the four collaborating universities: University of California at Berkeley, University of North Carolina, University of Pittsburgh, and University of Illinois, Chicago.

Acknowledgments

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Paper 1: Disparities in Objective and Perceived Neighborhood Characteristics and Perceptions of Neighborhood Safety in Older Adults

There is much evidence that neighborhood and neighborhood socioeconomic status are important to health outcomes. Census-based socioeconomic status measures originally were used as proxy measures for individual-level socioeconomic status when individual data were unavailable (Krieger 1992; Krieger 1993; Berkman and Macintyre 1997; Krieger 2001). However, more recent studies have shown that individual-level and area-level SES measures have independent effects on health (Haan, Kaplan et al. 1987; Diez Roux 2001; Pickett and Pearl 2001; Diez Roux 2004; Subramanian 2004). That is, the neighborhood level measures can capture attributes of the neighborhood environment which impact health over and above the individual-level socioeconomics determinants of health. In a study of the association between SES and health outcomes, a nine year study of mortality in a random sample of residents aged 35 and older in Oakland, California, found that those living in a federally designated poverty area experienced higher age-, race-, and sex-adjusted mortality, compared to those living in non-poverty areas (Haan, Kaplan et al. 1987). Moreover, the relationship between place of residence and mortality persisted, even after adjusting for characteristics of the individual residents, including baseline health status, race, income, employment status, access to medical care, health insurance coverage, smoking, and alcohol consumption, suggesting that the risk of poor health for residents of poor areas may be due more to the neighborhood environment facing the residents than to the characteristics of the residents themselves. Expanding on this idea, Macintyre et al indicate that these environmental demands may be associated with the availability of decent housing, transportation, affordable and nutritious food, safe and healthy recreation, as well as access to social and health services (Macintyre 1993).

Robert advocates that the study of neighborhood SES needs to move beyond census measures of wealth and education and incorporate more specific measures of the neighborhood environment to facilitate understanding of the mechanisms by which individual health is affected by one's surrounding environment (Robert 1999). As such, aspects of neighborhoods, such as crime rates, distance to service providers, deprivation, inequality, neighborhood ties, social control, and institutional resources (Macintyre 1993; Sooman and Macintyre 1995; O'Campo, Xue et al. 1997; Yen and Kaplan 1999; Subramanian 2004), have also been considered in examining public health outcomes. Epidemiology has recently drawn on the research traditions of health psychology and urban planning to further examine the association between area characteristics and health (Ewing, Schmid et al. 2003; Giles-Corti and Donovan 2003; Jackson 2003; Leyden 2003; Northridge, Sclar et al. 2003; Powell, Martin et al. 2003; Wallerstein, Duran et al. 2003). These studies include the assessment of built environment measures such as the availability of and accessibility to recreational facilities, pharmacies, stores, and the walkability of a neighborhood in relation to health outcomes such as low birth weight (O'Campo, Xue et al. 1997), depression and perceived health status (Sooman and Macintyre 1995), motor vehicle and pedestrian fatalities (Ewing, Schmid et al. 2003), physical activity and walking outcomes, and death (Yen and Kaplan 1999). Many of these studies also support associations of such health indicators with health outcomes as well as interactions with individual-level variables.

There are a number of possible mechanisms by which the social and built environment of a community may impact health. Taylor, Repetti, and Seeman review how an unhealthy environment could "get under the skin" (Taylor and Sallis 1997) by way of repeated assaults whereby the cumulative effect is chronic stress. After adjustment for individual SES,

neighborhood deprivation has been shown to be associated with adverse health and health-affecting behaviors, including diabetes, smoking, higher blood pressure, and physical inactivity (Cubbin, Hadden et al. 2001). The built environment literature suggests an association between individual physical activity (Ewing 2003; Ewing, Schmid et al. 2003; Talen 2003; Boslaugh 2004) (Ewing, Schmid et al. 2003) and sprawl, (Ewing 2002), distance to service providers, and availability of recreational facilities, and sidewalks or other places to walk (Giles-Corti and Donovan 2003; Powell, Martin et al. 2003). The impact of the built environment on physical activity and walking is an area of active research, particularly given the recognized benefits of physical activity for many different health outcomes, including maintaining mobility in older adults. Morland and colleagues found that neighborhood food environment was associated with residents' individual diets (Morland, Wing et al. 2002) such that increasing number of supermarkets was associated with more fruit and vegetable intake. Furthermore, supermarkets were less abundant in poorer and predominantly Black neighborhoods (Morland, Wing et al. 2002).

Perceptions of neighborhood safety have emerged as a particularly important characteristic of the neighborhood environment, associated with walking behavior and physical activity. Research has suggested that neighborhood socioeconomic status and perceptions of safety may have different determinants and effects on health outcomes in older adults than in other age groups. An analysis of data from the 1996 Behavioral Risk Factor Surveillance System (BRFSS) in several states found that higher levels of perceived safety were associated with less physical **in**activity, with the effect greatest among people 65 and older (2005). Perceived lack of neighborhood safety has also been found to be associated with increased risk of mobility disability among low income older adults (Clark, Kawachi et al. 2009).

An important issue for any study examining neighborhood connections to health is how to measure neighborhood. Neighborhoods may be measured objectively, such as with on the ground audits, in which objective neighborhood characteristics are scored by researchers, and with secondary data sources, such as census data or administrative records kept by city agencies. Neighborhoods may also be measured subjectivity, by self-report, in which study participants are asked to evaluate aspects of the neighborhood in which they live. The Neighborhood Environment Walkability Score (NEWS) is a commonly used, validated, and reliable instrument (Cerin, Saelens et al. 2006; Adams, Ryan et al. 2009). A variation of the self-report method combines the self reports of residents in each neighborhood together to create an average score for each neighborhood. Each person can then be assigned their neighbors' average score, without including their own score. Unfortunately, however, most studies do not include enough respondents in each neighborhood to provide an average neighborhood score that is independent of a particular respondent. Therefore, most studies that use self-reports must rely on the self-report from the same respondent for whom health outcomes are collected.

Research has shown that these self-reported, perceived neighborhood characteristics are associated with objective neighborhood characteristics. For example, a comparison of neighborhood perceptions of people age 19-65, as measured by the NEWS in a "highly walkable" and a "less walkable" neighborhood in Australia found that perceived residential density, land use mix, and street connectivity, but not traffic or crime safety, varied between neighborhoods, validating the ability of measured neighborhood perceptions to distinguish

between objectively different neighborhoods (Leslie, Saelens et al. 2005). People living in a low SES neighborhood also perceived their neighborhood to be less attractive, safe, and interesting for walking, and have more traffic and busy roads as did people living in high SES neighborhoods (Giles-Corti and Donovan 2002). Despite the association between objective and perceived neighborhood measures, residents' perceptions of the neighborhood are more than pale approximations of the objective neighborhood characteristics. Rather, items such as demographics and personal characteristics, prior experiences, and years living at a particular address, in addition to objective neighborhood characteristics, are likely to influence one's view of one's neighborhood. Attempts to validate measures of neighborhood perceptions solely by associating them with objective characteristics do provide useful information as to what extent perceptions may be used as proxy measures for objective characteristics, however, they contribute to a failure to recognize the multitude of factors that may contribute to perceptions beyond objective characteristics. A study in the Netherlands found that differences in perceptions between individuals living in low SES and high SES neighborhoods were partly explained by objective neighborhood characteristics, such as objectively measured decreased traffic safety, decreased aesthetics, and increased destinations, and personal characteristics, such as depressed mood and stressful life events (Kamphuis, Mackenbach et al. 2010). Another analysis found that adults with less education, lower income, who were overweight, or less active for transportation, were more likely to view their objectively "highly walkable" neighborhood as "low walkable" (Gebel, Bauman et al. 2009). An Australian study of adults 18-59 years found that while access to open space did not vary by neighborhood SES, people living in low SES neighborhoods were less like to perceive that there was a park within walking distance (Giles-Corti and Donovan 2002). Perceptions of neighborhood safety have been found to be highly associated with objective crime statistics, including "serious incidents against persons and narcotics arrests" as well as individual characteristics such as race/ethnicity and instrumental support in women (Elo, Mykyta et al. 2009).

Our aims here are to:

1) Determine to what extent objective and perceived neighborhood characteristics vary by the socioeconomic status of the neighborhood.

2) Determine what objective neighborhood and personal characteristics are associated with perceived neighborhood safety in older adults.

Methods

Sample Population

The Healthy Aging Research Network (HAN) Walking Study is a cross sectional study conducted between 2005 and 2007. This analysis is based on interviews with 884 participants aged 65 and older, recruited from senior centers in Alameda County, CA; Cook County, IL; Allegheny County, PA; and Durham and Wake Counties, NC. Inclusion criteria included age 65 and older, English-speaking, lived in the county of interest, and had lived at current address for at least one year with no plans to move in the next three months. Exclusion criteria included self-reported inability to walk outdoors because of a medical condition or doctor's orders, or exhibiting signs of cognitive impairment that would be sufficient to impede completion of the

informed consent, interview or walking diary. The inclusion/exclusion criteria ensured that all participants were healthy enough to potentially walk outdoors, but include participants with a range of physical functioning. Subjects were recruited from senior serving organizations, primarily senior centers, in the counties of interest. In each county, a sampling frame was created of senior organizations. A random sample of senior centers was selected for recruitment, stratified by housing density, to ensure a diversity of environments. Study staff visited the senior centers at different times of day and days of the week to ensure that participants who were there for a variety of purposes were recruited. The protocols were approved by IRBs at each of the four study sites and informed consent was obtained from all participants. The study is described in greater detail in Satariano 2010 (Satariano, Ivey et al. 2010).

Study Variables

Interview

Covariates: Standard covariates related to physical activity and walking were self reported in an in-person interview. These include age, gender, race, current spouse, years of schooling, income, self-reported health, whether financial resources adequately meet needs, how many friends the participant feels close to, and whether or not the participant currently drives a car or other motor vehicle or has someone who drives them on a regular basis. Depression was defined as a score of 10 or more on the short version of the CESD.

During the interview, lower-body functional capacity was measured with a modified version of the Short Physical Performance Battery (SPPB) (Guralnik and Simonsick 1993; Guralnik, Simonsick et al. 1994; Guralnik, Ferrucci et al. 1995) as described in Satariano 2010 (Satariano, Ivey et al. 2010), and included walking speed, one-legged stand, full and semi-tandem stand, and chair stand. This modified SPPB, like the original version, was summarized in quartiles from poor to excellent lower-body function.

Perceived neighborhood environment: Measurement of the perceived neighborhood environment used questions from the abbreviated Neighborhood Environment Walkability Scale (NEWS). The NEWS is a widely used tool for measuring people's perceptions of their neighborhoods on the domains of importance to walking behavior. The NEWS has been validated, and in addition, a factor analysis of the NEWS components was used to create an abbreviated NEWS with domains of related items. The NEWS is a standard set of questions divided into subscales. This analysis used an abbreviated scoring scheme developed by Saelens and colleagues (Saelens, Sallis et al. 2003; Cerin, Saelens et al. 2006; Adams, Ryan et al. 2009; Cerin, Conway et al. 2009) for each of the subscales, using a 4-point scale from 1 (*strongly disagree*) to 4 (*strongly agree*). Results for each subscale were summed, and then totals were divided into quartiles. The algorithm used to divide into quartiles sometimes results in less than four categories when over a quarter of participants reported the same score. In the case of crime safety, more than a quarter of the participants reported the same highest possible score for crime safety, resulting in three instead of four categories of perceived crime safety.

Objective neighborhood environment: Home addresses were collected from study participants and geocoded with GIS. The first round of geocoding was done using ESRI Business

Analyst 9.2. For the second round of geocoding, ArcInfo 9.3 was employed to take advantage of improvements to the base map. Geocoding provided both a point location and a census tract for each participant. Data sources included 2000 U.S. Census data from the SF3 files for census tract housing unit density and percent of households below poverty, and RAND Center for Population Health and Health Disparities (CPHHD) database for census tract median block length. The CPHHD median block length data for 2000 were supplemented with 1990 data when 2000 data were missing, after validating that when both 1990 and 2000 median block length data were available, they were usually identical. A count of destinations was obtained within a 400 meter radius (approximately a quarter of a mile) of each participant's address, a commonly used distance which has been found to be inclusive of the majority of walking trips. Business data was taken from ESRI Business Analyst, which contained data from InfoUSA for businesses listed on January 1, 2006. Businesses were categorized according to North American Industry Classification System (NAICS) codes in order to select which businesses were possible retail walking destinations, and summed to create a count of the number of retail businesses within the 400 meter buffer.

Analytic Plan

All data were analyzed in SAS 9.2 statistical software(SAS). For the first aim, to look at disparities in neighborhood by neighborhood SES, Spearman's correlation coefficient was calculated for the relationship between each ordinal environmental variables and ordinal neighborhood poverty, ignoring the potential correlation caused by sampling by senior center (Table 1). For the second aim, to examine predictors of perceived neighborhood safety, analyses were conducted in two steps (Table 2). Ordered logistic regression was used to examine odds ratio between the three categories of crime safety. First, main effects were examined for separate unadjusted models for each of the standard hypothesized covariates and four objective neighborhood characteristics. Main effects with $p<0.05$ were considered significant. Second, all the covariates were combined into a final adjusted model, in which included all considered variables of interest and covariates. This model assumes that the odds ratios between categories of crime safety are the same, and that the resulting OR for a unit increase in the covariate is the same for when the odds are defined by any unit increase in the crime safety outcome. SAS PROC LOGISTIC was used to determine that the score test for this proportional odds assumption is not significant, and thus multinomial logistic regression is appropriate. The inference reported for all models accounted for clustering by senior center using a generalized estimating equation (GEE) approach with SAS PROC GENMOD (Zeger and Liang 1986).

Results

Perceived and objective neighborhood characteristics are associated with neighborhood poverty in the direction expected (Table 1). Participants living in low SES neighborhoods have objectively shorter block lengths, higher housing density, and more businesses. Participants living in low SES neighborhoods perceive less safety from crime, less traffic safety, more density, and greater percentages of apartments and condominiums. In looking at the predictors of crime safety, both individual characteristics as well as objective neighborhood characteristics were predictive of perceived crime safety (Table 2). In separate models, all of the hypothesized individual characteristics, except for age, as well as the four objective neighborhood

characteristics, are significantly associated with perceived crime safety. People living in less dense, sprawling neighborhoods are less likely to perceive their neighborhoods as unsafe due to crime then were people living in more dense, compact neighborhoods. Neighborhood socioeconomic status is highly associated with perceived crime safety, with residents of high poverty neighborhoods perceiving their neighborhoods as more unsafe than residents of low poverty neighborhoods. When all of the covariates were entered into a combined adjusted model, site, gender, financial resources, depression, how many people participants felt close to, and overall health are predictive of perceived crime safety, as are housing density, count of businesses, and neighborhood poverty. Despite adjustment for this large number of variables, neighborhood poverty still has the greatest effect size on predicting perceived crime safety.

Discussion

Physical activity, a critical component of healthy aging, varies by neighborhood socioeconomic status, and it is important to understand why. Perceptions of neighborhood, including perceptions of safety from crime, as well as neighborhood SES, are known to be associated with health behaviors and health outcomes. This analysis examines how neighborhood perceptions vary by neighborhood socioeconomic status, which contributes to an understanding of the pathways through which neighborhood SES might influences health outcomes. This analysis shows that perceptions of crime, which have been shown to be a determinant of walking behavior, to be influenced both by neighborhood SES as well as individual characteristics. An important strength of this analysis is the socioeconomic, geographic, racial, and functional diversity of study participants, as well a diversity of neighborhood environments.

Limitations: This is a cross-sectional study in which temporality cannot be established. Low income neighborhoods may share many characteristics besides crime safety that may impact health outcomes. In addition, we did not have objective data on crime rates in each neighborhood. Crime data which is available and comparable across the five counties for this study, like the FBI uniform crime reports, is available at the county level, a large area containing many neighborhood with much heterogeneity of crime rates within county boundaries. Crime statistics at a smaller neighborhood level would likely have to be calculated from crime data from each city's police departments, which may not result in data comparable across cities. Despite these limitations, this analysis is useful for demonstrating how objective and perceived neighborhood characteristics vary by neighborhood socioeconomic status, as well as the individual and neighborhood determinants of perceived crime safety in older adults.

Ultimately, policies which reduce actual crime would be expected to increase feeling of crime safety in older adults. Certainly, the large effect size of neighborhood socioeconomic status in predicting perceived safety suggests that perceived crime safety is closely dependent on objective crime rates. However, because perceived safety is also influenced by individual characteristics, and likely neighborhood experiences over the life course and not just current neighborhood conditions, older adults may require more than objectively low crime rates in order to feel safe enough to walk in their neighborhood. For example, low income residents may feel that they lack control over important aspects of their lives which leave them feeling more vulnerable to crime, regardless of actual objective crime rates. It is possible that interventions which target individuals in neighborhoods, such as walking clubs for older adults so they do not

need to walk alone, would both make them objectively safer as well as impact their perceived safety from crime, even in the absence of objective changes in overall neighborhood crime rates.

Future research which includes objective crime statistics comparable across the different counties would be desirable. This would allow not only an examination of how objective crime rates vary by neighborhood socioeconomic status, but also how perceived safety is dependent on objective crime rates in addition to personal characteristics, as well as what interactions are present. For example, in neighborhoods with low crime rates, people may feel generally safe regardless of individual characteristics, while in neighborhoods with high crime rates, perceptions of safety may be more dependent on personal characteristics such as functional capacity or gender. In addition to crime safety, other perceived neighborhood characteristics may be dependent on personal characteristics as well as objective neighborhood characteristics. For example, future research on this dataset will examine how people's perceptions of neighborhood destinations to walk to are possibly dependent both on objective neighborhood destinations as well as individual characteristics. Research examining neighborhood interventions would contribute greatly to untangling the true causal effects of various correlated aspects of neighborhoods.

Table 1. Characteristics of Neighborhood Perceptions by Neighborhood Poverty

	Neighborhood Poverty Greater than 20% (%)	Neighborhood Poverty 10-20% (%)	Neighborhood Poverty 5-10% (%)	Neighborhood Poverty Less than 5% (%)	Correlation	p value
NEWS variables						
Primary type of buildings in neighborhood					0.23	<0.0001
Residential	68.2	75.8	85.2	93.0		
Commercial or a mix of residential and commercial	31.8	24.2	14.8	7.0		
Primary type of housing in neighborhood					0.26	<0.0001
Single family homes	32.0	53.2	61.2	74.0		
Mix of single family homes and apartments/condos	49.2	35.3	28.5	19.0		
Apartments or condominiums	18.8	11.5	10.3	7.1		
Walking times to specific destinations					0.13	<0.0001
Long walking time to named destinations	20.2	26.8	27.0	33.3		
Somewhat long walking time to named destinations	21.7	16.4	23.2	21.5		

Somewhat short walking time to named destinations	26.4	24.6	26.6	27.8		
Short walking time to named destinations	31.8	32.3	23.2	17.4		
Land use mix/access to services scale					0.14	<0.0001
Low accessibility of services by walking	27.9	22.8	34.3	43.3		
Somewhat low accessibility of services by walking	30.2	25.6	22.3	23.0		
Somewhat high accessibility of services by walking	20.2	25.1	20.6	17.4		
High accessibility of services by walking	21.7	26.5	22.8	16.3		
Street connectivity scale					0.08	0.02
Low street connectivity	31.0	28.1	33.1	40.3		
Somewhat low street connectivity	24.0	20.3	21.5	18.7		
Somewhat high street connectivity	45.0	51.6	45.5	41.0		
Places for walking scale					0.08	0.02
Poor sidewalks/infrastructure for walking	26.4	26.6	36.5	35.3		
Somewhat poor sidewalks/infrastructure for walking	27.9	20.6	22.3	23.4		
Somewhat good sidewalks/infrastructure for walking	27.9	28.0	20.2	24.2		
Good sidewalks/infrastructure for walking	17.8	24.8	21.0	17.1		
Neighborhood surroundings scale					0.25	<0.0001
Not attractive/interesting neighborhood surroundings	47.3	28.0	25.3	13.0		
Somewhat not attractive/interesting neighborhood surroundings	21.7	33.0	36.5	26.8		
Somewhat attractive/interesting neighborhood surroundings	14.0	19.7	20.2	23.8		
Attractive/interesting neighborhood surroundings	17.1	19.3	18.0	36.4		
Traffic safety					0.18	<0.0001
Poor traffic safety	42.6	38.1	33.6	21.9		
Fair traffic safety	21.7	26.2	31.0	25.7		
Good traffic safety	20.2	19.3	16.0	19.0		
Excellent traffic safety	15.5	16.5	19.4	33.5		
Crime safety						
Feel unsafe from crime in neighborhood	46.9	27.8	13.4	2.2	0.44	<0.0001
Feel somewhat safe from crime in neighborhood	22.7	34.0	26.4	16.0		
Feel safe from crime in	30.5	38.2	60.2	81.7		

neighborhood						
Neighborhood satisfaction scale					0.11	<0.01
People DON'T know each other, assist each other, walk, and bike	42.2	30.7	37.1	21.6		
People somewhat DON'T know each other, assist each other, walk, and bike	25.8	31.7	32.3	36.4		
People somewhat know each other, assist each other, walk, and bike	11.7	10.6	13.4	11.9		
People know each other, assist each other, walk, and bike	20.3	27.1	17.2	30.1		
Lack of parking					0.22	<0.0001
Parking is easy	30.6	32.0	45.4	56.9		
Parking is somewhat easy	19.0	20.2	23.4	14.5		
Parking is somewhat difficult	28.9	28.1	21.1	19.2		
Parking is difficult	21.5	19.7	10.1	9.4		
Cul-de-sacs					0.11	<0.01
Lots of cul-de-sacs	11.8	21.7	19.1	28.4		
Some cul-de-sacs	13.4	12.4	17.8	14.9		
Few cul-de-sacs	25.2	19.4	18.3	17.5		
No cul-de-sacs	49.6	46.5	44.8	39.2		
Hilliness					0.08	0.02
Streets are hilly	20.5	14.8	18.5	12.3		
Streets are somewhat hilly	16.5	19.4	17.7	15.3		
Streets are somewhat flat	21.3	11.6	9.9	16.0		
Streets are flat	41.7	54.2	53.9	56.3		
Major barriers					0.10	<0.01
Major walking barriers	11.6	5.9	7.4	6.3		
Somewhat major walking barriers	7.8	9.1	6.9	9.0		
Few walking barriers	23.3	17.8	16.5	10.5		
No walking barriers	57.4	67.1	69.3	74.3		
GIS variables						
Median block length (feet)					0.55	<0.0001
Shortest block length (compact)	65.1	33.6	17.9	4.2		
Short block length	24.8	31.3	30.8	15.2		
Long block length	8.5	21.2	30.8	31.2		
Longest block length (sprawling)	1.6	13.8	20.5	49.4		
Count of businesses within 400m of participant's residence					0.36	<0.0001
Few businesses in area	9.3	24.1	30.4	51.9		
Somewhat few businesses in area	18.6	17.3	22.4	21.9		
More businesses in area	27.9	24.1	28.7	13.3		

Many businesses in area	44.2	34.6	18.6	13.0		
Housing density (per sq. mile)					0.44	<0.0001
Least dense (sprawling)	5.4	17.3	32.1	34.4		
Less dense	8.5	19.1	18.1	44.1		
More dense	35.7	24.1	27.0	17.8		
Most dense (compact)	50.4	39.6	22.8	3.7		

[a] p value for the Spearman correlation coefficient
[b] Neighborhood Environment
Walking Survey

Table 2. Odds self-reporting less crime safety

	Separate Unadjusted Models			Adjusted Models [a]		
	Odds Ratio	**95% CI**	**p value**	**Odds Ratio**	**95% CI**	**p value**
Main effects:						
Site			0.0002			0.0097
Allegheny County, PA	1.82	(1.01 - 3.09)		0.85	(0.49 - 1.47)	
Cook County, IL	0.59	(0.29 - 1.20)		0.73	(0.44 - 1.23)	
Wake and Durham Counties, NC	0.58	(0.33 - 1.03)		0.38	(0.21 - 0.70)	
Alameda County, CA (ref)	1.00			1.00		
Age			0.4927			0.7373
75+	0.90	(0.66 - 1.22)		1.06	(0.75 - 1.50)	
65-74 (ref)	1.00			1.00		
Sex			<0.0001			0.0003
Female	1.91	(1.38 - 2.62)		1.98	(1.37 - 2.86)	
Male (ref)	1.00			1.00		
Race			<0.0001			0.3621
Other race	6.58	(2.82 - 15.39)		2.35	(0.75 - 7.32)	
Two or more races	2.59	(0.91 - 7.37)		1.47	(0.47 - 4.58)	
African-American	3.34	(2.31 - 4.82)		1.62	(0.92 - 2.84)	
Asian	1.05	(0.35 - 3.16)		1.09	(0.45 - 2.60)	
White (ref)	1.00			1.00		
Current spouse			<0.0001			0.3769
No	1.98	(1.43 - 2.73)		0.83	(0.54 - 1.26)	
Yes	1.00			1.00		
Years of schooling			0.0008			0.5093
0-11 years	2.28	(1.49 - 3.50)		0.74	(0.43 - 1.27)	
12 years	1.39	(1.00 - 1.94)		0.82	(0.55 - 1.24)	
over 12 years (ref)	1.00			1.00		
Income			<0.0001			0.6524
Don't know/refused	3.52	(2.07 - 10.20)		1.55	(0.78 - 3.07)	
Less than $15,000	6.14	(3.7 - 10.2)		1.36	(0.69 - 2.65)	
$15,000-$24,999	4.62	(2.74 - 7.80)		1.56	(0.84 - 2.90)	
$25,000-$49,999	2.94	(1.72 - 5.02)		1.48	(0.78 - 2.80)	

$50,000 or more (ref)	1.00						1.00						
Financial resources meet needs						<0.0001							0.0001
Not adequately	4.34	(	2.57	-	7.31	)	3.39	(	1.77	-	6.48	)	
Somewhat adequately	3.09	(	2.22	-	4.30	)	1.74	(	1.23	-	2.46	)	
Very adequately	1.00						1.00						
Lower-body Function						0.0063							0.5185
Poor	1.81	(	1.14	-	2.90	)	0.73	(	0.45	-	1.19	)	
Fair	1.22	(	0.75	-	2.00	)	0.86	(	0.53	-	1.40	)	
Good	0.93	(	0.57	-	1.53	)	0.74	(	0.44	-	1.25	)	
Excellent (ref)	1.00						1.00						
Currently drive or access to driver						0.0029							0.8581
No	1.85	(	1.23	-	2.78	)	1.05	(	0.64	-	1.72	)	
Yes (ref)	1.00						1.00						
Depressed (CESD>=10)						<0.0001							0.0045
Yes	2.87	(	2.02	-	4.07	)	2.00	(	1.24	-	3.22	)	
No (ref)	1.00						1.00						
Overall Health						<0.0001							0.0261
Poor or fair	3.07	(	2.04	-	4.62	)	1.93	(	1.19	-	3.13	)	
Good	2.22	(	1.59	-	3.09	)	1.54	(	1.04	-	2.29	)	
Excellent (ref)	1.00						1.00						
How many people feel close to						<0.0001							0.0003
Feel close to 0-3 people	4.19	(	2.72	-	6.45	)	2.45	(	1.57	-	3.83	)	
Feel close to 4-5 people	1.83	(	1.13	-	2.98	)	1.43	(	0.80	-	2.56	)	
Feel close to 6-10 people	2.27	(	1.47	-	3.49	)	1.56	(	0.99	-	2.46	)	
Feel close to 11-20 people	1.00						1.00						
Objective environment variables													
Neighborhood poverty						<0.0001							<0.0001
Greater than 20%	14.04	(	8.98	-	21.96	)	5.33	(	2.62	-	10.88	)	
10-20%	7.41	(	4.80	-	11.46	)	4.63	(	2.66	-	8.06	)	
5-10%	3.04	(	1.95	-	4.74	)	2.38	(	1.47	-	3.84	)	
<5%	1.00						1.00						
Median block length (feet)						<0.0001							0.4706
Longest block length (sprawling)	0.19	(	0.11	-	0.34	)	0.62	(	0.31	-	1.24	)	
Long block length	0.33	(	0.2	-	0.54	)	0.80	(	0.46	-	1.41	)	
Short block length	0.52	(	0.32	-	0.84	)	0.97	(	0.57	-	1.65	)	
Shortest block length (compact)	1.00						1.00						
Count of businesses within 400m of participant's residence						<0.0001							0.0159
Few businesses in area	0.34	(	0.2	-	0.55	)	0.83	(	0.48	-	1.44	)	
Somewhat few businesses in area	0.7	(	0.45	-	1.08	)	1.65	(	0.98	-	2.79	)	
More businesses in area	0.86	(	0.59	-	1.26	)	1.37	(	0.89	-	2.11	)	
Many businesses in area	1.00						1.00						

Housing density (per sq. mile)						<0.0001							0.007
Least dense (sprawling)	0.32	(	0.19	-	0.55	)	1.68	(	0.87	-	3.25	)	
Less dense	0.21	(	0.13	-	0.32	)	0.80	(	0.45	-	1.42	)	
More dense	0.64	(	0.44	-	0.92	)	0.92	(	0.58	-	1.46	)	
Most dense (compact)	1.00						1.00						

Paper 2: Health Symptoms and Perceived Barriers to Walking in Older Populations

Introduction

The simple act of walking is associated with positive health and well-being among older adults (Lee and Buchner 2008). Although levels and intensity of physical activity tends to decline with age, walking represents the most common form of physical activity in older populations (Lee and Buchner 2008). Walking is classified as either a form of leisure-time physical activity or as a form of everyday mobility, i.e., "utilitarian walking." Given the positive health and functional benefits of walking, it is important to understand why some older adults are more likely than others to walk. In addition to clarifying the reasons for engaging in walking, research of this kind serves as the basis for designing and evaluating programs and policies to encourage walking among older adults.

Walking has been shown to be associated with a variety of individual, social, and environmental factors in older populations. In contrast to other types of health behaviors, older women are less likely than older men to walk and engage in other forms of physical activity (Haley and Andel 2010). There is also evidence that levels of walking and other forms of physical activity are associated with the number and types of health conditions. Older people diagnosed with chronic health conditions are less likely to walk than older adults with fewer health conditions (Ashe, Miller et al. 2009). In addition, older adults who live alone are less likely to walk than are older adults who live with others and have a more extensive social network (Satariano, Haight et al. 2002). There is also a growing body of research that indicates that older residents of high-density, mixed-use neighborhoods (i.e., businesses and services in close proximity to places of residence), and perceived as being safe for pedestrians and residents, are more likely to walk than older residents of other types of neighborhoods (Yen, Michael et al. 2009).

While it is very useful to identify a range of factors ***associated*** with walking, it is also important to ask older adults directly about what serves as barriers to walking as part of everyday life. For example, one study in the United Kingdom asked older adults about factors that impeded their level of walking (Dawson, Hillsdon et al. 2007; Dawson, Hillsdon et al. 2007). Women were significantly more likely than men to report concerns about safety and the absence of a walking companion as barriers to walking (34.6% vs. 13.6%). These results are consistent with a separate report of minority women aged 40 and older who reported concerns about safety as a significant barrier to everyday walking (Eyler, Baker et al. 1998).

To provide a more comprehensive assessment of reported barriers to walking among older adults, we report the results of a survey of older adults and their identification of barriers to walking associated with (a) common health symptoms and (b) other aspects of everyday life. In addition to identifying the overall prevalence of different types of barriers, the age and gender differences are specified.

Methods

Sample

The Healthy Aging Research Network (HAN) Walking Study is a cross-sectional study of health, functioning, and the social and built environments among older residents in four locations across the U.S. The sample consists of 884 people aged ≥ 65 years identified through senior organizations in Alameda County CA, Cook County IL, Allegheny County PA, and Wake and Durham Counties NC. These counties, selected from among participating sites in the CDC-funded HAN, reflect a range of weather and topographic patterns.

All senior organizations (in most cases, senior centers) were geocoded and categorized into quintiles of housing-density levels as a general proxy for "walking," based on the 2000 U.S. Census. In each geographic area, four senior organizations were randomly selected from each of the five categories to ensure variability in walkability. A maximum of 15 participants per center were recruited to reduce clustering by recruitment site.

Prospective participants completed a brief questionnaire to determine eligibility: aged ≥ 65 years, English-speaking and residing at current address for 12 months or more with no plans to move during the next 3 months. Exclusion criteria included any chronic or serious condition that could limit participation in unsupervised light-to-moderate physical activity, outdoor walking restricted on doctor's orders, self-reported inability to walk outdoors because of a medical condition, or signs of cognitive impairment sufficient to prevent completion of the interview. Enrollment was monitored to ensure recruitment of people with range of self-reported overall health.

Eligible participants were interviewed at the senior organization (78.7%); in the participant's home (17.4%); or at some other location (3.9%). Informed consent was obtained prior to the interview, as provided by the IRBs at each of the participating universities: University of California, Berkeley; University of Illinois, Chicago; University of Pittsburgh; and University of North Carolina, Chapel Hill. The interviews were conducted between September 2005 and November 2007.

Baseline Interview

The interview included a range of questions that addressed demographic and socioeconomic factors, living arrangements, neighborhood environment, chronic conditions and symptoms, psychosocial factors, and a range of questions on a variety of measures of functioning (Prohaska, Eisenstein et al. 2009; Satariano, Ivey et al. 2010). For the purposes of this report, however, the primary focus is on age and gender differences in reports of symptoms and the extent to which those symptoms cause difficulty in outdoor walking, as well as reports of other reasons that keep non-walkers from walking or walkers from walking more.

Study Variables

Symptoms. From a list of sixteen common symptoms, respondents were asked to report whether in the past month they experienced the symptom and, if so, whether the symptom caused the respondent difficulty when walking outside.

Other Reasons that Impeded Walking. Later in the interview, respondents were asked whether any of twenty-six reasons prevented them from walking if they did not walk or from walking more if they walked. They also had the opportunity to report a reason that was not listed.

Analysis Plan

All data were analyzed in SAS 9.2 statistical software. Reports of difficulty were summarized as "yes" or "no." Symptoms and other reasons were separately ranked-order by prevalence of reported difficulty for the total sample and separately for females and males by age (65-74 and 75 and older years). To examine differences in proportions between the group groups, (Women 65-74, Women 75+, Men 65-74, Men 75+) a Rao-Scott Chi-Square, taking into account clustering by senior center, was calculated.

Results

Symptoms that Cause Difficulty with Outdoor Walking

Respondents were asked about sixteen separate symptoms and whether those with the symptom experienced difficulty with outdoor walking. Eight, or half, of those symptoms were identified by at least 10 percent of the respondents as causing them difficulty with walking outdoors. The symptoms included leg pain (30.9%), fatigue (19.0%, back pain (17.7%), problems with glare (16.8%), leg weakness (16.0%), imbalance (14.0%), shortness of breath (13.7%), and bladder control issues (12.3%) (Table 2). Of these eight symptoms, three of the symptoms seem to demonstrate age and/or gender differences. For example, the percentage of respondents reporting that fatigue limited their outdoor walking increased by age for women and men. Problems with vision/glare, on the other hand, were most likely to be reported by women aged 75 and older.

Other Reasons that Impede Outdoor Walking

A variety of other factors are reported to cause difficulty with walking. The most serious impediment is bad weather. Over half (nearly 70%) of the respondents reported that bad weather is a limiting factor, especially among older women regardless of age. Other reasons reported by over 10 percent of the respondents included individual or situational barriers such as carrying heavy items (40.2%), lack of energy or laziness (38.8%), lack of time (26.6%), lack of interest (21.3%), and need to have car later in the day (21.1%). Social and safety barriers included concern about crime (36.7%), having no one to walk with (23.0%), concern about not being seen if help was needed (18.4%), and concern about being able to call for help in an emergency (17.2%). In addition to bad weather, other environmental impediments included that distances are too great to travel (42.4%), concern that there are no good places to stop and rest along the way (30.5%), lack of restrooms (28.0%), unattended dogs (27.1%), poor lighting (25.1%), traffic (21.3%), hills (20.4%), dangerous street-crossing conditions (18.3%), no safe place to walk (14.1%), lack of sidewalks or continuous sidewalks (12.9%) and not knowing where to shop or run errands within walking distance (10.3%).

It seems clear that safety-related reasons are more likely to be reported by older women than by older men. These reasons included concerns about crime or dangerous people, unattended dogs, not enough lighting at night, lack of a walking companion, too much traffic, dangerous street crossing, concern that no one would be there to see or call upon if help was required, no sidewalks or continuous sidewalks, and having no safe place to walk nearby.

Most participants reported multiple barriers to walking outside. Specifically, 55.2 percent reported that at least one symptom caused difficulty in walking outside, with a range of 0-15 and a mean of 1.9 symptoms causing difficulty. A total of 94.5 percent reported at least one other barrier to walking outside or walking more, with a range of 0-24 and a mean of 6.2 barriers. Overall, 95.5 percent reported at least one health symptom or other barrier to walking, with a range of 0-37 and a mean of 7.9 barriers.

Discussion

Older adults report multiple barriers to walking. These barriers include health symptoms, as well as social and environmental factors. Key symptoms that impede walking include age-related impairments associated with reduced lower-body strength (leg pain and weakness), back pain, imbalance, fatigue, shortness of breath, problems with glare, and problems with urinary urgency. It is fair to assume that the level of difficulty with walking is due to the number and severity of these symptoms. It is also fair to assume, however, that the effects of these symptoms can be either aggravated or moderated by other factors, including social and environmental factors, such as the relative distance of destinations, hills, and/or the presence of an exercise companion.

Programs and policies to enhance walking among older adults may include some combination of interventions to enhance capacity, e.g., improving lower-body strength and balance, providing social supports, e.g., an exercise companion, reducing environmental challenges and/or providing environmental supports. Addressing one factor may be necessary, but not sufficient to enhance walking. These interventions may include enhancing capacity, e.g., improving vision through better glasses, in conjunction with strategies to adapt to the environment by providing maps of safe walking routes (Rosenberg, Kerr et al. 2009; Satariano WA 2011, In press). Environmental modifications, on the other hand, can range from modest interventions that include extending the time of timed pedestrian crossing signals, painting the surfaces of walls and sidewalks to reduce glare, the placement of shaded benches and drinking fountains to more extensive changes that include the installation of accessible and clean restrooms, the placement of pedestrian crossing islands, and traffic calming devices. In the end, it may also involve the adaptation of universal design principles and health impact assessment in the planning process to improve community design for walking outside for older adults as well as other members of the community.

Finally, the results underscore the importance of gender in the study of barriers to walking among older adults. For example, older women are more likely than older men to report that carrying heavy items impedes their ability to walk outdoors. This is consistent with research that indicates that older women have less upper-body strength and poorer grip strength than older men (Desrosiers, Bravo et al. 1995). However, the most dramatic gender differences in this area

are related to safety. A systematic program or policy to enhance walking in older adults, especially older women, must address the issue of safety. This could include the provision of safe walking routes, greater surveillance of public places, and wider dissemination of cell phones to ensure contact with others. Other strategies may include programs to facilitate the location of walking companions or groups or the provision of controlled walking environments, such as provided by "mall walking programs."

In conclusion, this report is designed to provide an overview of the barriers older adults face in walking outdoors as part of everyday life. Systematic interviews with older adults themselves about these barriers will enhance research and practice in aging and mobility.

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Table 1:

Symptoms causing difficulty walking outside	**Study Population (%)**	**Females 65-74 (%)**	**Females 75+ (%)**	**Males 65-74 (%)**	**Males 75+ (%)**	**Rao-Scott Chi-Square p value**
Pain in one or both legs (including hips, knees, ankles, feet)	30.9	32.1	30.8	23.7	33.3	0.46
Tired easily	19.0	16.9	22.4	10.9	23.0	0.03
Pain or spasm in your back or spine	17.7	17.5	18.4	14.0	19.3	0.75
Trouble seeing due to glare	16.8	14.6	21.7	12.9	13.2	0.04

General weakness in legs	16.0	13.4	18.2	14.0	19.3	0.37
Trouble keeping balance	14.0	11.5	17.7	9.7	15.2	0.06
Shortness of breath	13.7	12.9	16.1	7.5	14.3	0.21
Need to use the bathroom frequently and/or urgently without warning	12.3	10.6	14.5	9.8	13.4	0.37
Problems straightening up or standing tall	9.6	7.3	11.7	5.4	14.0	0.03
Dizziness or lightheadedness	7.7	7.0	9.4	4.3	7.9	0.41
Problems with memory	7.0	6.7	8.5	0	9.6	0.18
Pain or stiffness in your neck	6.5	6.5	7.2	3.2	7.0	0.63
Trouble seeing steps	5.9	3.7	9.2	7.5	2.6	<0.01
Trouble concentrating	3.6	4.2	3.5	2.2	3.5	0.81
Trouble starting or stopping a movement	3.4	3.4	3.5	1.1	5.4	0.45
Pain or discomfort in chest	3.1	2.5	3.8	2.2	3.5	0.72

Table 2:

Reasons keeps from walking [non-walkers] or from walking more [walkers].	**Study Population (%)**	**Females 65-74 (%)**	**Females 75+ (%)**	**Males 65-74 (%)**	**Males 75+ (%)**	**Rao-Scott Chi-Square p value**
Bad weather	66.7	69.9	69.0	59.8	55.8	0.01
Distances to places are too great	42.4	43.7	45.1	31.5	39.8	0.15
Having to carry heavy items	40.2	44.2	43.8	25.0	30.1	<0.01
A lack of energy or lazy or just do not feel up to it	38.8	38.9	41.9	31.5	36.3	0.43
Concern about crime	36.7	44.2	40.6	17.4	17.7	<.0001

or dangerous people						
Concern that there are no good places to stop and rest along the way	30.5	32.7	33.9	14.1	27.4	<0.01
No convenient restrooms along the way	28.0	34.4	25.6	21.7	19.5	<0.01
The presence of unattended dogs	27.1	33.0	28.4	16.3	14.2	<.0001
Lack of time	26.6	28.2	29.4	20.7	18.6	0.09
Not enough lighting at night	25.1	28.5	25.9	14.1	21.2	0.04
Having no one to walk with you	23.0	26.8	24.6	14.1	14.2	0.01
Too much traffic	21.3	19.7	26.8	9.8	20.4	<0.01
A lack of interest in walking	21.3	21.1	19.5	25.0	23.9	0.62
A need to have your car later in the day	21.1	25.1	19.5	17.4	15.9	0.15
Too many hills	20.4	18.9	26.2	13.0	15.0	<0.01
Concern about your health	18.6	18.6	20.4	9.8	20.4	0.08
Concern that no one would see you if you needed help	18.4	19.4	22.7	7.6	12.4	<0.001
The presence of dangerous street-crossing conditions	18.3	18.3	21.7	8.7	16.8	0.05
Concern that walking would make you too tired	17.2	13.5	20.8	13.0	22.1	0.05
Concern that you could not call on someone to help you if you needed help	16.8	17.7	19.8	9.8	11.5	0.05
Having no safe places to walk nearby	14.1	15.2	16.6	9.8	7.1	0.05
No sidewalks or no continuous sidewalks	12.9	11.8	18.5	8.7	4.4	<0.01
Concern about your vision or eyesight (e.g. glare)	11.1	8.7	16.3	4.3	9.7	<0.001
Not knowing where	10.3	9.3	12.5	5.4	11.5	0.18

to shop or run errands within walking distance						
Concern that it would not look right for someone your age to walk to shop or run errands	4.9	5.9	5.8	1.1	2.7	0.18
Having care giving responsibility	4.5	5.4	4.8	2.2	2.7	0.42

Paper 3: Self-Reported Physical Activity, Neighborhood Characteristics, and Socioeconomic Status in Older Adults

Background

"Few factors contribute as much to successful aging as having a physically active lifestyle. Regular physical activity is important for the primary and secondary prevention of many chronic diseases (e.g., coronary heart disease, non-insulin-dependent diabetes mellitus, obesity), disabling conditions (e.g., osteoporosis, arthritis), and chronic disease risk factors (e.g., high blood pressure, high cholesterol)" (CDC website(CDC 2003)).

Physical activity is essential to healthy aging, including a variety of health outcomes and maintaining physical function and mobility. Despite the known health benefits of physical activity, many older adults do not meet recommendations for leisure time physical activity. Increasing physical activity is an explicit goal of Healthy People 2020. A CDC/Health Canada evidence-based symposium in 2000 found evidence supporting a dose-response relationship between physical activity and many health outcomes, including all cause-mortality, total cardiovascular disease, coronary heart disease incidence and mortality, incidence of type II diabetes mellitus, and weight loss in randomized controlled trials lasting less than 16 weeks (Kesaniemi, Danforth et al. 2001). Increased physical activity may also contribute to meeting other Healthy People 2020 goals, such as reducing disparities in health outcomes experienced by different socioeconomic and racial/ethnic groups. Much research attention has recently been focused on trying to understand how the characteristics of the physical and social environment influence physical activity behavior. This work has integrated the research traditions of transportation and land use planning into understanding how the physical environment influences walking behavior. The International Obesity Task Force identifies numerous determinants of physical activity and obesity, including the availability of leisure activity facilities, public transportation, and public safety (Kumanyika 2001). In a sample of adults in San Diego, which over-represented high income white adults, it was found that among people who were initially sedentary at the start of the study, self-efficacy, younger age, and neighborhood environment predicted the adoption of vigorous exercise in men, and education, self-efficacy, and friend and family support for exercise predicted the adoption of vigorous activity in women (Sallis, Hovell et al. 1992). People who perceive their neighborhood to be unsafe are less likely to be physically active (MMRW 1999). Frequency of seeing others in the neighborhood has also been found to be associated with physical activity (King, Castro et al. 2000). Focus groups of US ethnic minority women over age forty found that the most commonly reported environmental barriers to physical activity were safety, availability, and cost (Eyler, Baker et al. 1998). Studies in Alameda County have found neighborhood poverty to be associated with physical inactivity (Yen and Kaplan 1998), and self-reported neighborhood problems to be associated with overall and lower extremity functional loss in older adults (Balfour and Kaplan 2002).

Socioeconomic status has been associated with numerous health outcomes, including physical activity. Beyond measures of individual socioeconomic status such as individual income and education, neighborhood socioeconomic status has been found to be associated with physical activity outcomes (Lee, Cubbin et al. 2007). There are various pathways which may mediate this

relationship, including the neighborhood environment. The effects of neighborhood environment may be different for older adults than for other age groups (Shigematsu, Sallis et al. 2009).

Previous research has pointed to the importance of feeling safe from crime as an important neighborhood determinant of physical activity. Older adults who reported feeling unsafe from crime have been found to be less likely to walk for at least 150 minutes per week (Satariano, Ivey et al. 2010). Focus groups and photo voice with African Americans over 60 living in an urban area found that safety from crime, along with the presence of people and characteristics of the surroundings were frequently identified as important to outside walking (Gallagher, Gretebeck et al. 2010). Browning reports that older adults who report feeling less safe report less physical activity (Browning, Sims et al. 2009). An Australian qualitative study of women age 18-65 found that low income but not high income women mentioned neighborhood safety as a barrier to physical activity (Ball, Salmon et al. 2006).

Energy expenditure, one measure of physical activity, is a function of body size and physical activity. A variety of self-reported physical activities can be combined into one summary measure of energy expenditure with the Compendium of Physical Activity. The compendium was first published in 1993 by Ainsworth, with an update published in 2000 (Ainsworth, Haskell et al. 1993; Ainsworth, Haskell et al. 2000). It is a compilation of the best available MET values from various research sources for different physical activities, and has been widely used for research purposes. While the Compendium does not take into account body size, it does provide an average MET value that is useful for comparing levels of physical activity in different people engaging in different activities. A study of multiethnic women 40 and over found that compared with self-reported intensities, Compendium estimated intensities were more closely related to pedometer counts, and also led to greater estimates of kilocalories per day (Wilcox, Irwin et al. 2001). However, differences in estimates based on participant-rated intensities versus compendium-coded estimates did not vary by race, age, education, or obesity status (Wilcox, Irwin et al. 2001) suggesting that any bias in over or under estimates of METS values from Compendium values would be similar across these groups. This lack of bias between groups suggests that compendium coded values are useful for distinguishing more active and less active participants.

The specific aims of this study are to:

1) Examine the proportion of older men and women who engage in various physical activities

2) Examine the perceived and objective neighborhood correlates of physical activity in older adults

Materials and Methods:

Sample Population

The Healthy Aging Research Network (HAN) Walking Study is a cross sectional study conducted between 2005 and 2007. This analysis is based on interviews with 884 participants

aged 65 and older, recruited from senior centers in Alameda County, CA; Cook County, IL; Allegheny County, PA; and Durham and Wake Counties, NC. Inclusion criteria included age 65 and older, English-speaking, lived in the county of interest, and had lived at current address for at least one year with no plans to move in the next three months. Exclusion criteria included self-reported inability to walk outdoors because of a medical condition or doctor's orders, or exhibiting signs of cognitive impairment sufficient to impede completion of the informed consent, interview or walking diary. The inclusion/exclusion criteria ensured that all participants were healthy enough to potentially walk outdoors, but include participants with a range of physical functioning. Subjects were recruited from senior serving organizations, primarily senior centers, in the counties of interest. In each county, a sampling frame was created of senior organizations. A random sample of senior centers was selected for recruitment, stratified by housing density, to ensure a diversity of environments. Study staff visited the senior centers at different times of day and days of the week to ensure that participants who were there for a variety of purposes were recruited. The protocols were approved by IRBs at each of the four study sites and informed consent was obtained from all participants. The study is described in greater detail in Satariano 2010 (Satariano, Ivey et al. 2010).

Study Variables

Covariates: Standard covariates found in previous research to be associated with physical activity were self-reported in an in-person interview. These include age, gender, race, current spouse, years of schooling, income, and whether or not the participant currently drives a car or other motor vehicle or has someone who drives them on a regular basis,

During the interview, lower-body functional capacity was measured with a modified version of the Short Physical Performance Battery (SPPB) (Guralnik and Simonsick 1993; Guralnik, Simonsick et al. 1994; Guralnik, Ferrucci et al. 1995) as described in Satariano 2010 (Satariano, Ivey et al. 2010), and included walking speed, one-legged stand, full and semi-tandem stand, and chair stand. This modified SPPB, like the original version, was summarized in quartiles from poor to excellent lower-body function.

Perceived neighborhood environment: Measurement of the perceived neighborhood environment used questions from the abbreviated Neighborhood Environment Walkability Scale (NEWS). The NEWS is a widely used tool for measuring people's perceptions of their neighborhoods on the domains of importance to walking behavior. The NEWS has been validated, and in addition, a factor analysis of the NEWS components was used to create an abbreviated NEWS with domains of related items. The NEWS is a standard set of questions divided into subscales. This analysis used an abbreviated scoring scheme developed by Saelens and colleagues (Saelens, Sallis et al. 2003; Cerin, Saelens et al. 2006; Adams, Ryan et al. 2009; Cerin, Conway et al. 2009) for each of the subscales, using a 4-point scale from 1 (*strongly disagree*) to 4 (*strongly agree*). Results for each subscale were summed, and then totals were divided into quartiles. The algorithm used to divide into quartiles sometimes results in less than four categories when over a quarter of participants reported the same score. In the case of crime safety, more than a quarter of the participants reported the same highest possible score for crime safety, resulting in three instead of four categories of perceived crime safety.

Objective neighborhood environment: Home addresses were collected from study participants and geocoded with GIS. The first round of geocoding was done using ESRI Business Analyst 9.2. For the second round of geocoding, ArcInfo 9.3 was employed to take advantage of improvements to the base map. Geocoding provided both a point location and a census tract for each participant. Data sources included 2000 U.S. Census data from the SF3 files for census tract housing unit density and percent of households below poverty, and RAND Center for Population Health and Health Disparities (CPHHD) database for census tract median block length. The CPHHD median block length data for 2000 were supplemented with 1990 data when 2000 data were missing, after validating that when both 1990 and 2000 median block length data were available, they were usually identical. A count of destinations was obtained within a 400 meter radius (approximately a quarter of a mile) of each participant's address, a commonly used distance which has been found to be inclusive of the majority of walking trips. Business data was from ESRI Business Analyst, which contained data from InfoUSA for businesses listed on January 1, 2006. Businesses were categorized according to North American Industry Classification System codes in order to select which businesses were possible retail walking destinations, and summed to create a count of the number of retail businesses within the 400 meter buffer.

Physical activity: Physical activity was self-reported based on an adaptation of the Study of Physical Performance and Age-Related Changes in Sonomans (SPPARCS) study protocol (Tager, Hollenberg et al. 1998). Participants were asked to report whether or not they engaged in 17 physical activities, as well as "other" physical activities in a typical week. If they engaged in an activity, they were asked to report how many times per week and minutes per session they engaged in that activity. A total MET score was calculated based on the Compendium of Physical Activity 2000 update (Ainsworth, Haskell et al. 2000). A cut point of 50 METS per week was chosen to divide the participants approximately equally into high and low physical activity. 50 METS per week is equivalent to 3000 MET-minutes per week, the cut point for "high" levels of physical activity recommended in the scoring protocol for the International Physical Activity Questionnaire (IPAQ), an instrument similar to the SPARRCS instrument(Ainsworth BE).

Analytic Plan

All data were analyzed in SAS 9.2 statistical software. In table 1, examining the proportion of men and women who engaged in each individual physical activity, a chi-square statistic was used, not taking into account the clustering of senior centers. In table 2, looking at the correlates of physical activity, the analyses were conducted in two steps. Logistic regression was implemented with SAS PROC GENMOD. The standard errors were derived using a generalized estimation equation (GEE) approach, adjusting for potential correlation at the senior center level (Zeger and Liang 1986). First, main effects were examined for separate unadjusted models for each of the standard covariates (site, age, gender, race, income, education, access to a car, lower body function) and four objective and fourteen self-reported neighborhood characteristics. Results are reported in column 1 of table 2. Second, all the individual covariates and the environmental variables that were significant with $p<0.01$ were combined into a final model (results shown in column 2 of table 2). Environmental variables with $P<0.01$ were included in order to be conservative and reduce the number of related environmental variables

included in the models, and since several of the variables between $p<0.01$ and $p<0.05$ did not have a dose response or other interpretable relationship. In addition, a sensitivity analysis was conducted to examine only METS spent in the "traditional exercise" leisure time physical activity as calculated from items 1-12 of Table 1, not including yard and housework, errands, care giving, etc.

Results

The most frequent type of activity reported by both women and men was light housework (93.0%) and shopping or running errands (93.0%), followed by walking at a normal or leisurely pace (77.7%). Of the "traditional exercises," women were significantly more likely than men to report strengthening exercises, aerobics, dancing, and yoga and tai chi, while men were significantly more likely than women to report jogging or running, doubles tennis, cardio gym equipment, and cycling (on level ground.) In the other category of physical activity, women were significantly more likely than men to report housework (both heavy and light), shopping or running errands, and caring for another person. Men were significantly more likely than women to report heavy yard work or gardening and home repairs.

In dichotomizing our participants into "high" and "low" physical activity, the cut point of 50 METS was used, with 60.4% of women and 48.5% of men meeting the criteria for "high" levels of physical activity. The percentage of participants meeting "high" levels of physical activity is higher than expected from other studies, likely due to the inclusion on not only the "traditional exercise" leisure time physical activities found in many studies but other activities such as yard work, housework, errands, care giving, and 'other' physical activities. In the sensitivity analysis when only the "traditional exercise" activities were included, and participants were dichotomized as to more or less than 20 METS/week in these traditional exercises, more men (55.3%) than women (45.2%) achieved the cut point of 20 METS/week.

In the unadjusted models, geographic site, age, gender, race, having a current spouse, education, income, lower body function, drives a car or access to driver were associated with physical activity. Of the four objectively measured neighborhood characteristics, neighborhood poverty was associated with physical activity in the direction expected, with participants living in neighborhoods with higher poverty having higher odds of being in the low activity category. Of the perceived neighborhood characteristics, primary type of housing in neighborhood and perceived safety from crime were significantly associated were associated with physical activity. Participants who reported feeling less safety from crime and participants who reported more apartments or condominiums as compared to single family housing in their neighborhood were more likely to be in the low reported activity group. When the variables were all put into the same model, crime safety but not neighborhood poverty nor primary type of neighborhood housing were associated with physical activity. Further analysis looking for possible interactions showed that here was no interaction between either crime safety and income, nor crime safety and neighborhood SES (results not shown). While this is a cross-sectional analysis in which we cannot determine temporality, these results are consistent with the theory that perceptions of crime may mediate the relationship between neighborhood socioeconomic status and physical activity outcomes.

In a sensitivity analysis examining only the "traditional exercise" measures (1-12) used in many physical activity studies separately, neighborhood attractiveness and accessibility of neighborhood services were also associated with leisure time physical activity in the unadjusted but not the final model (results not shown), perhaps because walking is more heavily weighted when the more limited rather than the full list of physical activities is considered.

Discussion

In addition to providing information about the different physical activities engaged in by older men and women, this analysis confirms other research that both neighborhood socioeconomic status and perceived safety from crime are associated with physical activity. The combined model is suggestive that perceived safety from crime might be a mediator of the relationship between neighborhood socioeconomic status and physical activity. An important strength of this analysis is the socioeconomic, geographic, racial, and functional diversity of study participants, as well a diversity of neighborhood environments.

Limitations: This study is a cross-sectional study, in which temporality cannot be determined. However, it does provide estimates of what physical activities older adults are engaging in a diverse population of older adults attending senior centers. Neighborhood poverty is highly associated with physical activity in the unadjusted model, and yet that relationship disappears in the adjusted model. The other variables in the model, such as perceived safety from crime, may not be confounders but mediators of the relationship between neighborhood socioeconomic status and physical activity. Including mediators in the final model would lead to an underestimate of the effects of neighborhood socioeconomic status, but it is revealing nonetheless to examine how the model changes with the inclusion of various variables.

Future Directions: This analysis combined multiple types of physical activity into one summary measure. As Giles-Corte pointed out, increased specificity of different physical activities with different specific characteristics of the environment are warranted (Giles-Corti, Timperio et al. 2005). Planned future analysis with this dataset may examine hypotheses related to more specific physical activities, such as walking for recreation and walking for transportation.

In conclusion, safe neighborhoods may be expected to contribute to increased physical activity in older adults. The disparities that are seen descriptively in physical activity by neighborhood SES are important determinants of health outcomes regardless of what pathways they are operating through. In this analysis, it appears that individual factors as well as perceptions of safety from crime may mediate the relationship between neighborhood SES and physical activity. Policies that lead to actual increased safety from crime may be expected to lead to changed perceptions of safety, which may lead to increases in physical activity.

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Table 1

Leisure time physical activities (LTPA)	Female respondents engaging in activity (%)	Male respondents engaging in activity (%)	Total respondents engaging in activity (%)	p*	MET values per hour
"Traditional exercise" physical activities					
Jogging or Running	2.2	5.8	3.1	<0.01	7.0
Walking at a brisk pace	40.6	38.1	40.0	0.52	5.0
Walking at a normal or leisurely pace	78.7	74.6	77.7	0.24	3.5
Swimming laps	5.5	5.3	5.4	0.93	7.0
Singles Tennis	0.3	1.0	0.5	0.21	8.0
Doubles Tennis	0.6	2.9	1.1	<0.01	6.0
Cardio gym equipment	26.9	39.1	29.8	<0.001	7.0
Strengthening exercises	49.8	39.6	47.4	0.01	3.5
Aerobics, water aerobics	29.8	11.1	24.5	<0.0001	4.0
Dancing	19.1	10.6	17.1	<0.01	6.5
Cycling on hills	0.6	1.9	0.9	0.07	10.0
Cycling on level ground	3.3	10.1	4.9	<0.0001	8.0
Hiking on hills or backpacking	2.7	3.9	2.9	0.37	7.0
Golf	2.4	3.9	2.7	0.24	4.5
Yoga or Tai Chi	20.7	13.5	19.0	0.02	4.0
Other Physical activities					
Yard work, gardening (heavy)	15.9	23.7	17.7	<0.01	6.0
Yard work, gardening (light)	49.2	49.3	49.2	0.98	4.0
Housework (heavy)	61.2	37.7	55.7	<0.001	4.0
Housework (light)	96.5	81.6	93.0	<0.0001	2.5
Shop or run errands	96.5	81.6	93.0	<0.001	2.3
Home repairs	4.0	17.9	7.2	<0.0001	3.0

Care for another person	13.2	6.8	11.7	0.01	3.0
Other physical activities not mentioned	15.1	18.1	15.8	0.30	variable

*Chi-square comparing males and females

Table 2

Odds self-reporting less than 50 METS/week of physical activity

	Separate Unadjusted Models			Fully adjusted model		
	Odds Ratio	**95% CI**	**p value**	**Odds Ratio**	**95% CI**	**p value**
Main effects:						
Site						
Allegheny County, PA	1.79	(1.18 - 2.73)	0.01	1.81	(1.11 - 2.97)	0.11
Cook County, IL	1.17	(0.79 - 1.72)		1.18	(0.72 - 1.95)	
Wake and Durham Counties, NC	1.75	(1.14 - 2.70)		1.85	(1.08 - 3.16)	
Alameda County, CA (ref)	1.00			1.00		
Age						
75+	1.44	(1.15 - 1.81)	<0.01	1.18	(0.88 - 1.57)	0.26
65-74 (ref)	1.00			1.00		
Sex						
Female	0.62	(0.44 - 0.86)	<0.01	0.42	(0.27 - 0.65)	<0.0001
Male (ref)	1.00					
Race						
Other race	1.38	(0.54 - 3.51)	<0.001	1.71	(0.57 - 5.10)	0.07
Two or more races	1.24	(0.45 - 3.43)		0.76	(0.17 - 3.39)	
African-American	2.28	(1.58 - 3.38)		1.86	(1.18 - 2.93)	
Asian	0.90	(0.45 - 1.79)		1.11	(0.53 - 2.32)	
White (ref)	1.00			1.00		
Current spouse						
No	1.89	(1.45 - 2.46)	<0.0001	1.40	(1.01 1.93)	0.04
Yes	1.00			1.00		
Years of schooling						
0-11 years	2.28	(1.42 - 3.67)	<0.001	1.05	(0.59 - 1.87)	0.25
12 years	1.09	(0.80 - 1.48)		0.78	(0.53 - 1.15)	
over 12 years (ref)	1.00			1.00		
Income						
Don't know/refused	2.50	(1.57 - 3.98)	<0.0001	1.58	(0.91 2.76)	0.03
Less than $15,000	3.72	(2.35 5.91)		2.05	(1.08 - 3.89)	
$15,000-$24,999	1.45	(0.92 - 2.29)		0.90	(0.51 - 1.61)	
$25,000-$49,999	1.35	(0.87 - 2.10)		1.12	(0.68 - 1.87)	
$50,000 or more (ref)	1.00			1.00		
Lower-body Function						
Poor	3.48	(2.33 - 5.19)	<0.0001	2.83	(1.82 4.42)	<0.0001
Fair	1.71	(1.10 - 2.65)		1.39	(0.85 2.29)	
Good	1.43	(0.84 - 2.42)		1.60	(0.89 2.86)	
Excellent (ref)	1.00			1.00		

Currently drive or access to driver													
No	2.60	(	1.76		3.83	)	<0.0001	2.07	(	1.32	-	3.23	)	<0.01
Yes (ref)	1.00							1.00						
Significant main effects for environmental variables														
Primary type of housing in neighborhood														
Single-Family homes	0.53	(	0.34	-	0.83	)	<0.001	0.72	(	0.42	-	1.22	)	0.21
Mix of single family homes and apartments/condos	0.91	(	0.57	-	1.47	)		0.96	(	0.54	-	1.69	)	
Apartments and condominiums	1.00							1.00						
Crime safety														
Feel unsafe from crime in neighborhood	1.85	(	1.27	-	2.70	)	<0.01	1.61	(	1.04		2.48	)	0.03
Feel somewhat safe from crime in neighborhood	1.43	(	1.05	-	1.95	)		1.48	(	1.00		2.19	)	
Feel safe from crime in neighborhood (ref)	1.00							1.00						
Neighborhood poverty														
Greater than 20%	2.50	(	1.48	-	4.22	)	<0.01	0.67	(	0.35	-	1.29	)	0.54
10-20%	1.62	(	1.10	-	2.37	)		0.72	(	0.44	-	1.20	)	
5-10%	1.28	(	0.84	-	1.95	)		0.08	(	0.47		1.18	)	
<5%	1.00													

[a] All covariates adjusted for each other

Significant main effects for environmental variables >0.01 and <0.05

Count of businesses within 400m of participant's residence				
Few businesses in area	0.61	0.41	0.89	0.01
Somewhat few businesses in area	0.63	0.43	0.91	
More businesses in area	0.96	0.06	1.45	
Many businesses in area	1.00			
Places for walking scale				0.03
Poor sidewalks/infrastructure for walking	0.76	0.53	1.09	
Somewhat poor sidewalks/infrastructure for walking	1.08	0.72	1.63	
Somewhat good sidewalks/infrastructure for walking	1.29	0.86	1.92	
Good sidewalks/infrastructure for walking	1.00			
Major barriers				0.03

Major walking barriers	0.69	0.37	1.29	
Somewhat major walking barriers	1.19	0.70	2.01	
Few walking barriers	1.83	1.18	2.84	
No walking barriers	1.00			
Neighborhood satisfaction scale				<0.05
People DON'T know each other, assist each other, walk, and bike	1.37	0.97	1.95	
People somewhat DON'T know each other, assist each other, walk, and bike	0.90	0.67	1.22	
People somewhat know each other, assist each other, walk, and bike	1.37	0.83	2.24	
People know each other, assist each other, walk, and bike	1.00			

Conclusions

Place matters to healthy aging. The preceding three analyses contribute to an understanding of how the characteristics of neighborhoods influence mobility, especially walking behavior and physical activity. Socioeconomic status and neighborhood environment have been associated with numerous health outcomes, including physical activity. Beyond measures of individual socioeconomic status such as individual income and education, neighborhood socioeconomic status has been found to be associated with physical activity outcomes (Lee, Cubbin et al. 2007). There are various pathways which may mediate this relationship, including aspects of the neighborhood environment. The affects of neighborhood environment may be different for older adults than for other age groups (Shigematsu, Sallis et al. 2009). The first analysis presented found that participants living in low SES neighborhoods have objectively shorter block lengths, higher housing density, and more businesses. Participants living in low SES neighborhoods perceive less safety from crime, less traffic safety, more density, and greater percentages of apartments and condominiums. This suggests possible pathways through which neighborhood SES might influence walking behavior and other health outcomes. In addition, this analysis shows how perceptions of crime are influenced by both individual as well as objectively measured neighborhood conditions. The second analysis, in which people self-reported barriers to outdoor walking, crime safety emerged as a barrier for over a third of study participants, validating the findings in the third analyses that perception of safety from crime was associated with physical activity. The second analysis also brings attention to the reality that many older adults face multiple barriers to walking outside, both from individual symptoms as well as environmental concerns such as crime safety, traffic safety, and distances to destinations. This finding is consistent with the work of Shumway-Cook, who found that neighborhood environment is associated with mobility disability (Shumway-Cook, Patla et al. 2002; Shumway-Cook, Patla et al. 2003). The fact that participants self-report these environmental factors as barriers to walking supports the research examining neighborhood correlates of walking. The high number of barriers suggests a new possible model for future research as well as interventions. It is reasonable to hypothesize that when individuals face multiple barriers to a behavior such as walking, they may not engage in the behavior until all of the barriers are removed. For example, an individual who avoids walking due to back pain, fear of crime, and fear of traffic many not engage in walking in their neighborhood until all of these barriers are removed, or they learns how to circumvent or navigate around all of these barriers. For example, Shumway-Cook found that adults with mobility disabilities were more likely to walk shorter distances, walk with others, and carry less items than adults without mobility disabilities (Shumway-Cook, Patla et al. 2002). Interventions need to be multilevel and address the multiple barriers faced by older adults in order to be effective. The final analysis showed that physical activity in older adults is also influenced by neighborhood factors. Perceptions of crime safety are a possible mediator of the relationship between neighborhood socioeconomic status and physical activity. This is consistent with previous work which found that neighborhood environments, perceptions of safety for walking and number of nearby recreational facilities were associated with walking in older adults (Li, Fisher et al. 2005)

Frequently in epidemiological research, self-reported perceptions are viewed as inferior to objectively measured variables. When examining something as complex as walking behavior, however, looking at perceived barriers and perceived neighborhood attributes may contribute information beyond what can be objectively measured. For example, in addition to the objective

crime rates in their neighborhood, an individual's experiences over their life course may contribute to their perceptions of safety. Some researchers resolve the discrepancies between objectively and subjectively reported variables by treating the subjectivity measured variables as merely mis-measured objective characteristics, and perform validation studies in an attempt to quantify the measurement error that occurs when substituting subjective for objective measurements. Other researchers treat objectively measured and perceived characteristics as two completely separate constructs, and ignore the fact that perceived neighbor characteristics are likely based at least partly on objective characteristics. This leads to analyses which try to determine if objective or perceived characteristics are more important to walking behavior, which is a false dichotomy if perceived characteristics are in fact based on objective characteristics. If we assume that objective characteristics cause perceived characteristics, which in turn cause health behaviors such as walking, then it is misleading to include these variables on the causal pathway in the same model, except to examine possible mediation. In the case of neighborhood perceptions, the second analysis presented shows that perceptions of one's neighborhoods are based on individual characteristics as well as objective neighborhood characteristics. One's perceptions of one's neighborhood are a unique construct of interest important in their own right, not merely as an approximation of objective neighborhood characteristics. The perceptions of neighborhood analysis may have implications for other health outcomes besides physical activity and walking. For example, neighborhood social capital and social support may both be dependent on as well as influence residents' perceptions of safety from crime.

There is a lack of established methods to deal satisfactorily with the complexity of these issues. Pathway analysis, such as structural equation modeling, does provide a theoretical framework to examine these multiple variables on the same causal pathway. However, practical limitations of pathway analysis require that the model be correctly specified. Similar to other modeling techniques, we can determine if the data fit the model, but the model cannot tell us WHY various variables are associated with each other, especially in a cross-sectional analysis. In the absence of simple answers, the separate models presented in this dissertation do serve to illuminate the different relationships to each other of the determinants of mobility, walking, and physical activity.

Future research which considers the contributions of neighborhood environments over the life-course to perceptions of neighborhood may be informative. Longitudinal studies may contribute to understanding the causal direction of these associations. Residential histories over the lifetime would be useful to inform longitudinal studies. Michael Oakes has written extensively about the possible effects of selection bias on neighborhood effects (Oakes 2006). Complete residential histories that include not only addresses but also reasons for moving to an address may contribute to untangling the directions of the relationships between neighborhoods and health outcomes. As archives of electronic and GIS data become available for greater numbers of years, this life course approach will become increasingly feasible. Additional strategies for collecting data, such as videotaping methodology developed by Shumway-Cook, may improve both assessment of the environment as well as individual's interactions with the environment (Shumway-Cook, Patla et al. 2005).

Taken together, these analyses highlight the complexity and multiple determinants of health behaviors such as walking and physical activity. Interventions are needed on multiple levels to reduce barriers to walking outside and physical activity. The adaptation of universal design principles and health impact assessment in the planning process may improve community design for walking outside for older adults. As both the numbers and the proportions of older adults in our communities increase, community design must increasingly consider the wide ranges of abilities and functional capacities in older adults. Universal design principles that result in neighborhoods and communities that encourage walking and activity in people of various abilities will lead to a healthier society.

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