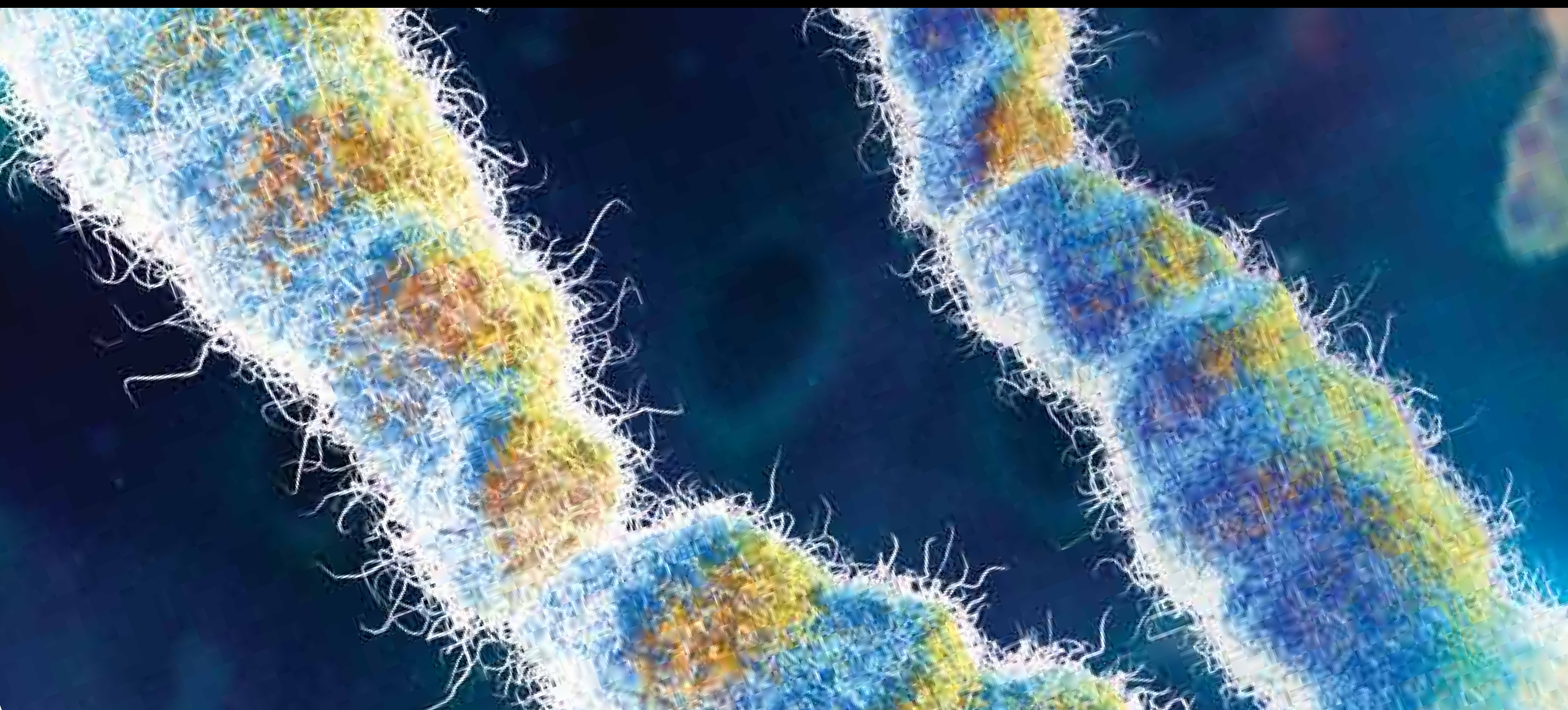
Journal of Aging Research

Mobility and Aging: Transference to Transportation

Guest Editors: Thomas R. Prohaska, Basia Belza, Steven P. Hooker, Susan L. Hughes, and Lynda A. Anderson



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Editorial Board

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Editorial

Mobility and Aging: Transference to Transportation

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Mobility is fundamental to everyday life and is critical to an understanding of the health and well-being of older populations. The construct of mobility focuses on the ability of individuals to meet the challenges of the environment given their capabilities associated with *movement within and between environments*. Mobility can also be characterized by its form including transferring from bed to a chair, walking and ambulation, engaging in activities associated with independence, work, leisure-time activities, driving a car, and using various forms of passenger transport (William Satariano, personal communication, April 24, 2011). It is a central tenet of successful aging [1] and healthy aging [2]. CDC's Healthy Aging Research Network defines healthy aging as "the development and maintenance of optimal physical, mental, and social well-being and function in older adults. It is most easily achieved when physical environments and communities are safe and support the adoption and maintenance of attitudes and behaviors known to promote health and well-being and when health services and community programs are used effectively to prevent or minimize the impact of acute and chronic disease on function" [2].

When we developed the call for papers for this special issue titled "Mobility and Aging: Transference to Transportation," we viewed this as an opportunity to advance how we conceptualize mobility and recruit authors whose work would provide new insights into how mobility is framed from diverse perspectives and add critical thinking about community-based programs and policies to promote mobility in older populations. Another goal is to stimulate interest and dialogue among a broader community of researchers concerned with mobility. Overseeing the development of this special issue has enhanced our appreciation of the contributions being made to the field and expanded our thinking about options for individual, community, systems, and policy interventions to increase the impact of our individual work and the collective contributions as members of the CDC Healthy Aging Research Network (http://www.prc-han.org/).

Although research literature exists for several forms of mobility, including use of transportation, driving, walking, use of assistive devices for ambulation (walkers, wheelchairs), and exercise, this research has largely focused on specific, individual forms of mobility without the benefit of a comprehensive unified framework for study. That is, research has typically focused on a single domain or form of mobility. This body of research tends to focus on a limited set of causal antecedents such as the role of the built environment and functional status as determinants of walking for leisure among older adults. Without a broadly-based unified framework to examine the spectrum of mobility disability across structural and personal antecedents, we will fail to fully identify and capture the factors needed to address the mobility needs of older populations. We may also potentially fail to see the commonalities across types of mobility and the potential for designing interventions, environments and policy to address mobility disability. For example, the influence of obesity and patterns of multiple chronic conditions across several types of mobility may not be apparent in research that addresses a single form of mobility. We, therefore, take this opportunity to provide new and critical ways of framing mobility from an integrated public health perspective.

We examine several theoretical models that can guide a unified approach to mobility and aging research. We conclude with a call to action to move the science and the field forward. The significance of this field is apparent: the US Census 2000 counted 49.7 million people with some type of long-lasting condition or disability—whether due to age, injury, or birthrelated [3]. It is critical to ensure that all people have an opportunity to participate in valued activities. Mobility is more than an outcome or end point of the research; mobility restrictions have consequences for the health and well-being of older adults which often result in a cascade effect of continuing deterioration.

The theoretical foundation that we propose can help guide an integrated mobility research agenda and is based on disablement models posed by the early work of Nagi [4] and later expanded by Verbrugge and Jette [5]. These disablement models distinguish between impairment (a body system disease or injury) and disability (a limitation in performing social roles and activities) while recognizing these activities are conducted in a setting that include a sociocultural and environmental context that influences the level of disability observed. More recently, the World Health Organization (WHO) proposed the International Classification of Functioning, Disability, and Health [6, ICF]. ICF was designed to provide a standard language and framework for describing health and health-related states. It includes a multipurpose classification of health (rather than just illness) and health-related domains. As in previous disablement models, ICF is a biopsychosocial model that integrates biological, individual, and social perspectives. Thus, the model recognizes that activities such as types of mobility are influenced by health conditions and contextual factors including the environmental and personal factors. Another feature of the framework important to understanding mobility is that it distinguishes between *performance* and *capacity*. *Performance* can be thought of as activities that are observable whereas *capacity* refers to a person's ability under optimal personal and situational contexts. In summary, ICF underscores the positive, or potential, abilities of the individual and provides a framework that stresses personal situational and environment influences. ICF framework can contribute to observational and intervention research on mobility in older populations and is consistent with the social-ecological framework that identifies personal, structural, and environmental factors that may influence mobility including the following.

(i) Modifying the environment through policy change to maximize mobility options.

(ii) Providing appropriate assistive devices to enhance mobility.

(iii) Improving the capacity or reserve through exercise and health-promoting strategies.

(iv) Supporting assistance through informal support networks to address unmet mobility needs.

(v) Addressing beliefs, motivations, and perceptions about mobility limitations among individuals and families to help overcome "self-restricted" mobility limitations or effectively cope with the circumstances related to mobility restriction.

The challenge for future intervention research is to determine the most appropriate combination of intervention elements that would result in minimal restriction due to mobility limitations. Research focusing on both performance and capacity could help to determine the appropriate elements for the intervention.

As mentioned previously, we also need to think about the public health impact of the strategies we propose and how they can be brought to scale at a population level. The Social Ecological Model [7] and the Health Impact Pyramid [8] are useful in this regard. Similar to the ICF, within the Social Ecological Model the role of ecological factors which can influence individual behavior are noted. The model stresses the need to address interventions at multiple levels including the individual, interpersonal, institutional, community, and policy level. The Health Impact Pyramid provides an organizational structure for categorizing intervention strategies to promote health, or, in this case, mobility, with respect to their potential relative impact on the targeted health concern. The five tiers of the pyramid include socioeconomic factors, changing the context to make individuals' default decision healthy, long-lasting protective interventions, clinical intervention, and counseling and education. Beginning at the base of the pyramid with socioeconomic factors, interventions rise up from those that have the largest population impact and change the context to make healthy choices the default [8]. Depending on the causal antecedents and underlying risk factors (e.g., environmental, personal) an intervention on mobility restriction for an older population would have its greatest impact as close to the pyramid base as possible. Green and Kreuter [9] have further recommended that population intervention strategies should be blended depending on the complexity and etiology of the health concern. To use the example of walking among older individuals, an intervention to increase walking that focuses on increasing safe and desirable places to walk would fall in the category of a long-lasting protective intervention while an intervention that makes assistive devices readily available among disadvantaged older population with limited walking ability would be a socioeconomic intervention strategy. Similarly, a health education nutrition and exercise health promotion intervention to promote walking and lose weight would be a counseling and education intervention. While policy directed at promoting walking for health among older populations would have the greatest potential for reach and population level impact, we need to be cognizant of the fact that a *combined blended intervention strategy* is likely to be required to address situational and environmental barriers and opportunities [9].

We hope that this special issue is a call to action, helping to stimulate expanded and new research on mobility and aging. The diversity of the articles provide evidence that researchers recognize the range of mobility domains critical to independence of older populations and the broad array of structural, personal, and environmental factors effecting mobility. Additionally, the diversity of disciplines represented by the authors in this special issue attests to the collaborations that are essential if we are going to make progress. What is missing is a unified and comprehensive approach to mobility and aging research. We expect this editorial to stimulate discussion and challenge scholars and practitioners to think differently and act together to advance the field.

Acknowledgments

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Research Article

Shut-In? Impact of Chronic Conditions on Community Participation Restriction among Older Adults

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Community participation may be especially important for older adults, who are often at risk for unwanted declines in participation. We estimated the prevalence of community participation restriction (PR) due to perceived environmental barriers among older adults (≥50 years) and compared the impact among those with selected chronic conditions. Individuals with low-prevalence conditions reported high community PR (9.1–20.4%), while those with highly prevalent conditions (e.g., arthritis) had relatively low community PR (5.1–10.0%) but represented the greatest absolute numbers of condition-associated burden (>1 million). Across all conditions, more than half of those with community PR reported being restricted "always or often." Community PR most often resulted from modifiable environmental barriers. Promising targets to reduce community PR among adults ≥50 years with chronic conditions, particularly arthritis, include building design, sidewalks/curbs, crowd control, and interventions that improve the built environment.

1. Introduction

The World Health Organization (WHO) defines "participation restriction" (PR), a key feature of the revised International Classification of Functioning, Disability and Health (ICF), as "problems an individual may experience in involvement in life situations," and it reflects the negative consequences of health conditions on important personal and societal domains [1]. Community participation is an important type of participation because having and maintaining valued life roles and activities is associated with better psychological well-being and self-rated health [2–4] and may be especially important for older adults, who are often at risk for unwanted declines in participation [5–7]. There is a growing interest in PR from public health, medical, and social perspectives, partly because "even when poor health persists, participation may still be maintained" [8]. PR from an ICF perspective considers the influence of environment, in all its forms, on one's ability to engage in life situations. A recent independent validity study found that the ICF model, including its conceptualization of participation, is useful for examining disability in aging research [9].

Despite some studies [10–14], gaps remain in research on the interaction between older adults and their environment. Among limited findings, arthritis has consistently been associated with high levels of PR and disability in both cross-sectional and longitudinal studies [2, 15–21]. Also, features of the "built environment" and poor "walkability" of neighborhoods have been identified as barriers for individuals with varying levels of physical impairment [11]. Combining both health status and environmental perspectives provides an ideal context in which to examine how older adults with chronic health conditions participate in their communities.

The purpose of this study was to estimate the prevalence of community PR due to perceived environmental barriers among older adults (≥50 years) and to compare the impact among those with selected chronic conditions. Previous reports in the literature suggest that community PR would be greatest among older adults with disabling conditions (e.g., arthritis, stroke) and sensory deprivation (e.g., hearing or vision loss) [5, 8, 19, 21–23].

2. Materials and Methods

Data Source. Data were obtained from the 2002 National Health Interview Survey (NHIS), an ongoing, multistage probability survey conducted annually by a standardized in-person interview in English or Spanish. The NHIS is designed to be representative of the US civilian, noninstitutionalized population [24]. In 2002, a supplement based on Healthy People 2010 content [25], Disability and Secondary Conditions Questions: Assistive Technologies and Environmental Barriers, was added to the Sample Adult Core questionnaire [26], from which our sample was drawn. The Sample Adult Core was administered to 31,044 individuals ages ≥18 years; only respondents ≥50 years ($n = 12,376$) were included in this analysis.

2.1. Definition of Variables

2.1.1. Sociodemographic Characteristics. Sociodemographic characteristics were examined to characterize the sample. These were age, sex, race/ethnicity (Non-Hispanic White, Non-Hispanic Black, Hispanic Non-Hispanic Other), annual household income (≥$20,000, < $20,000, and unknown), and education (≥high school, < high school, and unknown).

We examined the prevalence of three main outcomes: (1) community PR, (2) condition-associated absolute burden of community PR, and (3) community environmental barriers.

2.1.2. Community Participation Restriction and Related Environmental Barriers. Participants were shown a list of ten environmental barriers (building design, lighting, sound, crowds, sidewalks and curbs, and transportation, household or workplace equipment hard to use, attitudes of other people, policies, and other) and were asked: "Thinking of COMMUNITY ACTIVITIES such as getting together with friends or neighbors, going to church, temple, or another place of worship, movies, or shopping, do problems with any of these things on the list NOW limit or prevent your participation in community activities?" (Figure 1). Community PR was defined as a "yes" to this question. Respondents answering yes were next asked to identify which items on the list were barriers to them and to report how often they experienced these barriers (collapsed to always/often or sometimes/rarely). Conceptually, the first three barriers (building design, lighting, and sound) fit together as "accessibility barriers," while crowds, sidewalks/curbs, and transportation made up a category of "mobility barriers." "Household/workplace equipment hard to use" was omitted because it pertained to noncommunity settings; "other" was excluded because of high item nonresponse. "Attitudes of other people" was analyzed independently. The policy category was excluded from the analysis because it had a low item response rate with estimates failing to meet minimum reliability criteria (relative standard error <30.0) for any condition examined.

2.1.3. Condition-Associated Absolute Burden of Community PR. For each condition (defined below), the associated burden of community PR was estimated as the absolute number of respondents with the condition reporting community PR. Condition-associated absolute burden was also examined for those with each chronic condition who also had arthritis as a comorbidity (described below).

2.1.4. 12 Chronic Conditions. The presence of seven diagnosed chronic conditions or condition categories was based on a "yes" response to "Have you EVER been told by a doctor or other health professional that you have..." for each of arthritis, diabetes, hypertension, stroke, heart conditions (i.e., angina pectoris, coronary heart disease, heart attack, heart failure, or heart condition/disease), neurological conditions (i.e., multiple sclerosis, Parkinson's disease, neuropathy, or seizures), and respiratory conditions (i.e., asthma, emphysema, or chronic bronchitis). Hearing impairments were defined as a response of "a lot of trouble hearing" or "deaf" to "Which statement best describes your hearing without a hearing aid: good, a little trouble, a lot of trouble, deaf?" Vision impairments were defined as a response of "yes" to "Do you have any trouble seeing, even when wearing glasses or contact lenses?" Obesity was defined as a body mass index (weight in kg/height in m^2) of ≥30. Depression/anxiety was determined by a "yes" response to "DURING THE PAST 12 MONTHS, have you been frequently depressed or anxious?" Serious psychological distress (SPD) was measured with the Kessler 6 (K6), a psychological distress scale developed to screen for and monitor population prevalence and trends of nonspecific SPD. It comprises 6 questions on a 0 (none of the time) to 4 (all of the time) point scale asking how often in the past 30 days a person felt sad, worthless, nervous, restless, hopeless, or that everything was an effort. Responses are summed for a total score (0–26); we used a cutoff of ≥13 as recommended by the scale developer to identify SPD among respondents [27]. Respondents could have more than one chronic condition; therefore, chronic conditions examined were not mutually exclusive.

Missing values for community PR and individual barriers were assigned to the most conservative category, that is, if a respondent did not identify community PR with a "yes" response, he/she was assigned to the no category. Missing values for chronic conditions ranged from $n = 8$ (0.06%) for respiratory conditions to $n = 613$ (5.0%) for obesity. Age, sex, and race/ethnicity variables were provided by NCHS with no missing values.

2.1.5. Comorbidities. To examine the effects of comorbidities on community PR, we created a count variable indicating how many of the 12 chronic conditions described above each respondent reported (categorized as 0, 1, 2, 3, 4, and ≥5).

2.1.6. Arthritis as a Comorbidity. Given its widespread prevalence and status as the most common cause of disability among US adults [28], arthritis was expected to be associated with high levels of community PR. We examined community PR among those with each of the other chronic conditions plus arthritis as a comorbidity.

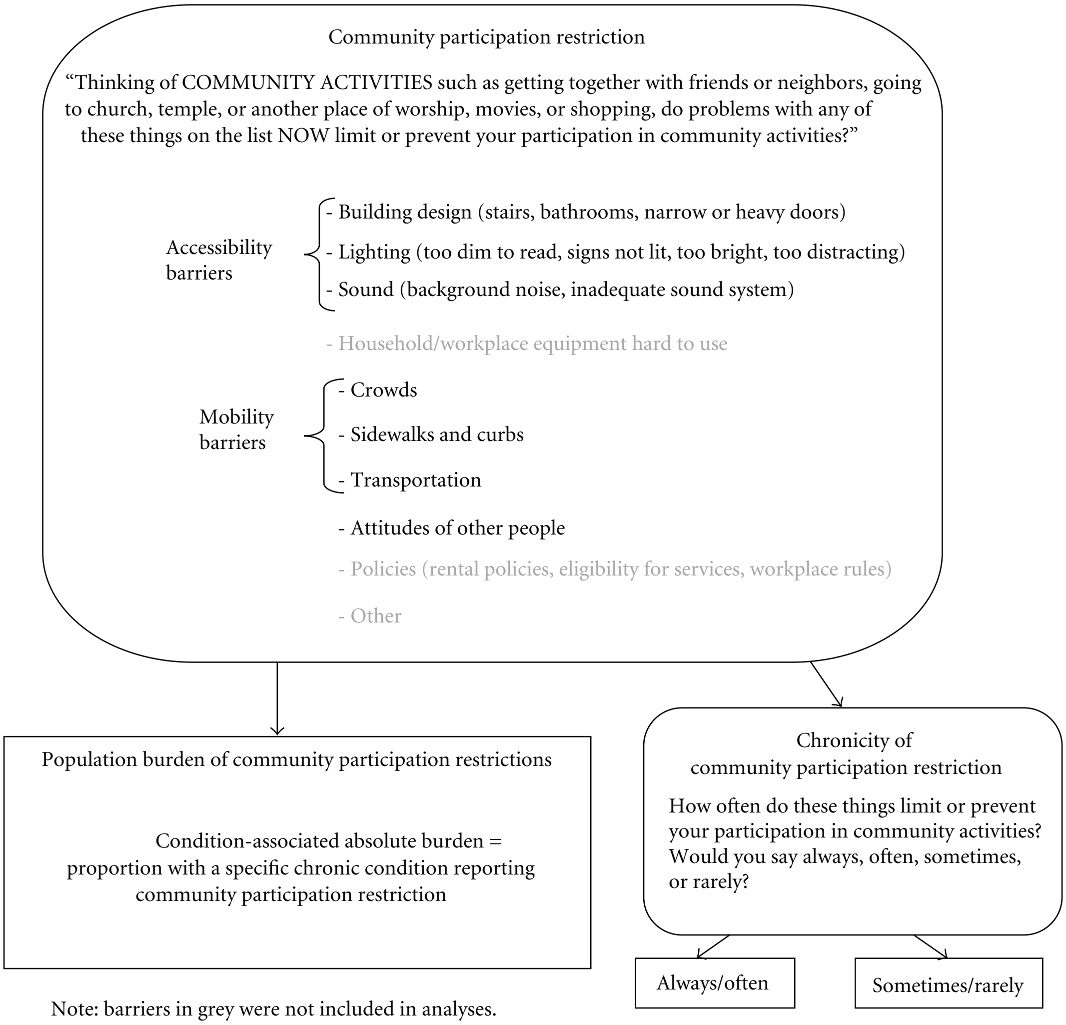

Figure 1

2.2. Statistical Analysis. Weighted frequencies, 95% confidence intervals (95% CI), and proportions were obtained using SAS 9.2 [29] and SUDAAN v10 [30] statistical software, accounting for the complex sampling design. Statistical significance was determined by nonoverlapping 95% CI. Estimates were considered unstable if they did not meet minimum reliability criteria (i.e., a relative standard error (RSE) ≥30%) and are not reported [31]. Estimates were considered potentially unreliable if they had an RSE between 20% and 30% and have been flagged as such in tables and footnotes.

3. Results and Discussion

3.1. Characteristics of the Sample. The weighted median age of the participants was 61.5 (mean = 64.0; standard deviation 13.4) (Table 1) (The age of respondents ≥85 years are reported as 85 years in the NHIS public release files: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2002/samadult.pdf. Therefore, the mean, standard deviation, median, and range of ages may be underestimated.). The majority of the participants were female (54.2%), non-Hispanic Whites (80.4%) and those with an annual household income of ≥ $20,000 (70.7%) and at least a high school education (77.8%) (Table 1).

3.2. Chronic Conditions. Chronic conditions were common among adults ≥50 years; 23.7% reported one condition and 55.8% reported two or more conditions Most condition groups examined (8 of 12) were reported by >10% of the sample (Table 2). Hypertension was the most frequently reported chronic condition (44.4%, 95% CI = 43.5–45.3), followed by arthritis (39.8%, 95% CI = 38.7–40.8). Neurological conditions (4.3%) and SPD (3.1%) were the least reported conditions (Table 2).

3.3. Community PR. Among all adults ≥50 years, the prevalence of any community PR was 3.6% (3.2–3.9). Among adults with chronic conditions, the overall prevalence of any community PR ranged from 5.1% (4.3–6.0) for obesity to 20.4% (17.6–23.2) for SPD (Table 2).

3.4. Condition-Associated Absolute Burden of Community PR. Respondents with the most prevalent conditions (hypertension and arthritis) reported among the lowest

Table 1: Weighted characterization of the study sample of 12,376 USA Adults ≥50 years, 2002.

	Weighted frequency (in 1,000s)	%[1] (95% CI)
Total	76,634	100
Age (median, mean ± SD)	61.5, 64.0 ± 13.4	
Sex		
Male	35,123	45.8 (44.8–46.8)
Female	41,511	54.2 (53.2–55.2)
Race/ethnicity		
Non-hispanic white	61,597	80.4 (79.4–81.4)
Non-hispanic black	6,970	9.1 (8.4–9.8)
Hispanic	5,581	7.3 (6.7–7.9)
Non-hispanic other	2,486	3.2 (2.8–3.7)
Income		
$20K or more	54,144	70.7 (69.6–71.7)
Less than $20K	16,232	21.2 (20.3–22.1)
Unknown	6,258	8.2 (7.5–8.9)
Education		
>/= high school	59,616	77.8 (76.9–78.7)
Less than high school	15,930	20.8 (19.9–21.6)
Unknown	1,088	1.4 (1.1–1.7)

[1] May not add to 100 percent due to rounding.

proportion of any community PR, 5.3% and 6.4%, respectively (Table 2). The highest prevalence of community PR overall was among respondents with SPD (20.4%), followed by neurological conditions, hearing or vision impairments, and depression/anxiety (Table 2). However, due to the relatively low prevalence of these conditions, only depression/anxiety and vision impairments were among the top five conditions with the greatest condition-associated absolute burden of community PR. In absolute numbers, the greatest condition-associated burden was among people with arthritis, affecting 1.9 million adults ≥50 years (Table 2). The remaining top five conditions in terms of absolute numbers of condition-associated burden of community PR were, in order of magnitude, hypertension, depression/anxiety, heart conditions, and vision impairments.

3.5. Chronicity of Community PR. Across all conditions, more than half of those with community PR reported being restricted "always/often," ranging from 54.7% for neurological conditions to 75.8% for SPD (Table 2). Approximately two-thirds of respondents with community PR and stroke, obesity, or depression/anxiety reported restriction "always/often" (Table 2). Similar to condition-associated absolute burden, despite the lower prevalence of being "always/often" restricted, those with arthritis had the greatest disease burden in absolute numbers (~1.1 million), followed by hypertension (961,000) (Table 2).

3.6. Arthritis as a Comorbidity. The presence of arthritis as a comorbidity resulted in significantly higher community PR for respondents with hypertension (7.8 versus 5.3), heart conditions (9.4 versus 6.7), and obesity (7.5 versus 5.1) (Table 2). Despite the lack of significance for arthritis comorbidity in the remaining conditions, there was pattern of higher community PR for every condition examined; arthritis seemed to result in greater prevalence of community PR by 2-3% across conditions (Table 2).

3.7. Community Barriers. Respondents with SPD reported the highest prevalence of any accessibility (13.9%), any mobility (16.8%), and attitudes of others (8.5%) barriers (Table 3). Report of any accessibility barrier ranged from 3.4% for obesity (2.7–4.2) and hypertension (2.9–3.9) to 13.9% (11.6–16.2) for SPD. The prevalence of any mobility barrier ranged from 3.6% (2.9–4.3) for obesity to 16.8% (14.2–19.5) for SPD. Attitudes of others barriers were less frequent, ranging from 1.1% (0.8–1.4) for hypertension to 8.5% (6.6–10.4) for SPD (Table 3).

Although the frequency of accessibility barriers was the same as mobility barriers across conditions, the absolute number of people with mobility barriers was greater for all conditions except diabetes (Table 3; Figure 2). Among those with accessibility barriers, building design (2.5–8.6%) was reported significantly more often than either lighting (0.8–3.3%) or sound (0.9–7.4%) for all conditions, with the exceptions of hearing impairments, SPD, and stroke (Table 3). Within mobility barriers, there were no significant differences in the prevalence of any of the three components, with the exception that respondents with SPD reported crowds as a barrier significantly more often than those with other conditions (Table 3). Among the top five chronic conditions with the greatest condition-associated absolute burden of community PR (arthritis, hypertension, depression/anxiety, heart conditions, and vision impairments), the absolute numbers of those with mobility barriers were greater than accessibility barriers (Table 3).

3.8. Environmental Barriers to Community Participation among the Top 5 Most Common Chronic Conditions. Within accessibility barrier components, building design was reported with the greatest frequency across all 5 conditions and was highest among those with arthritis (Figure 2). Within mobility barriers, the category sidewalks/curbs was reported by more people than either crowds or transportation among respondents with arthritis (Figure 2). For the remaining top five conditions, crowds were cited by the greatest number (Figure 2). Overall, attitude barriers were

Table 2: Weighted estimates and 95% confidence intervals (95% CI) of prevalence of selected chronic conditions; community participation restriction (PR) and condition-associated absolute burden; chronicity of community PR; arthritis comorbidity and associated absolute burden among adults ≥50 years with selected chronic conditions, 2002.*

	Prevalence in population		Community PR		Chronicity of community PR†		Arthritis comorbidity‡	
	% (95% CI)	n (in 1,000s)	% (95% CI)	Condition-associated absolute burden, n (in 1,000s)	% (95% CI)	n (in 1,000s)	Community PR% (95% CI)	Associated absolute burden, n (in 1,000s)
Arthritis	39.8 (38.7–40.8)	30,312	6.4 (5.6–7.1)	1,929	56.7 (51.9–61.4)	1,058	~	~
Hypertension	44.4 (43.5–45.3)	33,908	5.3 (4.6–5.9)	1,781	56.3 (51.3–61.4)	961	7.8 (6.8–8.9)	1,323
Depression/ anxiety	17.3 (16.5–18.2)	13,229	9.9 (8.4–11.3)	1,304	65.7 (59.5–71.8)	813	12.0 (10.1–13.9)	868
Heart conditions	22.3 (21.4–23.1)	17,030	6.7 (5.7–7.7)	1,140	59.7 (53.5–65.8)	650	9.4 (7.8–10.9)	870
Vision impairments	13.6 (13.0–14.3)	10,444	10.0 (8.5–11.6)	1,049	58.0 (51.4–64.6)	576	11.1 (9.2–13.0)	659
Obesity	25.3 (24.3–26.3)	18,492	5.1 (4.3–6.0)	947	65.9 (59.9–71.9)	593	7.5 (6.0–9.0)	724
Diabetes	14.7 (13.9–15.4)	11,239	7.0 (5.7–8.4)	792	57.5 (50.0–65.1)	435	10.1 (8.0–12.1)	583
Respiratory conditions	14.6 (13.9–15.3)	11,174	6.7 (5.4–7.9)	743	55.9 (48.0–63.7)	399	9.2 (7.4–11.0)	562
Hearing impairments	6.7 (6.2–7.3)	5,132	10.8 (8.3–13.3)	554	59.7 (49.0–70.4)	322	11.7 (8.7–14.8)	343
SPD§	3.1 (2.7–3.5)	2,304	20.4 (17.6–23.2)	469	75.8 (67.6–84.0)	344	22.6 (19.2–25.9)	290
Stroke	5.4 (5.0–5.9)	4,160	9.1 (6.8–11.4)	377	66.8 (56.4–77.1)	244	10.6 (7.9–13.3)	249
Neurological conditions	4.3 (3.8–4.7)	3,254	11.3 (9.2–13.4)	367	54.7 (42.9–66.4)	195	11.8 (9.4–14.3)	219

* Descending order of condition-associated absolute burden.
† Respondents reporting being "always or often" restricted.
‡ Respondents with the specific chronic condition, plus arthritis as a comorbidity.
§ SPD: serious psychological distress, as measured by the Kessler 6 scale.

cited more often than either lighting or sound and were highest among those with arthritis, hypertension, and depression/anxiety (Figure 2).

3.9. Comorbidity Count. The prevalence of community PR rose with increasing number of chronic conditions, ranging from 0.6% (0.2–0.9) for zero chronic conditions to 13.0% (10.8–15.2) for ≥5 chronic conditions (Figure 3).

4. Discussion

This study is a novel examination of community PR in older adults with chronic conditions. Several important messages emerged from the findings. First, individuals with low-prevalence conditions (e.g., SPD, neurological conditions, and stroke) reported high community PR. Second, highly prevalent conditions (e.g., arthritis, and hypertension) had relatively low community PR but resulted in the greatest absolute numbers of condition-associated burden. Third, the presence of comorbid conditions had a significant effect, resulting in greater community PR as the number of conditions increased. Finally, the most frequently reported barriers were building design, sidewalks/curbs, and crowds.

Studies of participation in older adults demonstrate that PR is associated with several health, disability, demographic, and socioeconomic characteristics as well as suggesting discordance between physical limitations and PR [2, 5, 32, 33]. It is also well-established that functional limitations are associated with chronic conditions, older age, increased health care expenditures, and lower quality of life [34, 35]. This paper extends the literature through the examination of selected chronic conditions, as single and comorbid conditions, with associated community PR and specific environmental barriers.

Stroke and vision and hearing impairments were associated with high levels of community PR as expected; alternatively, respondents with arthritis reported among the lowest prevalence of community PR. Surprisingly, obesity was associated with low levels of community PR, despite cross-sectional and longitudinal studies consistently showing

Table 3: Weighted prevalence % (95% CI) of community barriers among adults ≥50 years with selected chronic conditions, 2002.*

	Accessibility barriers					Mobility barriers					Attitude barriers
	n in 1,000s	Any accessibility barrier	Building design	Lighting	Sound	n in 1,000s	Any mobility barrier	Sidewalks/curbs	Crowds	Transportation	Attitudes of others
Arthritis	1,262	4.2 (3.5–4.8)	3.2 (2.6–3.7)	1.0 (0.7–1.3)	0.9 (0.6–1.3)	1,336	4.4 (3.8–5.1)	2.0 (1.5–2.4)	2.1 (1.7–2.6)	1.7 (1.3–2.1)	1.3 (0.9–1.6)
Hypertension	1,149	3.4 (2.9–3.9)	2.5 (2.0–2.9)	0.9 (0.6–1.2)	0.9 (0.6–1.2)	1,238	3.7 (3.1–4.2)	1.8 (1.4–2.2)	1.6 (1.2–2.0)	1.5 (1.1–1.8)	1.1 (0.8–1.4)
Depression/anxiety	788	6.0 (4.9–7.1)	4.2 (3.2–5.1)	1.6 (1.0–2.1)	1.9 (1.3–2.6)	971	7.3 (6.1–8.6)	4.1 (3.2–5.1)	2.7 (2.0–3.4)	3.0 (2.2–3.9)	2.9 (2.0–3.7)
Heart conditions	744	4.4 (3.6–5.1)	2.9 (2.3–3.5)	1.2 (0.8–1.7)	1.4 (0.9–1.9)	793	4.7 (3.8–5.5)	2.2 (1.6–2.9)	2.0 (1.5–2.5)	1.8 (1.2–2.3)	1.4 (0.9–1.9)
Vision impairments	725	6.9 (5.7–8.1)	4.9 (3.9–5.9)	2.6 (1.8–3.3)	1.8 (1.1–2.5)	758	7.3 (6.0–8.5)	3.5 (2.5–4.4)	3.4 (2.7–4.2)	3.3 (2.4–4.2)	2.3 (1.5–3.1)
Obesity	637	3.4 (2.7–4.2)	2.7 (2.0–3.3)	0.8 (0.5–1.2)	0.6 (0.3–1.0)†	664	3.6 (2.9–4.3)	1.7 (1.2–2.2)	1.7 (1.3–2.2)	1.5 (1.0–2.0)	1.2 (0.7–1.7)†
Diabetes	560	5.0 (3.9–6.1)	3.6 (2.6–4.6)	1.5 (0.9–2.1)	0.9 (0.6–1.3)	516	4.6 (3.6–5.6)	2.1 (1.4–2.7)	2.2 (1.5–2.8)	2.1 (1.5–2.8)	1.3 (0.7–1.9)†
Respiratory conditions	453	4.1 (3.1–5.0)	2.9 (2.1–3.7)	1.0 (0.5–1.5)†	1.0 (0.5–1.6)†	507	4.5 (3.5–5.5)	2.2 (1.4–3.0)	1.8 (1.1–2.4)	1.9 (1.3–2.7)	1.2 (0.7–1.7)†
Hearing impairments	365	7.1 (5.1–9.1)	3.4 (2.0–4.7)†	1.9 (0.9–3.0)†	4.1 (2.4–5.9)†	390	7.6 (5.4–9.8)	3.9 (2.2–5.7)†	2.6 (1.6–3.6)	3.1 (1.7–4.5)†	‡
SPD§	320	13.9 (11.6–16.2)	8.6 (6.3–10.8)	3.3 (1.9–4.6)†	7.4 (5.8–9.0)	388	16.8 (14.2–19.5)	11.8 (9.6–14.0)	6.6 (4.4–8.8)	5.5 (4.3–6.6)	8.5 (6.6–10.4)
Stroke	251	6.0 (4.2–7.9)	4.1 (2.6–5.7)	2.5 (1.1–3.9)†	1.5 (0.7–2.3)	266	6.4 (4.5–8.3)	2.6 (1.7–3.5)	3.0 (1.7–4.3)†	3.5 (2.2–4.7)	1.8 (0.9–2.6)†
Neurological conditions	273	8.4 (6.5–10.2)	6.2 (4.5–8.0)	2.3 (1.0–3.7)†	2.2 (1.3–3.0)	299	9.2 (7.3–11.1)	5.5 (3.8–7.1)	5.2 (3.6–6.8)	3.9 (2.1–5.6)†	2.9 (1.6–4.2)†

* Descending order of condition-associated absolute burden from Table 2.
† Estimate is potentially unreliable, relative standard error (RSE) between 20.0% and 30.0%.
‡ Estimate is unstable, RSE ≥ 30.0%.
§ SPD: serious psychological distress, as measured by the Kessler 6 scale.

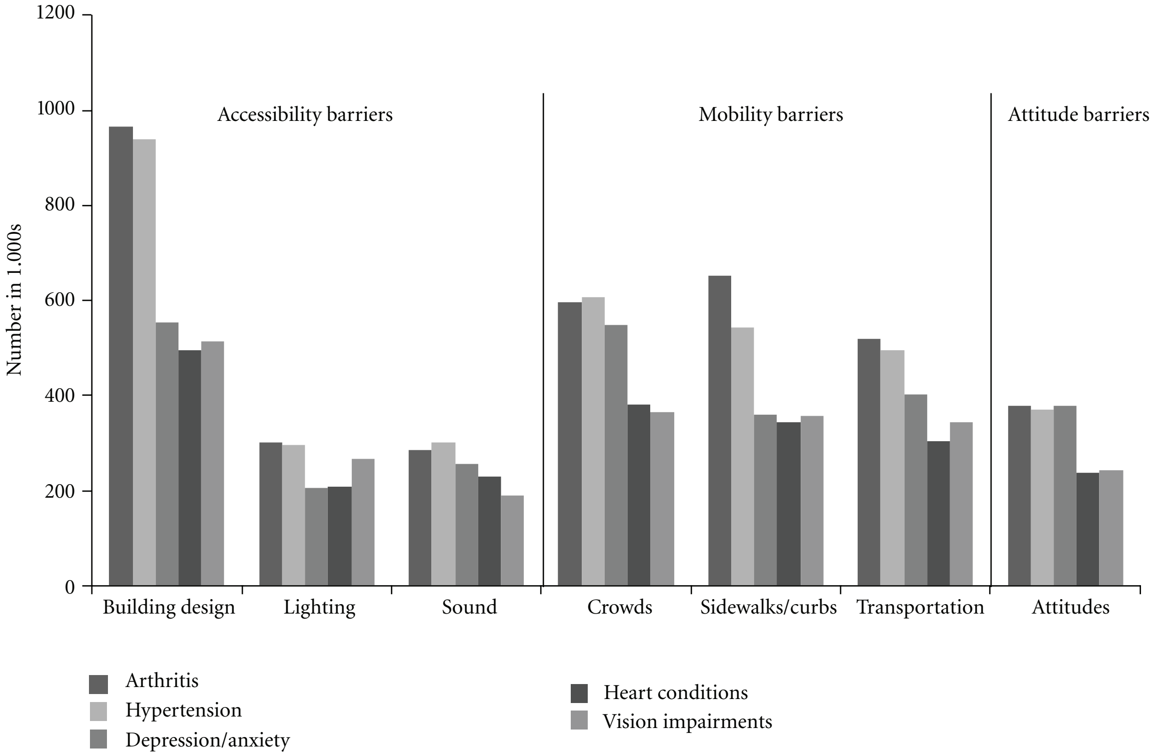

FIGURE 2: Environmental barriers among the top 5 most common chronic conditions.

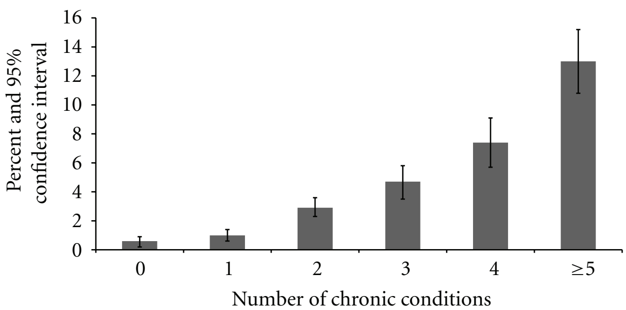

FIGURE 3: Prevalence of community participation restriction, by number of chronic conditions, 2002.

declining mobility in tandem with increasing adiposity in older adults [36].

Large condition-associated absolute burden was expected and observed with arthritis. Also, higher prevalence of community PR among respondents with arthritis comorbidity was consistent with *a priori* expectations. Arthritis has been shown to increase levels of physical inactivity among adults with heart disease [37] and diabetes [38], as well as being linked to negative physical and mental health outcomes, including increased activity limitation [35, 39], work limitation [40], frequent mental distress [41], and serious psychological distress [42].

There is consistent evidence in the literature that absent or poorly maintained sidewalks, lack of access to transportation, and heavy motor vehicle traffic [43–45] have negative impacts on mobility in older adults. For example, Clarke et al. found that adults with severe lower extremity physical impairments who lived in neighborhoods with fair/poor streets were 4.5 times more likely to report severe mobility disability than those living in neighborhoods with streets free from cracks, potholes, and broken curbs [11]. Also, a recent US study estimated that each year more than 9,000 older pedestrian fall-related injuries involve a curb [46]. Our findings regarding sidewalks/curbs and transportation as barriers support these known associations. Attitudes of the public [44] and "other persons' rudeness" [47] have also been identified as community barriers in other studies; in these studies, as in ours, physical barriers were more frequently reported by respondents. Participants in a Meyers et al. study also cited religious buildings, friends' or relatives' houses, restaurants, and other places for recreation or leisure as destinations participants, particularly those ≥50, wanted to but were unable to reach, suggesting these may be important destinations related to community PR in that sample as well [47].

Interestingly, there were insufficient responses from survey participants to create reliable estimates regarding policy barriers to community PR. This may reflect that, while community dwelling older adults in the USA do not report encountering policies that explicitly limit their community participation, these same adults may not be aware of or recognize that policy changes could facilitate their ability to maintain community participation [11, 13, 44, 45, 48–50]. As described in the Disablement Process [48] and the ICF [1], intervening factors of the physical environment, which can be influenced by policy, "speed-up and slow-down" disablement in the presence of functional limitations. A growing literature links environmental barriers to PR, particularly among older adults [5, 10, 11, 13, 49–51]. Many of these studies simultaneously reinforce that “for those adults at greatest risk for disability, the disablement process could be reversed or attenuated” [11, 48] through policy-supported efforts to improve community infrastructure, such as sidewalk repairs, creating greener street environments, removing obstacles, and adding or maintaining street lighting, which can assist individuals with impairments to remain engaged in their communities [10, 11, 13, 50].

Among the features consistently associated with greater community mobility are intact pavement [11, 45], greater land use density [45, 49, 52], greater land use diversity [13, 45, 49], and shorter distance to nonresidential destinations [45, 49]. In a study examining neighborhood design and walkability, Frank et al. reported that “walking levels could increase 2-fold if older adults had access to multiple destinations within short distances” [49], and Li and colleagues found a positive relationship between housing density, green and open spaces, number of nearby recreational facilities, and number of street intersections, among other features, and walking activity in older adults [52]. Based on these and other findings, Saelens and Handy concluded that “evidence on correlates appears sufficient to support policy changes” and recommended efforts related to land use patterns and transportation systems [45]. Regulatory and fiscal policies that affect zoning codes, land use development, street networks, housing density, intersection characteristics (e.g., cross walks, safety islands, and countdown timers), and city planning have also been recommended as important opportunities to reduce barriers in the built environment [43, 45, 46, 49, 53]. Based on a comparative study of the USA, The Netherlands, and Germany, Pucher and Dijkstra recommended that policies to improve urban design, support traffic calming, and provide better pedestrian facilities could be applied in the USA to increase walking safety [54]. The potential decrease in community barriers and community PR offered by policy change is important because even small environmental changes can postpone, reverse, and possibly prevent disability in vulnerable older adults (e.g., those with chronic conditions or functional limitations) [1, 8, 10, 11, 13, 44, 46–50, 52, 53, 55, 56]. Furthermore, changes to improve the built environment for older adults could benefit community members of all ages [10, 45, 46, 54].

This study is subject to at least four limitations. First, data were from survey participants’ self-reports and may be subject to recall bias, although such self-reports are considered valid for surveillance purposes [57]. Second, cross-sectional data cannot be used to infer causation; therefore, we cannot determine the temporal sequencing of the chronic conditions and community PR. Third, there was limited statistical power to examine sex and race/ethnicity differences. Previous literature suggests that disability may be experienced or perceived differently by men and women [12, 14], and future studies with the ability to examine these possible differences are warranted. Finally, the list of potential barriers shown to respondents to identify community PR was not exhaustive. There could be additional environmental and other barriers that result in community PR; therefore, our findings may underestimate community PR among older adults.

Strengths of this study include a large sample with simultaneously available data on both community PR and a substantial number of chronic conditions that allowed us to generate nationally representative estimates for older adults. Additionally, “accessibility,” “mobility,” and “attitude” barriers are self-reported, individual-level rather than community-level variables, reflecting individuals’ perceptions and experiences of barriers in their environments. Finally, establishment of a condition-associated absolute burden measure that describes the impact of arthritis and other chronic conditions on community PR can be used to target and leverage resources and interventions for the greatest population effect.

5. Conclusion

Millions of older adults experience community PR due to modifiable environmental characteristics, especially accessibility and mobility barriers. Given the rapid growth of the older population and the high prevalence of arthritis in this population [58], the burden of arthritis will likely continue to be the largest among the conditions studied. Furthermore, arthritis prevalence is projected to increase by an estimated 19 million Americans by 2030 and is already the most common cause of disability among older adults [28, 58]. Assuming that the current prevalence of community PR due to modifiable environmental barriers remains constant, given the aging of the population and the projected increase in arthritis prevalence, our findings suggest that increasing numbers of adults $\geq$50 years with arthritis will experience PR due to modifiable environmental characteristics. Moreover, many of these environmental features are barriers to older adults with other chronic conditions and are demonstrated to further limit people with comorbid conditions. Promising targets to reduce community PR among adults $\geq$50 years with chronic conditions, particularly arthritis, include building design, sidewalks/curbs, crowd control, and interventions that improve the built environment.

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Research Article

Older Adults' Perceptions of Clinical Fall Prevention Programs: A Qualitative Study

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Objective. To investigate motivational factors and barriers to participating in fall risk assessment and management programs among diverse, low-income, community-dwelling older adults who had experienced a fall. *Methods*. Face-to-face interviews with 20 elderly who had accepted and 19 who had not accepted an invitation to an assessment by one of two fall prevention programs. Interviews covered healthy aging, core values, attributions/consequences of the fall, and barriers/benefits of fall prevention strategies and programs. *Results*. Joiners and nonjoiners of fall prevention programs were similar in their experience of loss associated with aging, core values they expressed, and emotional response to falling. One difference was that those who participated endorsed that they "needed" the program, while those who did not participate expressed a lack of need. *Conclusions*. Interventions targeted at a high-risk group need to address individual beliefs as well as structural and social factors (transportation issues, social networks) to enhance participation.

1. Background

Falls are common among older adults [1], and their consequences often devastating and costly [2–4]. Evidence-based interventions are available to prevent falls [5–7]; however, we have observed that care-seeking by older adults to reduce their likelihood of falling is less than expected. Others have also observed that few older adults engage in proven behaviors to reduce fall risk after a fall [8–11]. Explanations identified through qualitative research with older persons have included an underestimation of personal susceptibility to falling [11], a sense of fatalism or a belief that falls occur due to bad luck [12], an attribution of falls to external (rather than within-person) causes [12], a belief that falls are accidental [13], a belief that falls are an inevitable consequence of aging [12], and a belief that one already knows what to do to prevent falls [13]. The majority of published research has been conducted with persons from Scandinavia, Britain, New Zealand, and Australia [10, 11, 13], and thus it is unknown whether the explanations for this phenomenon, as observed in these studies, are generalizable to elders residing in the United States. Additionally, most research has been conducted with samples that have not been fully characterized in terms of educational level and socioeconomic status [10–13] and with persons who may or may not have experienced a fall [10, 11]. Thus, it is also unclear whether the findings apply to elders of different ethnic backgrounds, to low-income elders, or to elders at high risk of falls. An understanding of contextual (personal, environmental) factors [14] affecting program participation is important, as program participation may ultimately influence an individual's likelihood of future falls and fall-related injuries, global functioning, and quality of life [2–4]. We, therefore, conducted the present study with a diverse, low-income, community-dwelling sample that had experienced a fall to better understand the lower than anticipated uptake of clinical fall prevention services by older Americans.

2. Materials and Methods

2.1. Study Design. We hypothesized that an array of complex factors would affect the decision to participate in a clinically oriented, fall prevention program and that beliefs, attitudes, and knowledge would differ between those who were receptive to a fall prevention service and those who were not. We conducted in-depth qualitative interviews of elders who had experienced a fall to explore differences between fall prevention program "joiners" and "nonjoiners." We employed a purposeful stratified sampling strategy to ensure an adequate balance of joiners and nonjoiners [15]. We use the terms "join" and "participate" interchangeably for those accepting an invitation to receive a fall risk assessment and management recommendations from either of two fall prevention programs.

2.2. Data Collection

2.2.1. Setting. Interviews were conducted between February and August 2008, in King County, Washington. All participants had previously been referred to one of two Seattle-based fall prevention programs: Harborview Medical Center's Fall Prevention Clinic or King County Emergency Medical Services (EMS) Fall Prevention Program, "One Step Ahead." The Harborview program is a hospital-based, outpatient clinic that offers multifactorial assessment and longitudinal management of modifiable fall and fall injury risk factors to persons with a history of falls [16]. The King County EMS program is a home-based program in which a physical therapist conducts a home safety assessment and arranges for any recommended adaptive devices to be installed. The therapist also assesses balance, strength, and footwear and reviews medical conditions and medications in order to customize a personal action plan. Upon written approval of the participant, the therapist sends a letter to the personal physician explaining the "One Step Ahead" program and detailing findings of the evaluation so that the physician may consider if other medical management might also be beneficial to prevent future falls. More information about the EMS program is available at http://www.kingcounty.gov/healthservices/health/ems/community/falls.aspx.

2.2.2. Recruitment. Participants were recruited from lists provided by the two programs. A representative of each program sent letters to potential participants with information about the study, an invitation to participate, and a phone number to call for further information or to schedule an interview. In addition, each mailing included a stamped postcard for potential participants to return if they preferred the option of receiving a phone call from an interviewer or if they wished to decline participation. A follow-up phone call was made to those potential participants who neither called nor returned a postcard within a few weeks of receiving the mailing. For each program, recruitment targeted an equal number of participants who had accepted and joined the program and those who had either declined to join or otherwise not followed up on an invitation or referral. Men and women aged 50 and above were recruited in proportion to their representation in the population. Other eligibility criteria included residing in King County, English fluency, and possessing the cognitive ability to clearly understand the decision to participate in the study.

2.2.3. Interview Instrument. The interview guide consisted of a series of open-ended questions designed to facilitate a conversation during which individual motivators and barriers to participation in the specified programs might be identified and discussed. The first half of the interview covered the role of health-related beliefs and behavior in participants' daily lives, particularly as it related to views on healthy aging and participants' core values. The second half focused specifically on attitudes and behaviors surrounding fall prevention, including participants' experiences of their own falls and efforts to prevent falling again. Interview questions were developed by the investigators to address the phenomenon of interest (i.e., lower than anticipated participation in available clinical services to address fall risk on the part of older adults with a history of having fallen). The first author (EAP) was familiar with the small body of relevant literature on the topic; however, no particular preconceived hypotheses were explored via the interview questions, nor were the interview questions designed to confirm or disprove findings from other published work.

2.2.4. Interview Procedure. All interviews were conducted by research assistants who received training in conducting semi-structured, in-person interviews. Interviewers scheduled appointments by phone and conducted the interviews at participants' homes or at another location of the participant's choosing. All interviews were audiotaped, and an incentive to participate was provided in the form of a gift card worth $25. Each interview lasted approximately 45 minutes, and upon conclusion, participants completed a paper questionnaire of standard demographic information about themselves and their households. Throughout the process, interviewers were monitored to ensure both quality control and interinterviewer consistency.

All study procedures were approved by the Institutional Review Board at the University of Washington.

2.3. Analysis. Each interview was transcribed verbatim by a professional transcriptionist. Transcripts were then uploaded into Atlas ti version 5.2 (Scientific Software Development GmbH, Berlin, Germany), a computer software program that facilitates qualitative data analysis. Interviews were grouped based on the participant's status as either a program "joiner" or "non-joiner," as the primary focus of this study was to ascertain differences between these two groups.

Coding and theme development was guided by the grounded theory approach of Strauss and Corbin [17, 18]. This methodology was chosen because our main purpose was to arrive at an understanding of people's actions/behaviors with regard to care-seeking for falls/fall risk. All coding was completed by two coders with experience in qualitative coding and analysis, working independently. The two coders and a third research team member read through all interviews prior to coding and theme development to establish initial impressions and to facilitate grounding in the data. An initial start list of codes [15] was developed by identifying a priori areas of interest, such as "consequences of falling" and "barriers to joining," and was included in the interview guide. The second stage of code development consisted of line-by-line reading of the interviews to capture subcodes that emerged from the data. These sub-codes were organized under the start list codes developed in the first stage. In this initial coding stage, an extensive codebook was developed that included definitions for the start list and all related sub-codes. Coding discrepancies were reviewed with the full research team until consensus on final codes was reached. Because coding was done by consensus, interrater agreement was not calculated. The codebook was then applied to all interviews, which were coded line-by-line.

After completion of the coding stage, comparison analysis [19] was conducted to uncover differences and similarities between "joiners" and "nonjoiners." To complete this analysis, we examined a number of important factors to determine if the groups differed on any of these factors. Factors examined included: if an injury had accompanied the fall, the stated cause of the fall (falling due to illness or medication verses falling due to environmental factors, such as slipping), aging-related loss, the effect of doctor referral, the emotional response to falling, participant core values, such as the importance of family and social connections, demographic factors, and program type (clinic versus home-based).

Atlas ti was used to perform both textual searches and visual displays of relationships and patterns emergent in the data. Initial themes resulting from this analysis were developed by one of the primary coders. An iterative process was then used to further develop and confirm the resultant themes by a third research team member.

3. Results

3.1. Recruitment. For the Fall Prevention Clinic, 35 letters of invitation were mailed to joiners and 40 to nonjoiners to reach our interview target of 20 completed interviews. For the EMS Fall Prevention Program, 30 letters were mailed to joiners and 37 to nonjoiners to reach our interview target of 20 completed interviews.

3.2. Demographics. Table 1 summarizes the demographics and self-perceived health of participants. Participants were predominantly females in their mid-70s. Just a few were nonwhite. Roughly one-quarter had an annual household income less than $15,000. About half were college graduates. Most lived alone. There were no significant differences by joiner status on any of the sociodemographic characteristics that we examined.

Table 1: Participant demographics and self-perceived health, by joiner status.

Characteristic	Nonjoiner ($N = 20$)	Joiner ($N = 19$)
Female, %	83	70
Age ≥75, %	30	45
Age, years, mean (SD)	76 (11)	77 (10)
Married or partnered, %	22	25
Non-white, %	6	0
College graduate, %	44	47
Household income < $15,000, %	29	26
Lives alone, %	72	65
Self-rated health excellent or very good, %	44	32

3.3. Overarching Descriptive Themes. One of the most striking findings in this work was the similarities between joiners and nonjoiners of fall prevention programs. The two groups did not differ in most of the factors we examined. They were similar in their experience of loss associated with aging, in the core values they expressed, and in their emotional response to falling. In addition, we discovered that both groups of interviewees were using common public health terms in ways different from how these terms are typically used and understood by health professionals using the same terminology.

3.3.1. Loss Associated with Aging. The group as a whole expressed significant aging-related loss, both in their own physical abilities and in their familial or social relationships. Over 70% of participants expressed diminishing physical function, and over half expressed familial or social loss.

> HFPC J5: I used to walk long distances every day, but I cannot do that anymore. I push it as far as I am comfortable pushing it. I regret that I cannot do it, but that's the way it is.

> EMS J2: I have just dropped out of UW's courses that I was taking, because of a number of reasons, one of which was that it's so difficult for me to get around. Even though I have the services of Dial-a-Ride on campus, still in some cases, just getting to the Dial-A-Ride meeting place was very, very difficult.

> EMS NJ4: Yes, I was married. My husband died on our 25th wedding anniversary so I have been alone ever since.

> HFPC J6: Because in two-and-a-half years I lost my husband and five close relatives. It just has not left me in very good spirits most of the time, because I was close to all of my relatives. My brother was one of them, and it's just not been easy.

> EMS NJ5: We have stopped doing lots of things that we did do, because it would take us longer to get to a meeting, for instance, and all of this kind of thing.

3.3.2. Independence. Nearly all participants expressed the importance of independence and of being able to maintain their current level of functioning. Interestingly, this value was expressed regardless of their current circumstances and level of physical functioning.

> EMS J7: I love my independence. I love it. I have never liked to depend on anyone.
>
> HFPC J5: It (being independent) is very important. The wonderful thing about living here is that this is independent living, and although we have housekeeping and we have a dining room downstairs, we are free to come and go and do whatever we wish to do.
>
> EMS NJ5: It's very important, because you just think that at least you can take care of yourself, if you cannot do all of these other things.

3.3.3. Emotional Responses to Falling. All participants in this study had experienced at least one fall, and many had sought medical attention for their fall. When asked how they felt right after the fall, the participants named emotional responses that were similar across groups, expressing anger at themselves, fear, and embarrassment.

> HFPC J7: It was sort of like, "Boy, how clumsy can you get?" I didn't immediately start thinking that, "oh, no, I am not going to be able to take care of myself" or anything like that. I was sort of annoyed with myself that I had done that, more than anything else.
>
> EMS NJ3: What have I done? I have really screwed up again. Then I said, "(Name), how could you have done this?"
>
> HFPC NJ3: I was scared. I was mostly scared, because I said, "Oh, is this what life has for me?" I was falling so hard, and they tell us that you can break a hip. If you break a hip, you are on your way out. That just really was scary.
>
> EMS J2: Well, you know, it's embarrassing. Here I am an old man, sort of, on the ground on my hands and knees.

In addition to the initial emotional response to falling, most participants expressed a heightened fear of falling and subsequent injury. They described trying to "be careful" to avoid falls and reported being very vigilant to avoid falling again.

> HFPC NJ9: I try to be really careful, especially down my basement stairs. I mean, I have fallen there before, and I do not want that to happen again.
>
> HFPC J7: I also watch where I put my feet now more often than I did before.
>
> EMS NJ4: I am very careful. The rug, I watch because it wrinkles up, but I am very careful... Well, I do not want to break a hip.

3.4. Discrepancies in Terminology. As coding was being conducted and themes were developed, it became clear that the participant's understanding and usage of terms such as "independence" and "physically active" were not in line with how public health professionals typically use those terms. For example, participants considered themselves independent and valued that independence even when they were being cared for in a facility or by a caregiver. Their view of independence was much broader than the definitions used by health and public health professionals and focused on maintaining their current level of functioning.

Additionally, "physically active" was used by participants to refer to the activities of simple daily functioning; again a broader definition than is usually used in public health. When asked, "What first comes to mind when you think about being physically active, or staying physically fit?" A typical response was: "Well, being able to get out of bed, being able to dress myself, being able to feed myself, and being able to function in the way that most of us do or want to."

3.5. Barriers and Facilitators to Program Participation. The analysis of these interviews revealed just one primary difference between those who participated in one of the fall prevention programs and those who did not. Those who participated expressed that they "needed" the program; those who did not participate expressed a lack of need. Transportation was also cited as a barrier, although it was unclear if it was a primary barrier for those who cited it.

3.5.1. Perception of Need—Joiners. Those who joined a fall prevention program stated their need for the program in very simple terms, giving a sense that they would do everything they could to avoid falling again. When asked why they decided to go to the fall prevention clinic or have the in-home visit from EMS, 17 of the 20 interviewees responded with a simple variation of, "I saw the need."

> HFPC J3: I needed to quit falling.
>
> EMS J6: Well, I am most eager to learn anything that would be helpful for me.

3.5.2. Perception of Need—Nonjoiners. For those who chose not to participate, need perception also played a large role in two different ways. Half the group stated that they did not need the program because they felt they had not yet "reached the point" of needing intervention and that they could prevent falling themselves by being more careful.

> EMS NJ10: I'd say, "Oh, I do not need that. I am just going to be aware." That's all that I can think of; I do not want that.
>
> EMS NJ1: At this point in time in my life, I do not feel like I need the extensive help that I might need later.

Others interviewed felt there was "no need" for the program because they felt beyond help or did not believe that anything could be done to prevent falling. There was also a sense from these respondents that, having multiple health conditions, they felt overwhelmed thinking about one more intervention.

> EMS NJ7: Well, I do not think that there's anything that you can do. I do not know what you can do.

> HFPC NJ1: Yes, I am just not interested because I do not think that they can help me any, frankly.

> HFPC NJ5: I have been through so many of these evaluations, and it's just yadda, yadda, yadda.

3.5.3. Transportation Barriers. Lack of transportation was the one other significant barrier that affected the Harborview Clinic participants. (EMS is an in-home program.) This barrier was discussed by 5 people who declined to participate in the Harborview clinic. This barrier was often mentioned in combination with other reasons for not participating, such as, "I just forgot," and "I am not sure what they do for me."

> HFPC NJ2: I hate to ask people that I know to drive me, and so even from here to there, it's a bitch. That's my first thought, how am I going to get there? Then I put it out of my mind because I cannot go.

4. Discussion

The results of our study suggest that the main reasons for older adults accepting an invitation to participate in a fall risk assessment and management program relate to outcome expectations of the program. Participants who followed through on a referral to the fall prevention clinic or who received the home-based EMS fall risk assessment program believed that such a program would benefit them in helping them reduce their fall risk. Falling and its consequences instilled a great deal of anxiety and fear in our participants, and the older adults who chose to join a community fall prevention program reported interest in *any* program or resource that could help them prevent falls. In contrast, older adults who turned down the invitation for either program did not perceive a great need, either because they did not think they needed such a program at that particular point in their lives or because they felt they were beyond help. Nonjoiners reported relying on their own strategies (e.g., being more careful) for risk reduction.

These findings share some similarities with those reported in published studies involving elders in other countries. In a study of accepters and decliners of referral to a falls clinic in Denmark [13], all accepters believed that something could be done about their falls problem, that the time investment was worthwhile, and that they would use the advice received, whereas decliners expressed concerns that the healthcare system would take over their life, that the logistics and time commitment were excessive, and that providers had "hidden agendas" and might criticize them if they didn't follow advice. Yardley et al. [11] found that those they studied underestimated their personal susceptibility to falling and believed that no additional fall prevention measures were necessary. Those they interviewed also cited practical factors, such as transportation, effort, and cost as precluding their participation [11]. We did not identify among our sample the perception that fall prevention as a concept threatened personal identity and autonomy, as has been described by others [10]. However, in a departure from other published studies, we did find a prominent belief in self-reliance, that is, the power of the individual him- or herself to use their own methods to control his/her likelihood of falling again in the future. Of interest, a recent study of a sample ($N = 36$) of homebound women in their mid-80 s to mid-90 s who resided in the Midwestern U.S. and had a history of falling in their home describes in great detail a variety of strategies that these women articulated as ways that they planned to avoid falling again, such as avoiding quick turns, taking care not to bend over, wearing shoes that will not slip, and using one's cane or walker more consistently [20].

In addition to perceived need and beliefs about the outcome of joining a fall risk assessment program, our participants highly valued "independence." However as mentioned above, participants' perception of independence was different from and more limited than what is usually presented in the literature. The same was true for other constructs, including "healthy aging" or "physical activity." That is, the predominant thoughts around independence, healthy aging, and physical activity were related to the ability to perform daily activities (i.e., get dressed by themselves, cook dinner, clean house). Participants took pride in listing the daily activities they were capable of doing (no matter how few), and their ability to maintain this level of "independence" was extremely important to them.

4.1. Recommendations for Practice: Conveying Program Benefits. The results of this qualitative study suggest that, in order to participate, older adults have to perceive a need for a community fall risk assessment program and that this perceived need is related to their assessment of how a program will benefit them in maintaining their current level of function. In portraying the benefits of a fall risk assessment program, it is important to emphasize program benefits that are consistent with the reality of many older adults' situation. Especially for high-risk elderly, who struggle with comorbidities, loss of physical abilities, and shrinking social networks, the emphasis should be on how falls are a major threat to remaining functional and independent [2, 3], and that through reducing the risk of falling by receiving and following recommendations provided by such preventive programs, these programs can help them maintain a level of confidence, mobility, and independence in their daily functioning [21].

4.2. Recommendations for Practice: Desirable Program Characteristics. In addition, access to such programs needs to be simple. Assisting such older adults in getting to a clinic and back, perhaps through a "patient navigator" or a volunteer transportation program, may be instrumental in getting a high-risk population to a regional center that offers fall risk assessments. Engaging family caregiver support for an elder being counseled to undergo a fall risk assessment may also be helpful in encouraging participation. Regular, ongoing contact with a supportive health professional, such as a physical therapist, may increase motivation to continue fall prevention activities (e.g., doing routine balance and strength exercises) over time.

4.3. Recommendations for Practice: Advice from a Trusted Source. The results of this study are informative for healthcare practitioners and aging service providers seeking to engage high-risk elderly to participate in a fall risk assessment program. Having a history of having fallen did not necessarily lead participants to perceive that they needed to undergo an individualized risk assessment. This finding supports practitioners directly educating older persons about the fact that having experienced a fall suggests that one is highly likely to fall again in the future [22]. For the present generation of elderly, the advice of a personal physician has been shown to facilitate participation in fall prevention activities [12], and thus educational guidance, along with a recommendation to undergo a risk assessment, delivered by an informed primary care provider, may be invaluable in shaping an older adult's understanding of the importance of avoiding falls to well-being and the role of individualized risk assessment in this context.

With regard to limitations of the present study, one limitation is that only 1 out of every 4 eligible participants agreed to participate in this study, which may have resulted in a selection bias. Even so, we believe this selection bias is limited, since the total pool of eligible participants were fairly homogeneous due to the fact they had all been invited to undergo assessment and management by one of two fall prevention programs (which have their own eligibility criteria). A second limitation is that our study sample was not as racially diverse as we had anticipated; thus, further studies involving non-white persons are warranted.

Our study has several strengths. The sample was well-defined in terms of its sociodemographics, inclusive of those of low income, and uniform with respect to all participants being at high fall risk due to having had a history of at least one fall in the past. This latter point is important, in that it allowed us to circumvent the phenomenon of low perceived relevance of fall prevention due to not having experienced a prior fall [23]. In addition, we did not find major differences in attitudes between joiners and nonjoiners according to program. Participants who qualify for one program are typically eligible for the other program as well, and so this finding is perhaps not unexpected. The fact that findings for joiners and nonjoiners were similar regardless of program speaks to the external validity of our key results.

5. Conclusions

The study sample consisted of a group of elderly all of whom had experienced a fall. Many participants had experienced significant age-related losses. The perception of need was the critical factor in determining participation in the fall prevention programs offered. Interventions targeted at this high-risk group will need to address individual beliefs as well as structural and social factors (i.e., transportation issues, social networks) to optimize participation of this group in such programs.

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Research Article

Prevalence and Correlates of Physical Disability and Functional Limitation among Elderly Rural Population in Nigeria

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Background. The number of people surviving into old age is increasing, and it has now become a global phenomenon. Studies on the prevalence and correlates of physical disability and functional limitation among elderly Nigerians are scanty. *Methodology*. This is a community-based cross-sectional study conducted in 3 local government areas (LGAs) in Nigeria, using a multistage sampling technique. Functional limitations of 1824 elderly persons were tested using Tinetti performance-oriented mobility assessment tool (TPOMAT) and self-reported activities of daily living (ADL). ADL disability of ten, six, and five basic items were compared. *Results*. The prevalence ratios (PRs) of physical disability using the ten, six, and five basic ADL items were 28.3 (95% CI 25.2–31.5), 15.7 (95% CI 13.4–19.8), and 12.1 (95% CI 9.8–15.3), respectively, while functional limitation was 22.5 (95% CI 18.1–24.4). Increased risk of disability was independently associated with female gender PR 3.6 (95% CI 1.5–7.4), advanced age ≥75 years; PR 22.2 (95% CI 14.5, 36.8), arthritis PR 3.7 (95% CI 2.6–4.6), stroke PR 4.8 (95% CI 3.7–7.9) and diabetes PR 6.1 (95% CI 4.3–7.1). *Conclusions*. The findings from this study are pointers to unmet needs of the elderly disabled Nigerians.

1. Introduction

The number of people surviving into old age is increasing, and it is a global phenomenon affecting developing and developed countries [1]. Information on disability is very important in responding to the care of the elderly. Disability is defined as a restriction in the ability to perform normal activities of daily living [2], and it helps to quantify the impact of disease or injury. Disability is particularly a useful concept in assessing the health of elderly people, because they have several diseases occurring simultaneously with varied severity and impacts on their daily lives. Gill and colleagues [3] have reported the powerful effects of disability on individual well-being, the need for informal help and health care, as well as long-term care needs and costs. On the basis of this, the epidemiology of elderly disability cannot be overemphasized. The process of disability represents a distinct phase in the life of many elderly persons [2]. Functional limitation is associated with loss of independence and with increased need for both formal and informal care [4, 5]. The prevalence of physical disability in elderly persons with functional limitation are, therefore, important for policy development on care of the elderly be it formal or informal care. Contrary to the developed nations [6], most developing nations, specifically those in sub-Sahara Africa, lack reliable data to formulate policy on aging even though the populations of their elderly persons (aged 60 years and above) are increasing even more than developed nations [7].

The pattern and profile of disability that is obtained among the elderly in developed countries differs from those in developing nations. This is expected because of the difference in life expectancy. For example, life expectancy in Nigeria is currently about 48 years for elderly men and 50 years for elderly women [8]. In the developed countries, the available data suggest that life expectancy at birth was around 35 to 40 years in the mid-1700s, rose to about 45 to 50 by the mid-1800s, so that by the middle of the twentieth century, it was approximately 66 to 67 years probably because of that rapid improvements that began at the end of the nineteenth century [9]. Physical disability and functional limitation are common among older people [10], leading to adverse consequences such as dependency and institutionalization. Older people's ability to function independently is important, as physical disability and functional limitation have profound public health implications with increased utilization of health care and a need for supportive services and long-term care [4]. Due to economic hardship and extreme limitation of well-paid job opportunities in rural areas, most children and caregivers of the elderly have migrated to towns and cities for greener pasture thus abandoning the elderly with their disabilities. This underscores the need to study the prevalence of physical disability and functional limitation especially in a Nigerian rural underserved population of older adults.

Several studies [11] on physical disability and functional limitation have been reported in developed countries. However, data are very scanty for developing countries especially in rural Nigeria. Apart from demographic factors like female gender and increasing age [12, 13], social variables like smoking and alcohol consumption, low-income earning, low education, and urban dwelling have been associated with increased risk of disability among elderly persons [12, 14]. In many respects, these correlates of disability are particularly germane to sub-Saharan Africa in general and Nigeria in particular [15]. The objective of this study is, therefore, to determine the prevalence and factors associated with physical disability and functional limitation among elderly Nigerian.

2. Methodology

2.1. Study Population, Research Instrument, and Methods. The study subjects were elderly rural dwellers aged 60 years and above from Abadam, Guzamala, and Mobbar local government areas (LGAs) in Borno State, North-Eastern Nigeria; and the study was conducted between March and August 2010. Elderly people who were non-Nigerians and those who were temporary residents (lived in the community less than 24 months) were excluded from the study. The study population was identified from 2006 community census list which was obtained from the LGA population census unit. Homes of the participants and primary health centers in each selected local government areas served as the venues of interview and clinical assessments, respectively. In order to reduce or avoid missed opportunity, interviews and clinical assessment were conducted three times a week. Period of interview was in the morning and evening, while the clinical assessment was between 8 am to 4 pm daily in the health centers.

The interview and clinical assessment were conducted by seven community health officers and three nurses mostly Kanuri indigenes that were very fluent in Kanuri and Hausa Languages and were trained as research assistants in all aspects of the study such as questionnaire administration and clinical assessment. The questionnaire was pretested in another Kanuri Community to avoid ambiguity and easy administration during the survey.

2.2. Relevant Health Related and Sociodemographic Information. Information on the following relevant health-related variables was obtained: presence of chronic conditions, depressive symptomatology, height and weight measurement, cognitive function, and presenting visual acuity. Questions about the presence of chronic diseases include have you ever been managed as a patient for diseases like hypertension, heart attack, diabetes, epilepsy, stroke, arthritis, pneumonia, and asthma? Chronic conditions were coded A, B, and C. Hypertension and heart attack belongs to code "A", diabetes belongs to code "B", while arthritis, pneumonia, and asthma were coded "C". Depressive symptomatology was assessed using the short version of the geriatric depression scale 15 item (GDS) [16]. Scores ranges from 0–15, with scores of six or more indicate depressive symptomatology. Height and weight were measured with the participants in light clothing and without shoes. Body mass index (BMI) was calculated as weight in kilogram divided by square of height in meter expressed as kg/m^2 in the result and table. BMI is an index, and therefore, it has no unit.

Cognitive function was assessed using the elderly cognitive assessment questionnaire (ECAQ) [17]. ECAQ has been shown to be a valid tool for assessment of cognitive impairment among older people living in developing countries [17]. ECAQ scores range from 0–10. A score of 0 to 4 indicates probable cognitive impairment, 5 to 6 borderline, and 7 and above as normal. Visual acuity was assessed at designated primary health care centers using a standard metric Snellen chart of alphabets E type at 6 meters. Participants' self reporting or presenting visual acuity (PVA) was ascertained with wearing of habitual optical corrective glasses (spectacles). The World Health Organization [18] defines mild or moderate visual impairment as PVA of less than 6/18 but equal to or better than 3/60. Blindness is defined as PVA of less than 3/60 in the better eye [18]. Mid-arm circumference wad used as a measure of malnutrition. Face-to-face interview was used to collect data on sociodemographic variables like gender, age, education level, marital status, social support, monthly income, ownership of motor vehicle, ownership of modern house, living arrangement, and ethnicity. Ethnic group was categorized as Kanuris, Fulanis, and Hausa.

2.3. Study Design and Sampling Technique. This is a population-based cross sectional study and multistage sampling technique was used. The three LGAs were purposively chosen but randomly selected using simple random sampling technique from the available rural LGAs and subjects were allocated to each LGA proportionately according to population of the elderly in the LGAs. Cluster sampling technique was used in the final selection of all participants (total sampling) in each LGA that met the inclusion criteria.

2.4. Measures of Physical Function. Two physical function measures were used in the assessment: performance-based functional limitation and self reported physical disability. The Tinetti Performance oriented mobility assessment tool (TPOMAT) was used and is a measure of functional limitation that assesses older people's gait and balance abilities [19, 20]. In conducting the balance assessment, the participants were seated in hard, straight-backed, armless chairs. Participants' balance abilities were assessed by performing maneuvers such as sitting in chair, rising from chair, immediate standing balance (first three to five seconds after standing), further standing balance, balance with eyes closed, turning balance, ability to withstand displacement when slightly pushed from the sternum, neck turning, one leg standing balance, back extension, reaching up, bending down, and finally sitting down. For gait assessment, participants were asked to stand with the examiner in an obstacle-free walkway. Participants used their usual walking aid and were asked to walk down the walkway at their usual pace. Participants' gaits were observed for initiation of gait, step height, step length, step symmetry, step continuity, path deviation, trunk stability, walk stance, and turning while walking. For maneuvers such as path deviation, trunk stability, and walk stance, the examiner walked behind the participants and for others next to the participants. Participants were then asked to walk back at a "more rapid than usual but safe pace" using usual walking aids.

Level of performance of each activity was rated 0-1, where a score of 0 meant inability to perform the activity and a score of 1 meant ability to perform the activity. The maximum score for the gait component was 12 points and for the balance component it was 16 points. Participants with scores of less than 12 (for gait) or less than 16 (for balance) were defined as having performance-based functional limitation. In order to test for physical disability, the ten-item Barthel index was used. Barthel index is an assessment of patients' level of independence in activities of daily living (ADL) [21]. The ten ADL items assessed were feeding, bathing, dressing, grooming, toileting, bladder control, bowel control, transferring from bed to chair, walking, and stair climbing. For this study, the operational definition of physical disability is needing help in one or more of these ADL activities. In order to compare this study with others, physical disability was also determined using the six Katz index of independence in ADL items related to self care (feeding, dressing, bathing, toileting, transferring, and walking) [22, 23] and five items related to self-care (feeding, dressing, bathing, toileting, and transferring) [24].

2.5. Data and Statistical Analysis. Following collection, collation, and editing, data were entered into a computerized data base. Data were analyzed using statistical package for social sciences (SPSS) version 16. Clustering of data and sampling probability weights were taken into consideration during the analysis. In order to allow comparison with prevalence of ADL disability reported in other studies, we estimated the prevalence of ten, six, and five items ADL dependence. In this study, the prevalence for disability was also aged standardized population using the indirect standardization method for proper comparison with studies elsewhere.

Indirect standardization method was also used for comparing prevalence of physical disability and functional limitation across the three ethnic groups (Kanuris, Fulanis, and Hausa), and in this study, Kanuris group was used as the standard population. As a result of the high prevalence of physical disability and functional limitation, prevalence ratio (PR) was calculated instead of odds ratio (OR) [25]. All analyses were carried out using SPSS log binomial regression and Poisson regression with strong and reliable variance [26]. Two sets of univariate analyses were performed using chi-square tests: firstly, analysis was done to identify associations between the ten items physical disability and health related and sociodemographic variables; secondly, similar analysis was done with functional limitation. Then, multivariate Poisson regression with robust variance was performed to test which of the health-related variables and sociodemographic variables were independently associated with physical disability and functional limitation. Variables with clinical and statistical significance (P value of <.05 in the univariate analysis) were regarded as being significant. Participants with cognitive impairment identified through scores of less than five based on the elderly cognitive assessment questionnaire (ECAQ), were removed from the analysis ($n = 43$). Individual medical conditions (such as stroke, diabetes, arthritis, etc.) were used as explanatory variables in the analysis to find out their association with disability as well as functional limitation.

2.6. Ethical Approval. Due to very high illiteracy level in the study areas, informed (verbal) consent was obtained from all participants.

3. Results

3.1. Response Rate. Of the 1905 questionnaires distributed to elderly people who satisfied the inclusion criteria, 1824 respondents completed the questionnaire and were also available for physical examination, giving a response rate of 95.7%. Reasons for nonresponse include lack of interest (25%), competing issues (60%), sickness (5%), and traveling (10%).

3.2. Respondents Sociodemographic and Health Variables. Table 1 depicts the sociodemographic and health variables of the respondents. The age of respondents ranged from 60 to 87 yrs (with mean age of 69 ± 7 years SD). Of the elderly men, 31.2% were within 60–64 yrs age group, 28.6% were 65–69 years, 23.7% were 70–74 yrs, and 16.5% were 70 years and above. In the elderly women category, 34.6% were within 60–64 yrs age group, 26.1% were 65–69 years, 21.1% were 70–74 yrs, and 18.2% were 70 years and above. There were more elderly women [977 (53.3%)] than elderly men [847 (46.7%)]. Illiteracy level was 85% and of those that were literate, 87% had primary education and 11% had secondary education and 3% had tertiary education. Of all the elderly women, only 4.6% had secondary education, 15.3% had primary education and 80.1% had no formal education. None of the elderly women had tertiary level of education. Kanuri (84.%) constitutes the major ethnic group, while Fulani and Hausa represent 8.8% and 7.2%, respectively. Marital status of elderly men showed 86.3% married, 10.8% widowed, 1.8% divorced, and 1.1% single. Of the elderly women, 45.7% were married, 38.5% were widowed, 11.1% were divorced, and 4.7% were single.

More than four-fifth (88.4%) of the respondents live with other family members, while 11.6% lived alone. In both sexes, more than two-thirds had normal cognitive function, 92.1% in elderly men and 81.2% in elderly women. Elderly women (12.6%) are two times borderline cognitive impaired compared with elderly men (6.1%). Also, elderly women (5.4%) are about three times probably cognitive impaired compared with elderly men (1.8%). More elderly women (24%) had more than one chronic disease than elderly men (15.5%). Elderly women (25.1%) are slightly more depressed than elderly men (22.7%). Elderly women (16.4%) are also more overweight than elderly men (12.5%). More than three-quarters (78.5%) earned less than one hundred American Dollars per month and less than 5% of the participants earned more than three hundred American Dollars per month (Table 1).

3.3. Physical Disability and Functional Limitation Prevalence Rate. The prevalence rates for physical disability and functional limitation are shown in Table 2. More than one-quarter (28.3%) of the respondents signified interest for assistance in at least one of the 10 ADLs in the Barthel index. The prevalence of disability based on at least one item of the six ADL scale was 15.7% and prevalence of disability based on at least one item in the five ADL scale was 12.1%. The prevalence of functional limitation was 22.5%. The overall prevalence of disability (10 items ADL, 6 items ADL, and 5 items ADL) and functional limitation increased with advancing age. The prevalence of needing help in at least one of the ten ADLs of the Barthel index increased from 11.7 in those aged 60–64 years, to 98.9% of those aged 75 years and older (Table 2). The prevalence of functional limitation rose from 12.4% in those aged 60 to 64 years to 98.3% in the 75 years and above age group (Table 2). In all the participants, the prevalence of both self-reported physical disability and objective measurement of functional limitation was higher in elderly women than in elderly men (Table 2). Among the three ethnic groups, Kanuris had the highest prevalence of physical disability (10 items ADL, 6 items ADL, and 5 items ADL) compared to the Fulanis and Hausa (Figure 1).

However, the prevalence of functional limitation was almost similar across all ethnic groups. The correlations between performance-based functional limitation and self-reported physical disability among the different ethnic groups showed thus that the correlation coefficient for Kanuris, Hausas, and Fulanis were 0.52, 0.48, and 0.23, respectively. Elderly persons with levels of mid-arm circumference indicative of severe malnutrition had an increased risk of physical disability and functional limitation (Table 3). Among the four groups of monthly level of income, respondents that earned less than 100 US$/month had the highest prevalence of physical disability (10 items ADL, 6 items ADL, and 5 items ADL). The prevalence of functional limitation rose from 0.6% in those that earned more than 300 US$/month to 33.2% in those that earned less 100 US$/month.

3.4. Outcome of Sociodemographic and Health Correlates on Physical Disability and Functional Limitation. With increase in age, elderly women with low education self-reported one or more chronic diseases than their elderly men counterparts.

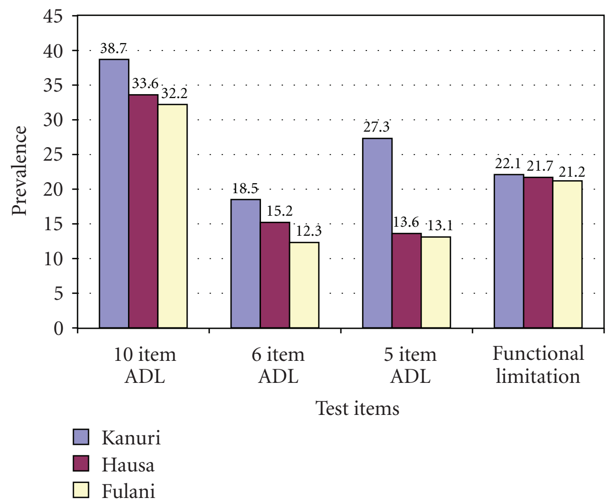

Figure 1: Prevalence of physical disability and functional limitation by ethic group among Nigerian rural elderly.

This study also showed that having depressive symptomatology and presence of visual impairment (mild-to-moderate blindness) were found to be more associated with physical disability. Furthermore, being at risk of isolation was associated with functional limitation (Table 4). In Table 4, all explanatory variables except ethnicity used in the univariate analysis were significantly associated with functional limitation. The multivariate associations between physical disability and functional limitation, and sociodemographic and health-related variables are shown in Table 5.

Table 5 shows a significant independent associations between physical disability and advanced age, (≥75 years: prevalence ratio (PR) 22.2; 95% CI 14.5–36.8), presence of diabetes (PR 6.1; 95% CI 4.3–7.1), and visual impairment (blindness: PR 6.6; 95% CI 3.6–11.9). The independent variables found to be associated with functional limitation include advanced age, (≥75 years: PR 10.5; 95% CI 5.4–16.4), female gender (PR 9.3; 95% CI 3.7–18.3), presence of arthritis (PR 5.2; 95% CI 3.5–6.8), and having depressive symptomatology (PR 6.4; 95% CI 4.7–9.2).

4. Discussion

In contrast to physical disability, functional limitation represents an outcome that is free from external factors or environmental influences. This adds clarity to the understanding of the dynamics of the pathway from disease to disability [27]. The study population was randomly selected from geographically defined rural communities, and a high response rate was recorded. The prevalence rates of physical disability for all the three ADL scales and functional limitations were less than one-third and increased with age. The increase was observed to be higher in elderly women than elderly men and among Kanuris than among Fulanis and Hausas. The increase observed among the ethnic groups was not statistically significant. Advance in age, presence of diabetes, stroke, depressive symptomatology, and visual

Table 1: Respondents sociodemographic and health related variables by sex.

Variables	Male frequency (%)	Female frequency (%)	Total frequency (%)
Age			
60–64	265 (31.2)	338 (34.6)	603 (33.1)
65–69	242 (28.6)	255 (26.1)	497 (27.3)
70–74	201 (23.7)	206 (21.1)	407 (22.3)
75 & above	139 (16.5)	178 (18.2)	317 (20.3)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
Marital status			
Married	730 (86.3)	446 (45.7)	1166 (63.9)
Widowed	93 (10.8)	376 (38.5)	469 (25.7)
Divorced	15 (1.8)	109 (11.1)	124 (6.8)
Single	19 (1.1)	46 (4.7)	65 (3.6)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
Educational level			
No formal education	352 (41.6)	783 (80.1)	1135 (62.2)
Primary education	365 (43.0)	149 (15.3)	514 (28.2)
Secondary education	116 (13.8)	45 (4.6)	161 (8.8)
Tertiary education	14 (1.6)	0 (0.0)	14 (0.8)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
Ethnicity			
Kanuri	645 (76. 2)	818 (83.7)	1532 (84.0)
Fulani	120 (14.2)	92 (9.5)	161 (8.8)
Hausa	82 (9.6)	67 (6.8)	131 (7.2)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
Living arrangement			
Living alone	70 (8.3)	142 (14.5)	212 (11.6)
Living with others	777 (91.7)	835 (85.5)	1612 (88.4)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
Social support status			
Likely to be isolated	115 (13.6)	216 (22.2)	331 (18.1)
Isolation not likely	732 (86.4)	761 (77.8)	1493 (81.9)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
Cognitive status			
Normal	780 (92.1)	801 (81.2)	1581 (86.7)
Borderline cognitive impaired	52 (6.1)	123 (12.6)	175 (9.6)
Probably cognitive impaired	15 (1.8)	53 (5.4)	68 (3.7)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
Depression assessment			
No	655 (77.3)	732 (74.9)	1387 (76.0)
Yes	192 (22.7)	245 (25.1)	437 (24.0)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
BMI (Kg/m^2)			
Underweight (<20.0)	401 (47.3)	357 (36.5)	758 (41.6)
Normal (20.0–24.9)	368 (43.3)	405 (41.5)	773 (42.4)
Overweight (25.0–29.9)	55 (6.5)	163 (16.7)	218 (11.9)
Obese (≥30.0)	23 (2.7)	52 (5.3)	75 (4.1)
Total	847 (100.0)	977 (100.0)	1824 (100.0)

Table 1: Continued.

Variables	Male frequency (%)	Female frequency (%)	Total frequency (%)
Chronic disease status			
0	254 (30.0)	387 (39.6)	641 (35.1)
1	462 (54.5)	535 (54.8)	997 (54.7)
>1	131 (15.5)	55 (24.0)	186 (10.2)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
Monthly income			
<100 US$/Month	651 (76.9)	780 (79.8)	1431 (78.5)
100–199 US$/Month	124 (14.6)	120 (12.3)	244 (13.4)
200–299 US$/Month	47 (5.5)	55 (5.6)	102 (5.6)
>300 US$/Month	25 (3.0)	22 (2.3)	47 (3.5)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
Owning a modern house			
No	807 (95.3)	951 (74.9)	1758 (96.4)
Yes	40 (4.7)	26 (25.1)	66 (3.6)
Total	847 (100.0)	977 (100.0)	1824 (100.0)
Owning a car			
No	799 (94.3)	908 (92.9)	1707 (93.6)
Yes	48 (5.7)	69 (7.1)	117 (6.4)
Total	847 (100.0)	977 (100.0)	1824 (100.0)

impairment were independent variables found to be more associated with physical disability. Furthermore, advance in age, female gender, arthritis, and depressive symptomatology were also significantly associated with functional limitation. As previously stated, studies on physical disability among elderly people in Nigeria is very scarce; therefore, comparison of findings in this study with studies elsewhere is limited by definition criteria, differences in the way disability was measured, and sample characteristics. Studies in which the scope of definition of disability was not wide; for example, in which disability is based on any level of difficulty in the performance of daily tasks, the prevalence of disability is expected to be high and probably higher than that from this study. In addition, studies that exclude institutionalized elderly persons, the range of disability will also be different. Institutional care of the elderly is very rare in Nigeria, and this study includes the entire range of functional limitations obtainable in rural population and thus excludes elderly in institutional care. Despite the scenario explained above, the rates of disability and functional limitation are comparable to levels reported among elderly persons in Malaysia [27].

Using the 10 items Barthel index, this study revealed that more than one fifth (28.3%) of the elderly aged 60 years and above were dependent in at least one ADL. This finding is similar to that reported by previous studies [27, 28]. However, a study in Singapore [29] found much lower disability prevalence than this study. Comparison with studies in other countries is difficult due to use of different ADL measurements; however, narrowing ADL disability to receiving help for at least one of five ADL items (eating, bathing, dressing, transferring, and toileting) or six ADL items (walking, eating, bathing, dressing, transferring, and toileting) allows reasonable comparison across some studies. Elderly women in this study have more functional disability than elderly men. Also, increase in age was found to be associated with increasing rates of disability. All these variables are often associated with the occurrence of disability as reported in the literature [30]. According to the six-item ADL index, the prevalence of physical disability for people aged 65 in this study was 21.4% (Table 2), which is moderately higher than the United States' National Long Term Care Survey [11], which is 13% (7.9% when age-standardized to the Nigerian population sample). However, the prevalence of six-item ADL disability among people age 60 years and above in the Caribbean [31], and among people age 75 years and above in Latin America and the Caribbean [23], appears to be similar to the prevalence rates in this study. Using the five-item ADL index, for people aged 65 years and above, the prevalence rates in this study is 15.6%. This appears to be much higher when compared to the findings from developed countries [4], for example 6% in Canada (3.2% when age standardized), 10% in France (5.5% when age standardized), 14% in Italy (7.3% when age standardized), and 11% in Sweden (5.5% when age standardized) [11].

Disability prevalence rates in this study appear comparable to rates in other developing countries; for example, among people aged 65 and older, the prevalence of 5 items ADL disability in Malaysia [28] was 16% (14.8% when age standardized) and 10% in Srilanka [32], (14.4% when age standardized). The prevalence of disability among people aged 60 years and above was 12.1%. This is almost similar to 12% in India [33] (9.3% when age standardized) and 11% in Malaysia [26] (10.5% when age standardized). However, the prevalence rate in this study is higher than 8% from

Table 2: Prevalence of physical disability and functional limitation among elderly Nigerian (n = 1824).

Variable	N	Activities of daily living (ADL) dependence 10 items RR [95% CI]	6 items RR [95% CI]	5 items RR [95% CI]	Functional limitation RR [95% CI]
Overall					
≥60	1824	28.3 (25.2, 31. 5)	15.7 (13.4, 19.8)	12.1 (9.8, 15.3)	22.5 (18.1, 24. 4)
≥65	1221	39.1 (35.4, 44. 5)	21.4 (17.8, 25.6)	15.6 (12.6, 19.2)	28.2 (25.3, 32.8)
≥70	824	45.5 (42.8, 52.8)	27.3 (22.4, 31.9)	22.2 (17.7, 25.4)	38.0 (32.5, 43.7)
≥75	317	52.8 (43.8, 61.7)	34.6 (28.3, 45.1)	26.6 (19.4, 35.3)	51.5 (43.7, 60.5)
Age group					
60–64	603	11.7 (7.5, 18.3)	10.3 (6.4, 17.30)	8.1 (4.2, 14.36)	12.4 (7.2, 19.2)
65–69	497	72.3 (52.2, 89.5)	31.3 (19.7, 50.5)	22.3 (11.5, 33.7)	38.4 (32.3, 55.2)
70–74	407	78.4 (64.2, 94.3)	37.7 (27.3, 53.2)	29.9 (20.2, 44.5)	48.8 (37.6, 66.4)
≥75	317	98.9 (85.3, 111.7)	59.9 (52.3, 86.2)	50.4 (35.5, 65.7)	98.3 (40.1, 56.6)
Male					
≥60 (overall)	847	34.8 (33.3, 52.3)	25.7 (17.7, 31.6)	16.6 (12.3, 25.6)	29.3 (22.7, 38.8)
60–64	2651	5.3 (7.1, 29.5)	10.8 (5.3, 20.3)	9.7 (3.5, 22.4)	9.8 (3.3, 11.2)
65–69	242	37.7 (23.0, 64.2)	15.4 (7.5, 32.6)	17.4 (6.8, 26.8)	27.7 (15.7, 26.8)
70–74	201	63.4 (40.7, 85.3)	32.4 (15.7, 59.3)	23.2 (11.4, 52.6)	34.7 (17.6, 63.2)
≥75	139	73.4 (51.1, 99.6)	41.3 (21.7, 69.8)	30.0 (14.4, 59.8)	72.2 (43.9, 52.7)
Female					
≥60 (overall)	977	58.5 (49.3, 64.7)	32.2 (25.3, 37.5)	23.4 (17.3, 29.6)	46.4 (40.1, 54.3)
60–64	338	19.7 (6.7, 13.3)	11.5 (7.7, 21.6)	15.7 (2.6, 16.2)	13.7 (7.1, 24.7)
65–69	255	52.4 (35.7, 73.4)	17.6 (7.5, 32.6)	23.7 (5.7, 28.3)	24.6 (13.8, 42.8)
70–74	206	85.7 (64.6, 105.8)	37.5 (25.7, 58.7)	32.3 (18.6, 53.2)	53.4 (40.2, 37.4)
≥75	178	84.7 (89.6, 135.3)	77.4 (60.2, 92.1)	60.3 (43.5, 80.6)	116.8 (89.8, 135.7)
Monthly income (US$/Month)					
<100	1431	33.2 (18.3, 34.7)	25.6 (22.7, 27.9)	18.8 (17.3, 20.3)	26.1 (23.7, 29.5)
100–199	244	6.9 (3.1, 8.3)	5.8 (4.7, 6.2)	7.1 (6.6, 8.4)	8.7 (7.3, 9.4)
200–299	102	2.4 (1.9, 3.7)	1.9 (1.1, 2.3)	2.5 (1.9, 3.6)	3.1 (2.8, 4.5)
>300	47	0.6 (0.2–0.9)	0.7 (1.2, 1.8)	0.6 (0.2, 1.4)	1.4 (0.8, 1.9)

Shanghai, China [34]. Differences in criterion definition and sample profile may account for disparity between this finding and that of China. The following may be other possible reasons why Nigerian's disability prevalence rate is different from those reported from the developed countries: sample for this study was drawn from rural community, high illiteracy level (85%), the low educational levels in elderly cohorts (90.4% had no formal education or low education level), a figure higher than the developed country [35], and the prevailing sociodemographic differences between Nigeria and the wealthy industrialized nations. Since disability in ADL [36] is one of the main reasons for institutionalization in the developed nations, this may be another reason why prevalence of physical disability in elderly people in developed countries is lower compared with this finding.

The African tradition, particularly Nigerian tradition, dictates that elderly people should be taken care of by their family members. The institutional care of the elderly is very rare in Nigeria, thus majority of the elderly people in Nigeria live with their spouse or other family members. Self-report or performance-based measures [4] are useful in assessing functional limitation. However, performance based measurements offers more information, because they help to identify important physical parameters involved in performing daily activity tasks [10]. Comparison of prevalence of functional limitation across studies is difficult due to differences in concept and measurement of functional limitation used. Using the Tinetti performance-oriented mobility assessment tool, the overall prevalence of functional limitation among Nigerian aged 75 years and above was 51.5% (Table 2). This is very close to a previous study [37] that reported 48% but much higher compared with that reported among the Italian [38] aged 75 years and above which was 21%. This study shows a higher prevalence of physical disability and functional limitation among elderly women than elderly men in all age groups and the higher the age the wider the gender difference. Previous studies [39, 40] have also reported higher levels of physical disability and functional limitation in elderly women than elderly men. Cumulative effect of pregnancy and childbearing, poor/lack

Table 3: Univariate analysis of variables associated with 10 items ADL dependence.

Variables	Physical disability (present) frequency (%)	Physical disability (absent) frequency (%)	Unadjusted prevalence ratio PR (95% CI)
Age group			
60–64	31 (9.5)	296 (90.5)	1.0 (Reference)
65–69	63 (27.5)	166 (72.5)	7.1 (5.2, 8.0)
70–74	94 (39.8)	142 (60.2)	12.3 (9.2, 19.6)
≥75	102 (50.5)	100 (49.5)	23.2 (15.2, 33.7)
Sex			
Male	197 (23.2)	650 (76.8)	1.0 (Reference)
Female	306 (31.3)	671 (68.7)	3.9 (2.8, 7.4)
Ethnic group			
Kanuri	402 (26.2)	1130 (73.8)	1.00
Fulani	49 (30.4)	112 (69.6)	2.8 (1.3, 3.6)
Hausa	43 (32.8)	88 (67.2)	2.2 (1.4, 4.6)
Education level			
Tertiary education	4 (28.6)	9 (71.4)	1.0 (Reference)
Secondary	45 (27.9)	116 (72.1)	1.6 (1.2–3.8)
Primary education	115 (22.4)	399 (77.6)	3.2 (2.6, 4.4)
No formal education	320 (36.6)	1105 (63.4)	4.7 (2.5, 7.8)
Marital status			
Married	308 (26.4)	858 (73.62)	1.0 (Reference)
Widowed	133 (28.4)	336 (71.6)	1.6 (0.9, 2.3)
Divorced	24 (19.4)	100 (80.6)	1.8 (0.7, 2.6)
Single	9 (13.8)	56 (86.2)	1.6 (0.8, 3.1)
Living arrangements			
Living with others	399 (24.8)	1213 (75.2)	1.0 (Reference)
Living alone	63 (29.7)	149 (60.3)	3.2 (2.7, 10.6)
Social support			
Not at risk of isolation	366 (24.5)	1277 (75.5)	1.0 (Reference)
At risk of isolation	115 (34.7)	320 (65.3)	1.8 (1.5, 3.8)
Presence of chronic disease			
None	93 (14.5)	548 (85.5)	1.0 (Reference)
One chronic disease	260 (26.1)	737 (73.9)	6.2 (7.7, 13.8)
More than one	101 (54.3)	85 (45.7)	13.6 (9.7, 15.3)
Diabetes			
No	40 (20.8)	152 (79.2)	1.0 (Reference)
Yes	145 (44.1)	184 (55.9)	5.7 (4.9, 12.3)
Arthritis			
No	47 (22.3)	166 (77.7)	1.0 (Reference)
Yes	90 (42.3)	123 (57.7)	4.1 (2.8, 5.3)
Stroke			
No	25 (25.0)	75 (75.0)	1.0 (Reference)
Yes	70 (51.5)	66 (48.5)	4.7 (3.1, 7.4)
Malnutrition			
No	69 (20.1)	274 (79.9)	1.0 (Reference)
Yes	242 (54.4)	203 (45.6)	5.3 (4.4, 7.9)
Depressive symptomatology			
No	313 (22.5)	1047 (77.5)	1.0 (Reference)
Yes	174 (39.8)	263 (60.2)	3.9 (3.0, 5.2)

Table 3: Continued.

Variables	Physical disability (present) frequency (%)	Physical disability (absent) frequency (%)	Unadjusted prevalence ratio PR (95% CI)
Presenting visual acuity			
Normal	260 (26.1)	737 (73.9)	1.0 (Reference)
Mild to moderate visual impairment	47 (35.9)	84 (64.1)	3.5 (3.3, 8.8)
Blind	240 (34.5)	456 (65.5)	4.8 (3.5, 8.7)
BMI (Kg/m^2)			
Normal	184 (24.7)	574 (75.3)	1.0 (Reference)
Underweight	142 (18.4)	631 (81.6)	2.8 (1.9, 3.7)
Overweight	53 (24.3)	165 (75.7)	2.5 (1.6, 3.5)
Obese	17 (22.7)	58 (77.3)	2.2 (1.4, 2.9)

of education, and poor health care may be responsible for higher physical disability and functional limitation seen in elderly women.

Poor or lack of education may be associated with low income and poverty, poor standard of living, unhealthy lifestyle behavior, malnutrition, and less frequent use of health and medical care services [27]. This study showed that more elderly women (80.1%) than elderly men (41.6) had no formal education; this is in conformity with the literature [41] that low socioeconomic status is associated with physical disability. Chronic disease like obesity was found to be commoner in elderly women than elderly men; this finding is similar to Malaysia study [27]. In addition, underweight is higher in elderly men than elderly women, this is also similar to Malaysia study [29]. Sedentary life style among elderly women and carbohydrate as the main food consumption could be the reason for overweight commoner in elderly women than elderly men.

In this study, the BMI values (20 to 24.9) associated with optimum physical function coincide with values associated with lowest risk of morbidity similar to previous studies in Chinese populations relating BMI to health outcomes [42, 43] and mobility decline [44]. This observation is not unexpected, given the close inverse relationship between walking speed and health-related outcomes in well-functioning older people [45, 46]. The findings from this study emphasize yet another adverse effect of obesity in the elderly apart from increased risk of various diseases—that of functional limitation. For example, more than one-quarter (28.3%) of the respondents signified interest for assistance in at least one of the 10 ADLs in the Barthel index (Table 2). The request for help for some of the activities of daily living suggests that muscle function may be adversely affected and may partly account for functional limitations. The association between grip strength and appendicular muscle mass emphasizes this point. In obese elderly people, an exercise component must be included in the treatment regimens to maintain or increase lean muscle mass and bone mineral density. Such regimens have been shown to result in a reduction in fat mass without changes in fat-free mass, increase physical performance, and improve quality of life [47].

Concerning the effect of ethnicity on prevalence of physical disability, this study showed that Hausas had the highest prevalence of self-reported physical disability followed by Fulanis and Kanuris. The observed differences among the ethnic groups may be attributed to different types of occupations as similarly expressed in a previous study [27]. In other words, hard labour is associated with physical disability due to increased risk of injury. This study revealed that Hausas and Fulanis are more commonly involved in very stressful and laborious manual occupations. Specifically, the Hausas and Fulanis are usually engaged in farming, tree felling, and truck pushing, while the Fulanis are usually engaged in nomadic activities. The Kanuris are mainly engaged in very less strenuous and laborious work. This study showed a significant association between functional limitations and advanced age, female gender, stroke, arthritis, and depressive symptomatology, and it is similar to findings from a previous study [27].

Living alone, poor social support, being overweight or underweight, presence of diabetes mellitus, stroke, and visual impairment were not associated with functional limitation. This finding is also similar to previous findings for advanced age [41], female gender [48], presence of arthritis [49] and depressive symptomatology [49, 50] being associated with functional limitation. This study is limited by involving only elderly people in rural community, excluding elders from institutions as well drawing of inferences between health-related variables and physical disability or functional limitation. Other limitations include study design (cross-sectional design), which does not allow determination of direction of causality despite the presence of associations. In addition, the study design does not also include information on duration of disability thus making it difficult to confirm that some of the disabilities were or were not transient in nature. This study, however, has a number of strengths; this is one of the very few studies to assess the prevalence and correlates of performance-based functional limitation among elderly Nigerians. Validated measures of disability that conform with theories of aging were used, for example, in the Nagi model of disablement; functional limitation takes priority before (precedes) disability [51]. This study

Table 4: Univariate analysis of variables associated with functional limitation variables.

Variables	Functional limitation present Present frequency (%)	Functional limitation absent Absent frequency (%)	Unadjusted prevalence ratio PR (95% CI)
Age group			
60–64	38 (6.3)	565 (93.7)	1.0 (Reference)
65–69	70 (14.1)	427 (85.9)	5.5 (4.2, 6.8)
70–74	105 (25.8)	302 (74.2)	10.3 (6.6, 14.7)
≥ 75	150 (47.3)	167 (52.7)	18.5 (11.1, 33.7)
Sex			
Male	130 (15.3)	717 (84.7)	1.0 (Reference)
Female	218 (22.3)	759 (77.7)	3.6 (2.5, 5.8)
Ethnic group			
Kanuri	320 (20.9)	1312 (79.1)	1.0 (Reference)
Fulani	38 (23.6)	123 (76.4)	1.2 (0.7, 1.5)
Hausa	15 (11.4)	123 (88.6)	1.1 (0.7, 2.4)
Education level			
Tertiary education	1 (7.1)	13 (92.9)	1.0 (Reference)
Secondary education	17 (11.8)	144 (88.2)	2.2 (1.3, 3.6)
Primary education	90 (19.5)	424 (80.5)	3.7 (2.6, 5.8)
No formal education	332 (29.3)	803 (70.7)	6.3 (3.8, 11.6)
Marital status			
Married	240 (20.60)	926 (79.4)	1.0 (Reference)
Widowed	110 (23.5)	359 (76.5)	2.2 (1.3, 3.5)
Single	2 (1.6)	122 (98.4)	2.7 (1.6, 3.7)
Divorced	1 (1.5)	64 (98.5)	2.9 (1.8, 4.4)
Living arrangements			
Living with others	340 (21.1)	1272 (78.9)	1.0 (Reference)
Living alone	37 (17.5)	175 (82.5)	2.3 (1.4, 2.7)
Social support			
Not at risk of isolation	280 (18.8)	1213 (81.3)	1.0 (Reference)
At risk of isolation	88 (26.6)	243 (73.4)	2.8 (1.9, 4.5)
Presence of chronic disease			
None	37 (5.7)	604 (94.3)	1.0 (Reference)
One chronic disease	230 (23.1)	767 (76.9)	9.6 (5.7, 12.4)
More than one chronic-disease	73 (39.2)	113 (60.8)	18.8 (9.4, 35.7)
Diabetes			
No	160 (17.2)	766 (82.8)	1.0 (Reference)
Yes	337 (37.5)	561 (62.5)	9.4 (8.7, 12.8)
Arthritis			
No	171 (14.5)	1001 (85.5)	1.0 (Reference)
Yes	260 (39.9)	392 (60.1)	8.9 (6.8, 11.5)
Stroke			
No	255 (20.4)	993 (79.6)	1.0 (Reference)
Yes	251 (43.6)	325 (56.4)	5.8 (3.9, 7.2)
Depressive symptomatology			
No	211 (15.2)	1176 (84.8)	1.0 (Reference) 1387
Yes	163 (37.3)	274 (62.7)	9.9 (7.4, 14.5)
Presenting visual acuity			
Normal	252 (16.8)	1250 (83.2)	1.0 (Reference)
Mild to moderate-Visual impairment	70 (31.7)	151 (68.3)	1.8 (1.2, 2.9)
Blind	40 (33.1)	81 (66.9)	5.6 (3.7, 8.8)

Table 4: Continued.

Variables	Functional limitation present Present frequency (%)	Functional limitation absent Absent frequency (%)	Unadjusted prevalence ratio PR (95% CI)
BMI (Kg/m^2)			
Normal	158 (20.8)	600 (78.1)	1.0 (Reference)
Underweight	198 (25.6)	575 (74.4)	2.4 (1.9, 4.2)
Overweight	44 (20.2)	174 (79.8)	2.6 (2.2, 4.7)
Obese	13 (17.3)	62 (82.7)	2.7 (2.5, 5.3)

Table 5: Adjusted prevalence ratios for associations between sociodemographic and health related variables and poor physical function among elderly rural Nigerian.

Variables	Physical disability* as-dependent variable (n = 1824)	Functional limitation as-dependent variable (n = 1824)
Age group		
60–64	1.0	1.0
65–69	3.1 (2.2, 3.6)	5.2 (3.7, 7.8)
70–74	14.4 (10.2, 17.6)	7.5 (5.4, 11.2)
≥75	22.2 (14.5, 36.8)	10.5 (5.4, 16.4)
Female	3.6 (1.5, 7.4)	9.3 (3.7, 18.3)
Self reported chronic medical condition **		
Diabetes mellitus	6.1 (4.3, 7.1)	3.8 (3.1, 5.2)
Stroke	4.8 (3.7, 7.9)	3.6 (2.2, 5.4)
Arthritis	3.7 (2.6, 4.6)	5.2 (3.5, 6.8)
Presence of depressive-symtomatology **	4.2 (3.3, 5.9)	6.4 (4.7, 9.2)
Presenting visual acuity		
Normal	1.0	1.0
Mild-to-moderate visual impairment	5.2 (3.4, 7.3)	3.8 (2.5, 6.7)
Blind	6.6 (3.6, 11.9)	4.7 (2.2, 10.4)

also revealed that severe malnutrition was associated with disability. Relationship between malnutrition and disability has also been reported by a previous study in rural Malawi, where Chilima and Ismail observed a relationship between undernutrition and handgrip strength, psychomotor speed and coordination, and mobility and ability to carry out activities of daily living independently [52].

5. Conclusion

Disability in old age is an important indicator of any community population health, as elderly people usually have more than one illness, and the functional impacts of combined conditions provide a better measure of health than do diagnostic categories. In addition, in developing countries, access to physicians is limited, and most ailments in the elderly are associated with old age. This study has shown that the overall pattern of disability in Nigeria has the relationships similar with studies elsewhere. Of particular note is that physical disability and functional limitation is common in Nigerian elderly. Though the prevalent rates of physical disability and functional limitation is higher than that obtainable in developed countries but similar and comparable to partner developing countries. More importantly, elderly women, especially those with advanced age, chronic diseases, depressive symptomatology, and visual impairments showed greater risk of disability and functional limitation compared with elderly men. This finding is indispensable when considering those to focus for appropriate prevention and intervention strategies like physical exercise, health education, and home visits of high-risk individuals in community-dwelling Nigerians.

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Review Article

Cognitive Speed of Processing Training Can Promote Community Mobility among Older Adults: A Brief Review

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Background. Community mobility is crucial for maintaining independent functioning and quality of life for older adults. *Purpose*. The present paper describes the relationship of cognition, particularly speed of processing as measured by the Useful Field of View Test, to mobility as indicated by driving behaviors, life space, and falls among healthy older adults. Research examining the impact of cognitive speed of processing training (SOPT) on older adults' community mobility (i.e., driving behaviors) is also summarized. *Key Issues*. Even slight cognitive declines can place older adults at risk for mobility limitations. However, cognitive interventions like SOPT can mitigate declines in driving mobility. *Implications*. The potential of SOPT to sustain community mobility among older adults is discussed.

1. Introduction

Mobility may be defined as the ability to move through one's environment in order to complete a task or achieve a goal [1, 2]. Continued mobility is crucial for maintaining independent functioning and quality of life [3, 4]. Yet, mobility limitations increase with age [3].

Decreased mobility among older adults, defined in this paper as individuals 55 years of age and older, may result from numerous factors such as failing health [3] and vision [5]. Age-related declines in aspects of cognition, including memory, reasoning, executive functioning, and speed of processing [6], may also predict mobility among community-dwelling older adults without dementia [7]. The Useful Field of View Test (UFOV, a registered trademark of Visual Awareness, Inc.) is a cognitive measure of visual processing speed for attentional tasks [8, 9] that has consistently emerged as a predictor of mobility. This paper describes the relationship of cognitive speed of processing, as measured by UFOV, to community mobility as indicated by driving, life space, and the occurrence of falls.

The relationship of UFOV to mobility is of particular interest in that UFOV difficulties can be rehabilitated with training [10–12]. Research has indicated that speed of processing training (SOPT), a cognitive intervention, not only improves speed of processing but also transfers to prolonged safe driving mobility among older adults [13, 14]. Research examining the impact of this intervention on older adults' driving mobility is summarized. The potential of such cognitive interventions to sustain mobility and quality of life among older adults is discussed.

2. Driving, Life Space, and Falls

Driving is an important aspect of community mobility, particularly for older adults in the United States [15, 16]. UFOV performance has been strongly connected to driving mobility outcomes in several studies [17, 18]. For example, recent prospective studies have found that poorer UFOV performance is a significant risk factor for driving cessation, even after controlling for demographics, vision, and physical performance [19, 20]. UFOV performance is also associated with motor vehicle crashes [21].

Life space, conceptualized as the distance that individuals move concentrically from their homes, is another distinct measure of community mobility [1, 22]. Stalvey and colleagues [1] found that UFOV performance predicted life space, while visual measures did not. Wood and colleagues [7] also found that a cognitive speed factor (which included UFOV) correlated most strongly with life space as compared with other cognitive and sensory factors. Thus, although vision is important, cognitive speed of processing may be a more salient predictor of life space.

Falls are also important to consider when examining community mobility. Older adults who fall reduce their activities within the community [23] and are at higher risk for long-term care placement [24]. Factors that lead to falls include failing vision, medication use, and decreased muscle strength and flexibility [25, 26]. Additionally, Vance et al. [27] found that cognitive decline (measured by UFOV, as well as tests of delayed recall, executive function, and visual perception) predicted higher incidence of falling among 694 older drivers.

The role of cognition in maintained mobility is of interest in that among older adults without dementia,cognitive abilities like speed of processing can be enhanced through training [28–31]. Some of the most consistent and encouraging findings of cognitive training transfer have been with a particular protocol, SOPT [32]. SOPT is a computerized, cognitive intervention that involves practice identifying and localizing visual targets at rapid display speeds (16 to 500 ms) that is designed to improve UFOV. Exercise difficulty is tailored to each individual's abilities, with the overall goal of increasing the speed and accuracy of visual information processing through practice. SOPT has evolved into an exercise, RoadTour, that is a part of the training program marketed by PositScience as InSight. The program is also available through the AAA Foundation as DriveSharp. These interventions can either be completed by older adults at home on a personal computer or can be administered in settings such as independent living facilities [33, 34].

The efficacy of SOPT for enhancing everyday functioning and cognitive speed of processing has been demonstrated in six clinical trials among older adults [35]. Given that UFOV is strongly related to driving [18, 36], of particular interest was whether training could enhance driving. Searches of the terms "speed of processing training and mobility," "speed of processing training and driving," "speed of processing training and life space," and "speed of processing training and falls" were conducted in the PubMed, Ageline, PsycInfo, and Medline databases; we were interested in articles that specifically examined the SOPT protocol on domains of mobility. These searches on mobility and driving yielded 39 articles. Of these, 29 did not use SOPT and/or did not measure mobility as an outcome, and 2 described driver training programs unrelated to SOPT. Each of the remaining 8 studies found that SOPT positively enhances driving mobility among adults aged 55 and older, and these results are described below. The searches on life space and falls yielded 23 articles, none of which examined the impact of SOPT on life space or falls.

3. Speed of Processing Training and Driving

Roenker and colleagues [37] examined the efficacy of SOPT among adult drivers aged 55 years and older who were randomized to either SOPT or a control group of driver instruction and simulator training. Speed trained participants' UFOV scores improved an average of 2.5 standard deviations (sd) more than control group members' scores, indicating a large effect size. Speed trained participants also showed significantly improved stopping time to road signs while in a driving simulator and made 40% fewer dangerous maneuvers during an on-road driving test. These improvements were maintained over an 18-month follow-up period [37].

In the Staying Keen in Later Life (SKILL) study, older adults aged 63 years and older without dementia and with baseline UFOV difficulties were randomized to either SOPT or a social- and computer-contact control group ($n = 126$). Training effect sizes were large and averaged 1.94 sd of improvement in UFOV performance relative to the control group [12]. Longitudinal analyses indicated that drivers in the control group experienced greater mobility declines as evidenced by decreased driving exposure and space and increased driving difficulty over a 3-year follow-up period [14]. Drivers who completed the training program were 40% less likely than controls to cease driving during the 3 years [13].

In the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study [38], approximately 3,000 healthy adults aged 65 and older were randomized to one of three cognitive interventions (including SOPT) or a control group. Among the SOPT group, 87% demonstrated reliable UFOV improvement at immediate posttest with an effect size of 1.45 sd relative to the controls, and significant training gains endured over 5 years [39, 40]. Older adults randomized to SOPT were about 50% less likely to experience a motor-vehicle crash over the next 5 years [41].

Aside from mobility and cognitive speed of processing as measured by UFOV, SOPT also positively influences other aspects of older adults' lives. The ACTIVE study demonstrated that SOPT prevents declines in self-rated health and health-related quality-of-life across 5 years [42, 43]. Recent analyses indicate that SOPT also resulted in statistically significant reductions in predicted medical care expenditures and risk of depressive symptoms [44, 45]. Thus, SOPT has many potential benefits for older adults.

4. Conclusion

Many factors impact mobility among older adults, including demographic, sensory, and medical factors [3]. However, even among community-dwelling older adults without dementia, cognition (particularly speed of processing) is independently associated with community mobility as measured by life space, falls, and driving. Even subtle cognitive declines can place older adults at risk for mobility losses.

Risk for mobility loss, particularly driving mobility, can be assessed relatively quickly with UFOV. UFOV Task 2 has been used to indicate mobility risk in a Department of Motor Vehicles-setting [18] and can be administered in

10–15 minutes. Older adults who show UFOV difficulties (Task 2 score ≥150 or Task 3 + 4 score ≥800) are most likely to immediately benefit from SOPT [35]. However, advantages from training have also been observed among general samples of older adults, including prolonged driving mobility and safety [14, 37, 41]. Furthermore, older adults have experienced maintained health-related quality of life and decreased risk for depression from participating in SOPT [42, 45]. This testing and training technology can be implemented to promote cognitive health and sustain safe driving mobility among older adults. Although current evidence demonstrates that SOPT prolongs safe driving mobility, further research should investigate if SOPT or other cognitive interventions may preserve other aspects of community mobility as well, such as life space and falls. Since there is evidence that UFOV is related to life space and falls, these domains may be positively impacted by SOPT.

In conclusion, even among older adults without dementia, evidence-based cognitive training programs like SOPT should be considered for the goals of maintaining and possibly enhancing mobility among older adults. Such interventions have great potential to preserve independence and quality of life with advancing age.

Disclosure

Dr. Edwards has worked in the past as a limited consultant to Visual Awareness, Inc., the company that holds the patent for the UFOV assessment, and for PositScience, the company that now owns intellectual property surrounding the speed of processing training program.

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Review Article

Driving into the Sunset: Supporting Cognitive Functioning in Older Drivers

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The rise in the aging driver population presents society with a significant challenge—how to maintain safety and mobility on the roads. On the one hand, older drivers pose a higher risk of an at-fault accident on a mile-for-mile basis; on the other hand, independent mobility is a significant marker of quality of life in aging. In this paper, we review the respective literatures on cognitive neuropsychology and ergonomics to suggest a previously unexplored synergy between these two fields. We argue that this conceptual overlap can form the basis for future solutions to what has been called "the older driver problem." Such solutions could be found in a range of emerging driver assistance technologies offered by vehicle manufacturers, which have the potential to compensate for the specific cognitive decrements associated with aging that are related to driving.

1. Introduction

There is no doubt that our aging population presents society with a number of economic and public health challenges. One of these challenges is transport, more specifically, personal transport. Recent figures released by the UK Automobile Association predict that, in 20 years, 90% of men and 80% of women aged over 70 years will hold a driving licence. Contrast this with the situation today, where three-quarters of men and only 31% of women in that age group drive. In absolute terms, the number of drivers over 70 is set to double in 20 years [1] and hit 10 million by 2050. It is also widely agreed that, per vehicle mile travelled, older drivers are at a higher risk of a fatal crash (e.g., [2]). These figures raise concerns for road safety—with more older drivers driving more miles, and, for more years [3], there could be a profound impact on absolute numbers of road casualties in the future.

But in an enlightened society, road safety is only one half of the older driver "problem," as Evans [4] puts it; we have a responsibility to meet the mobility needs of a growing population of older adults [5]. Well-being in older people depends to a large extent on their ability to successfully engage with various practical and recreational activities in daily life [6]. In turn, many of these activities are dependent on being able to drive. Driving thus enables older adults to "keep on living" independently and maintain their quality of life [7, 8]. Evans' [4] point is that the older driver "problem" is actually a problem for society—not just a case of getting them off the roads. Indeed, many older people actually restrict their driving boundaries to conditions where they feel safe and comfortable [9–11], further compounding the problem.

A solution is required which not only supports older drivers but also balances their requirements with road safety targets to continue reducing the number of killed and seriously injured on the roads. Adopting a more user-centred approach, such an alternative would be to compensate for the cognitive limitations of older drivers by making "...changes to the driving environment to make driving safer for the older person, both inside the car in terms of design factors, and perhaps advanced driving information systems, but also outside in terms of traffic system design" [12, page 5]. Both academic (e.g., [10, 13]) and policy reports (e.g., [1, 3, 7, 12] have suggested that such a solution should exploit vehicle design and safety technology innovations inside the car, underpinned by a sound understanding of the older driver's cognitive abilities and information requirements. "There is a very clear need for such research addressing appropriate technology to aid safe car driving behaviour amongst the older driver population" [10].

A major objective of this paper is to consider the literature from several perspectives to understand and propose solutions for the older driver "problem." Research from cognitive neuropsychology and driving ergonomics is examined, and important synergies and parallels between the two fields are identified as a basis for taking this work forward. Specifically, we suggest that a promising basis for future research stems from work into cognitive inconsistency in neuropsychology and interest in driving performance consistency in ergonomics. Firstly, though, we look at road safety statistics to determine the extent of the problem.

2. Older Drivers and Road Accidents

Although there is some debate over the prevalence of older drivers in road accident statistics, it is widely agreed that, when controlling for exposure, drivers over 70 are at increased risk of an at-fault accident—with the data being comparable to those for the under-25 age group (e.g., [2, 4, 9, 11, 13–15]). Casualty rates per mile driven increase with age after 70–75 years [16], and the risk increases exponentially for drivers in their 80s [4, 11, 14]. Whilst physical frailty is undoubtedly a factor in these statistics, the evidence for an association between age and crash risk is growing; any remaining doubt is probably more due to the smaller population of older drivers and "self-regulation" of their driving behaviours (cf. [4]).

Indeed, we currently rely on self-regulation to control the risk—expecting older drivers to declare for themselves when they are unfit to drive. But the evidence suggests this does not always work—many drivers are not aware of (or do not recognise) their own limitations [9, 11], and they either do not cease driving early enough or conversely cease driving too soon [17]. "Because of (a) lack of information, feedback, and insight, elderly drivers are not, I believe, in a good position to determine for themselves when they should reduce or cease driving" [9, page 171]. Moreover, as the older driving population grows and becomes more mobile, it is anticipated that mileages will increase, as will the need to face more challenging traffic conditions [12].

We have already said that, per mile driven, older drivers are almost at a similar risk of a crash as young drivers. When the types of accidents are analysed, though, it is clear that older drivers differ from younger groups in that their accidents are less about taking risks, but more about errors of perception or judgement [2, 4, 11, 14]. Rather than single-vehicle accidents involving speed, alcohol, or fatigue, older drivers have multiple-vehicle accidents at junctions involving giving way, or when turning or changing lanes. This tends to be due to deficits in "bottom-up" visual and cognitive processing, as opposed to "top-down" failures of experience or expertise [13]. Verhaegen [18] argues that this decrement in performance is consistent with the notion that cognitive abilities decline with age.

3. Cognitive Factors in Driving Performance

There is a wide body of scientific evidence to suggest that age-related declines in cognitive functions such as attention and decision making can be a source of increased crash risk on the roads (e.g., [18–20]). Aging leads to declines in many perceptual and cognitive functions related to driving, with visual, spatial, and attentional abilities all having been shown as potential sources of increased risk. Whilst the reduction in driver capabilities with age can be offset with experience [4, 21], as age increases beyond 65 years, fitness to drive (in terms of sensory, perceptual, and cognitive abilities) becomes the most important factor in driving competence [22]. It has been shown that older drivers (over 60) are slower, less accurate, and less coordinated in their responses [23]. Tsimhoni and Green [24] used visual occlusion to demonstrate that drivers over the age of 55 experience more demand during driving on curved road sections, while Brouwer et al. [19] found that drivers in their mid-60s were less able to divide attention and integrate their responses in a dual-task scenario. In terms of driving tasks, negotiating junctions and merging traffic are both known to cause particular difficulties.

Undoubtedly, many of the problems that older drivers face are in part due to declining visual capabilities with age, affecting visual search at junctions (e.g., [14, 25]). Typically, it is the ambient or peripheral visual field which degrades [25, 26], leading some researchers to argue for a "useful field-of-view" (UFOV) test to predict driving performance (e.g., [27]). One such test has demonstrated sensitivity to crash risk in older drivers [28] and shows promise as a screening instrument [27]. However, there is a significant body of evidence to show that visual acuity and the UFOV test do not predict all aspects of driving performance (e.g., [28, 29]) and that central cognitive processing plays a key role alongside visual perception and decision making [5, 11, 13, 18].

Attention and executive function have both been implicated as predictors of driving performance [19, 28, 30], with older drivers being more susceptible to errors under conditions of high mental workload [9, 11]. Such cognitive declines are an inevitable part of the aging process: "Age-related decline in cognitive functions such as attention, anticipation, executive functioning and information processing means that older drivers tend to have difficulty in dealing with complex traffic situations and reduced capacity to respond quickly and flexibly to changing traffic situations" [3, page 45]. Adrian [30] drew upon an established model of executive functioning and a standardised battery of tests to show that this is probably due to older drivers having difficulties with distraction and focusing their attention.

The idea of investigating independent cognitive measures in relation to driving performance in older adults is not new, and although meta-analyses and reviews (e.g., [31, 32]) suggest that tests of visuospatial skills may have some promise, the majority of studies have produced mixed findings. Efforts to develop metrics of individual cognitive abilities as correlates of driving performance have met with varying degrees of success [11, 31–33]. In particular, low to moderate correlations between cognitive measures and driving performance make it difficult to distinguish between those who are fit and unfit to drive, and those studies reporting high correlations have not been replicated. Reasons for these discrepant findings include the often small sample sizes, the wide variety of cognitive measures that have been assessed, and the different approaches to assessment of driving performance, their varying realism and their rigour. Thus there remains a "desperate" need for evidence-based guidelines and tests for front-line application [33].

4. New Perspectives from Cognitive Neuropsychology and Ergonomics

The most apparent consequence of cognitive decline with aging is reaction time, which is slower for older drivers [4, 9]. Recently though, there has been considerable interest in the cognitive aging field for investigating intraindividual variability, or inconsistency, of reaction time (RT) performance. Such measures index moment-to-moment fluctuations in performance over successive trials of a given cognitive task and are thought to reflect neurobiological integrity (e.g., [34, 35]). Consistent with this view, increased variability is associated with older age (e.g., [36, 37]) and a range of neurological conditions including dementia [38] and is a sensitive metric of cognitive function in older adults (e.g., [34]). Importantly, measures of RT inconsistency are sensitive to relatively subtle effects when standard measures of accuracy and mean RT from the same tasks are not. For example, recent work [39, 40] found that the cognitive effects of increasing age and mild mental health disorders (anxiety and depression) were detected by measures of inconsistency, but not by measures of accuracy and mean RT. Data supporting the view that inconsistency is associated with neurobiological integrity were produced in a recent neuroimaging study [41] of apparently healthy 60- to 64-year olds; RT inconsistency was related to the degree of white matter lesioning in the frontal cortex, whereas mean RT was not. This work has now been extended to demonstrate the same association in 44- to 48-year olds [42]. These studies clearly suggest that measures of RT inconsistency are sensitive not only to subtle effects in aging contexts but also to neurobiological integrity.

Meanwhile, ergonomics research into driving performance has developed along parallel lines, with an important and distinguishing aspect of performance being consistency in driving—both in terms of perceptual judgements [9] and vehicle control. Bloomfield and Carroll [43] pioneered measures of lateral and longitudinal inconsistency in a driving simulator, arguing that these variables were more appropriate metrics of driving performance than traditional measures of mean or standard deviation. Their measures have since been successfully applied in several of our studies in the Brunel University Driving Simulator (e.g., [44, 45]) and clearly distinguish good from poor drivers [46], in line with best practice for safe driving which suggests that smoothness and consistency is key [47]. Whilst the ecological validity of simulator studies may be called into question, many modern simulators offer realistic and immersive representations of driving and provide a safe, replicable, and controllable environment for studies of this nature. Moreover, with relevance to the present discussion, the higher-level cognitive and performance markers associated with driving are directly testable in a simulator.

Given the conceptual overlap with measures of cognitive inconsistency above, these studies together suggest that measures of RT inconsistency have huge potential in the present context. It is striking, though, that to date no work has drawn these two lines of research together. We believe the parallels between consistency-based metrics of driving and PC-administered measures of cognitive performance provide a promising and innovative basis from which to develop metrics and models that can help us better understand the cognitive limitations of older drivers. Pilot studies in our laboratory indicate that older adults (in comparison to a younger group) exhibit higher inconsistency on a neuropsychological test battery as well as higher inconsistency on driving performance metrics in a simulator.

Future research is planned to investigate and validate these associations in more detail. In terms of their application, there are two options. The first is in response to calls for compulsory screening tests for older drivers: "... instead of asking whether and why older people have more accidents ... perhaps we should be asking *which* older drivers are more likely to have accidents" [12, page 45]. Previous assumptions about identifying a threshold age beyond which deterioration in cognitive functioning presents an unacceptable risk to driving have met with limited success, as individual differences make crude age-related cut-offs inappropriate [1, 4, 7, 11, 48]. A more detailed instrument, tailored to individual differences, could be of use for drivers themselves in self-diagnosis, as well as by General Practitioners (GPs) as part of a wider battery assessing medical-psychological fitness to drive. Such cognitive testing could be in addition to existing practices for GP assessments, which include visual acuity, general health, and medications. Anecdotal evidence suggests that GPs are currently uncomfortable with screening patients for driving ability, since they are not experts in driving standards. A cognitive testing instrument, as suggested here and elsewhere (e.g., [22]), used in conjunction with standard medical assessment may help reassurance and reliability in these processes.

However, such screening remains contentious and does not accord with the spirit of solving the older driver problem—maintaining safety and mobility. The aim is to prolong independence, rather than try to remove older drivers from their cars. In that respect, we can turn to user-centred design and a raft of technological support systems that are becoming available in cars.

5. Vehicle Technology and Design to Support Older Drivers

Numerous in-car technologies are coming on stream now that could support the cognitive functioning of older drivers (cf. [3, 10]), such as blind spot warning systems, lane keeping assistance, adaptive cruise control, speed limit displays, and collision mitigation braking systems. Nevertheless, such systems are very much a result of technology "push" rather than user "pull"; what is needed is a balanced, user-centred assessment of these technologies.

The user-centred approach would argue that the cognitive limitations of older drivers may be compensated for by technological interventions which support the older driver in maintaining their independence and mobility. For instance, vision enhancement systems could assist visual impairment associated with night-time driving; similarly a head-up display (HUD) could relieve the visual accommodation problems of eyesight in old age. Collision avoidance systems could help with speed and gap judgements at junctions, while adaptive cruise control or active steering could help reduce the demands of challenging driving situations.

Earlier research in this area with younger drivers (i.e., under 55 years) has shown that these systems can reduce driver workload and bring some improvements to driving performance [44, 49–51]. Extrapolating such results to older drivers may not be straightforward, though; Waller [52] notes that the extent to which "... new technology could assist (older drivers) is not known. Nevertheless, if new technology is designed, taking into account the abilities and limitations of older users, it holds promise of extending the self-sufficiency of many elderly drivers" (page 24).

Lees and Lee [13] suggest that emerging vehicle technologies can be exploited to enhance the safety of older and younger drivers, by tailoring such systems to support bottom-up or top-down processing, respectively. Previous research on younger drivers supports this, indicating that advanced driver assistance systems (ADASs) can bring some improvements to driving performance [45, 49], while European projects such as PReVENT and EDDIT [53] have explored the potential for extending these findings for the specific needs of older drivers. Moreover, a recent UK project explored this very issue and reported that most new in-car technologies have so far ignored older drivers' needs [10]. Using participatory methods, older drivers identified systems that enhanced feedback as having potential to assist their driving. However, this approach could exacerbate problems of high mental workload with older drivers [9, 11].

In particular, the diminished capacities of older drivers could render them more susceptible to overload with poorly designed assistance (cf. [20, 48]). Earlier work in the DRIVAGE project (e.g., [48]) set out to evaluate the driving abilities of older people and to examine the potential benefits and distractions of providing additional information to the driver. More recently, a government report [3] noted that in-vehicle systems could specifically help older drivers but also cautioned that interface design and divided attention limitations might cancel out such benefits. That said, Horberry et al. [54] found that older drivers were no more susceptible to distraction from in-car systems than younger drivers. Moreover, the technological limitations of earlier systems are rapidly being overcome, and new advances in multisensory displays offer enhanced feedback whilst avoiding distraction or overload for the older driver (cf. [55]).

Results from the DRIVAGE project [56] and elsewhere [57] suggest that technological assistance inside the car is only of benefit if designed from a user-centred perspective. More recent research has indicated the potential of developing high technology vehicular interfaces using participatory methods specifically to meet the needs of older drivers [57]. This research also highlighted that the theoretical opportunity for a technology to assist with specific limitations of older drivers could not always be accessed by the older driver group for a variety of reasons, including poor user interface design and technology immaturity [57]. More research is clearly necessary to develop technologies and interfaces which not only support older drivers but are also acceptable and accessible to the population of older drivers.

Thus we see that, on the one hand we have technological options, and on the other we have the needs and wants of older drivers (e.g., [10, 57]). But so far we do not have a complete user-centred solution based not only on the desires of older drivers but also their objective information processing requirements. To finish, we bring together the themes covered in this paper to argue for a new stream of research addressing the older driver problem.

6. Summary and Conclusions

We have seen that, mile for mile, older drivers are at greater risk of a collision than those between the ages of 25 and 55. One reason for this increase in risk is the decline in cognitive abilities with aging, particularly executive function. But individual differences in the aging process, as well as societal acceptability, make it unreasonable to set an age-related threshold for dictating when older drivers should give up their licence. Indeed, the user-centred solution searches for technologies to support older drivers in maintaining safety and mobility.

There are many technologies offered by vehicle manufacturers now, with more arriving in the near future, that could fulfil this purpose. However, few—if any—of these have been designed specifically for older drivers, and so their benefits may be limited. Participatory research has identified the needs and wants of older drivers when it comes to technology; it is our contention that this is only half of the story, as systems should be specifically designed to compensate for the cognitive decrements associated with aging.

Many researchers have tried to identify those decrements with respect to driving performance, with varying degrees of success. We believe that we have discovered a promising avenue of investigation in the conceptual overlap between measures of intraindividual variability from the cognitive neuropsychology of aging and metrics of driving inconsistency from ergonomics. Future research is planned to explore these overlaps in rigorous empirical studies and to use the output as a basis for specifying technological support systems for older drivers. If we can identify systems to improve consistency in driving, we can go some way to solving the older driver problem.

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Review Article

Physical Activity Among Persons Aging with Mobility Disabilities: Shaping a Research Agenda

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With the aging of the baby boomer population and their accompanying burden of disease, future disability rates are expected to increase. This paper summarizes the state of the evidence regarding physical activity and aging for individuals with mobility disability and proposes a healthy aging research agenda for this population. Using a previously published framework, we present evidence in order to compile research recommendations in four areas focusing on older adults with mobility disability: (1) prevalence of physical activity, (2) health benefits of physical activity, (3) correlates of physical activity participation, and, (4) promising physical activity intervention strategies. Overall, findings show a dearth of research examining physical activity health benefits, correlates (demographic, psychological, social, and built environment), and interventions among persons aging with mobility disability. Further research is warranted.

1. Introduction

Disability rates are expected to increase with the aging of the baby boomer population [1]. Indeed, recent National Health and Nutrition Examination Survey (NHANES) data suggest that for those 60–69 years old, the prevalence of disability in activities of daily living, instrumental activities of daily living, and mobility is increasing [1, 2]. The future burden could overwhelm healthcare systems, rehabilitation medicine clinics, and public health agencies. With the increase in an aging demographic, researchers are focusing on ways to prevent secondary conditions in aging persons. Physical activity is recognized as a behavior with strong positive effects on mental, physical, and cognitive health [3]. The benefit of increased physical activity across all age groups is substantial. Thus, efforts to promote physical activity among older adults with existing mobility disability could help prevent a large burden of secondary illness.

Although much physical activity research has focused on older adults who are free of disability and illness, the need still exists for a healthy aging research agenda specific to older adults with mobility disability for tertiary prevention purposes. Promoting healthy aging among people who already have mobility disabilities has been neglected. People with mobility disabilities may benefit from living in accordance with a healthy aging model that includes "the development and maintenance of optimal physical, mental, and social well-being and function" [4]. While the underlying mobility disability may not be reversible, general mental, physical, and cognitive health can be improved.

Prohaska et al. [5] set forth a framework revolving around four questions to help shape the public health research agenda on physical activity and aging. The purpose of this paper is to employ this framework to organize a research agenda for promoting physical activity among persons aging with mobility disability. The four topic areas we describe in this paper, based on the framework of Prohaska et al. [5], are as follows:

(1) surveillance data on the prevalence of physical activity among older adults with mobility disability,

(2) overview of the health benefits of physical activity and the consequences of sedentary behavior in older adults with mobility disability,

(3) correlates and determinants of physical activity participation among older adults with mobility disability,

(4) promising intervention approaches for promoting physical activity in older populations with mobility disability.

While there are many categories of disability including mobility, sensory, intellectual, cognitive, or emotional disabilities [6, 7], in the current paper we focus on mobility disability. Mobility disability in this paper is defined by Patla and Shumway-Cook [8] as occurring "when impairments in mobility restrict the ability of individuals to move about in their natural environment in order to carry out activities essential to daily life."

The International Classification of Function (ICF) framework broadly defines health conditions that can lead to body functions and structure, activity, and participation alterations as "diseases, disorders, injuries, aging, and congenital anomaly" [9]. Therefore, while we use specific examples, we consider mobility disability to be caused by many different factors. Thus, individuals may be born with or develop mobility disability early in life and are aging with this condition. In addition, as people age, chronic diseases such as cardiovascular disease, diabetes, stroke, and arthritis can lead to mobility disability. Finally, mobility disability can be caused by a single, identifiable condition such as multiple sclerosis (MS) or a trauma which resulted in spinal cord injury (SCI) [8] but can also be compounded by development of other chronic diseases found in the general aging population [10].

Regardless of the etiology, there is a need to address physical activity promotion for those with any type of condition that leads to mobility disability. We include in this review both persons aging with specific disabling conditions, such as MS, and those with more general conditions (e.g., frailty or decreased ability to walk due to arthritis or diabetes) that result in mobility disabilities. Although we focus on persons with mobility disability, where data are lacking or when definitions are unclear, we will discuss research in the broader populations of persons with any type of disability.

2. Methods

To shape a research agenda on physical activity among persons aging with mobility disabilities, we conducted a scoping review. A scoping review was selected instead of a systematic review because the purpose of our investigation was to summarize research on a broad topic area and identify research gaps in an area that has not been reviewed before [11]. It was not deemed appropriate to limit our inclusion of studies nor to assess studies for quality as is required for a systematic review. To conduct our scoping review, we selected literature from the fields of public health and rehabilitation medicine which included evidence-based review articles, nationwide data systems, and landmark studies where reviews were lacking. Criteria for including studies were determined after review of the literature and was based on best fit to provide a broad background and to reflect the most current research on physical activity and mobility disability. Searches were conducted in PubMed using various key terms depending on the topic area. Key search terms for capturing populations with mobility disabilities included "mobility disability," "mobility limitation," and "mobility impairment" as well as terms for various chronic illnesses that can lead to mobility disability (e.g., stroke, multiple sclerosis, arthritis). We also used reference lists of review articles to find additional sources. Several well-known government reports were also included (e.g., Physical Activity Guidelines for Americans 2008, Institute of Medicine report on the Future of Disability in America).

3. Findings

3.1. Prevalence of Physical Activity among Populations Aging with Mobility Disabilities. Measuring the prevalence of physical activity among those with mobility disability presents several difficulties. Definitions and criteria for mobility disability are based on various indicators. People can self-identify as having a mobility disability, they may have a diagnosable condition that causes mobility disability, or they may have specific activity limitations which are considered to be related to mobility disability [12, 13]. There are little data available describing the prevalence of disability, particularly in the younger aging groups [14]. Recently published data suggest that "mobility difficulties," based on self-reports of ability to walk 1/4 mile, walk up 10 steps, stand or sit for 2 hours, and standing, bending, or kneeling without using special equipment, increased among all age groups over the 8-year period between 1998 and 2006 [14]. Another study estimated the prevalence of "mobility impairment" among Medicare beneficiaries over 65 years old [15]. In the study, mobility impairment was based on responses to questions about walking ability and function including difficulty walking 2 or 3 blocks, obtaining help for walking from another person, or using assistive devices to walk. Difficulty was based on a hierarchy in which people were classified as having mild, moderate, or severe mobility limitations. Nonwalkers were classified separately. The total number of those with mobility impairments in 2001 was 14.1 million [15]. Out of these, 9.5 million had mild mobility impairment, and 1.2 million had severe mobility impairment. Overall, 28.3% of Medicare beneficiaries had moderate to severe functional impairments [16]. The causes of mobility disability are diverse and span a variety of health conditions. Mobility disability has been highest for those with musculoskeletal diseases followed by neurological disorders, heart diseases, lung diseases, diabetes, and cancer [2, 17]. Additionally, mobility disability due to high body mass index (BMI), which stresses joints resulting in obesity-related mobility disability, is on the rise with 42.2% of persons with obesity reporting functional impairment in the National Health and Nutrition Examination Surveys [18, 19].

Regarding the prevalence of physical activity in persons aging with mobility disability, little is known about their physical activity patterns, and no specific population based information exists on the percent of people with mobility disability who meet the physical activity guidelines. Instead, there are data sources describing rates of physical activity among the general population with any type of disability. The 2008 Physical Activity Guidelines recommend that persons with disabilities meet the same guidelines as for healthy adults or do as much as they are able and avoid being inactive [20]. Healthy People 2020 includes an objective to increase the number of older adults with physical or cognitive function limitations who engage in any intensity of leisure time physical activity [16]. Data from the National Health Interview Survey indicated that 33.7% of older adults with physical or cognitive function limitations engaged in light, moderate, or vigorous intensity activity [16]. The goal is to increase the proportion to 37.1%. A different source of data, the Behavioral Risk Factor Surveillance System, demonstrated that fewer persons with disabilities meet physical activity guidelines (37.7% among those with disabilities compared to 49.4% among those without disabilities in this dataset) [21]. Similarly, data from the Healthy People 2010 database showed higher rates of engaging in no leisure time physical activity for people with disabilities (54%) compared to those without (32%) in 2008 [22]. For those with coronary heart disease (CHD), rates of attending cardiac rehabilitation are low and drop after completion [23]. While data sources vary, it is clear that at a population level, persons with disabilities are less active than those without.

Another way of viewing discrepancies in physical activity levels between those with and without chronic conditions is through Tudor-Locke's review of expected pedometer steps/day for persons with chronic illnesses and disabilities [24]. The researchers found that the median steps/day values were as follows: 5,887 (waist mounted) and 6,006 (ankle worn) for persons with neuromuscular diseases, 4,086 (waist mounted) for persons with arthritis, 4,695 (ankle worn) for persons with post-stroke chronic hemiparesis, and 6,515 (ankle worn) for persons with intermittent claudication. The values for those with chronic conditions were lower than those for otherwise healthy adults who typically obtain between 7,000 and 13,000 steps/day [24]. Regardless of the data source and definition used, the discrepancy in physical activity levels between those with and without various types of mobility disability appears to be consistent and has also been shown among those with SCI [25], arthritis [26, 27], heart disease [23], and MS [28].

Understanding physical activity patterns in individuals with mobility disability is complicated by the frequent use of single time point estimates. For example, research has shown that during inpatient rehabilitation, duration of dynamic activities increases over time, but shortly after discharge this decreases. In one study of SCI inpatients, activity duration decreased by 33% postdischarge [29]. In addition, health problems, such as illness, progression of disease, pain, and fatigue, can cause fluctuations in physical activity patterns. Longitudinal studies of physical activity patterns are needed to better assess the potential nuances among those aging with mobility disability and to help build interventions that address such differences.

3.1.1. Measurement of Physical Activity. Another difficulty in tracking physical activity among persons with mobility disability, whether for surveillance or in research trials, is the lack of validated measures for assessing physical activity in persons with mobility disability. It is important to use measures that capture lower intensity activities, which may be more common among persons aging with mobility disability, that include the use of assistive devices to ambulate and that can be administered in a variety of formats (e.g., interviewer administered by phone) [30]. Several self-reported measures of physical activity have been developed for use among persons with disabilities, which could include those with mobility disabilities [30]. These include the Physical Activity and Disability Survey [31], Physical Activity Recall Assessment for People with Spinal Cord Injury [32], and Physical Activity Scale for Individuals with Physical Disabilities [33]. There are also measures that have been developed for use among older adults including the Community Healthy Activities Model Program for Seniors (CHAMPS) [34], Physical Activity Scale for the Elderly [35], and Yale Physical Activity Survey [36]. Measures that assess physical activity for aging persons with mobility disabilities are lacking. A review of each measure and its validity evidence is beyond the scope of this paper, but more research on these self-report measures, including which perform the best for people aging with mobility disability, is needed.

In the rehabilitation medicine literature, rather than measuring the physical activities that a person engages in, it is more common to assess ability to independently perform activities of daily living and measures of more distal outcomes such as community integration. The problem is that even if someone is able to do an activity (e.g., walk 1/4 mile), this does not mean that they regularly do that activity (e.g., they may spend a half-hour walking each day or they may never spend time walking). Future opportunities that would enhance a rehabilitation medicine-public health collaboration could include measures that assess both functional capacity and ability, as well as regular physical activity that individuals regularly undertake. Dimensions of physical activity should include the types, duration, frequency, and intensity of the physical activities in which people with disabilities engage [30].

Objective measures of physical activity, such as pedometers and accelerometers, can detect all types of activity. However, these monitors are typically worn on the waist and were developed to measure lower extremity movement so may miss activities done by persons in wheelchairs, including upper body activity or users of assistive devices [37]. Some pedometers use accelerometer-type mechanisms that may make them more accurate in populations with gait problems but more commonly spring-levered pedometers are used, and these may not be accurate in those with mobility disability [38, 39]. The Step Watch Activity Monitor is worn on the ankle and has been shown to be more sensitive for those with slow or abnormal gait patterns [30, 40, 41].

Research supports the use of waist-worn accelerometers in populations with MS [42]. Some researchers have used wrist-worn accelerometers to capture upper-body movement in populations with spinal cord injury [30]. However, the equations used to determine the intensity of activity with accelerometers are based on healthy adults and may not be valid to use for older adults and those with mobility disabilities who move differently and often use assistive devices [30].

Activity and participation have also been assessed in persons with disability using newer technologies. The Participation and Activity Measurement System integrates self-reported data with wheel revolution counters, seat sensors, and GPS to capture activity data for people using wheelchairs [43]. Such systems could be adapted and applied to older adults who use walkers or other assistive devices. Other researchers are developing systems that integrate data from GPS and accelerometers in populations of older adults and those with disabilities (Physical Activity Location Measurement System [44]; Movement and Activity in Physical Space (MAPS) score [45]). The home is a setting where technology may be helpful in measuring physical activity objectively. Sensors are being developed that can be installed in homes to assess activity patterns within the home [46].

Additional research on the measurement of physical activity for populations aging with mobility disability is needed on several fronts. One is that it is imperative to include measures of physical activity in studies of persons aging with mobility disabilities. Another is that determining the best objective and self-reported measures of physical activity for individuals aging with mobility disability will be important. Integrating measures of functioning and physical activity could be an improved measurement approach. Further examination of the equations used to derive energy expenditure for persons aging with mobility disability is also needed. The use of newer technologies, such as GPS and home sensors, to examine physical activity patterns holds promise.

3.2. Health Benefits of Physical Activity for Older Adults with Mobility Impairment. Improving physical activity in an aging population helps to prevent mobility disability. Much of the research conducted in this area excludes those that already have mobility disability [47]. For persons who already have a disability, adopting a physically active lifestyle can help prevent or control secondary conditions as well as further declines in functioning and further loss of mobility. Because persons with mobility disability are at higher risk for secondary conditions that physical activity can prevent, adopting a physically active lifestyle could potentially result in greater health benefits among persons with disability [48]. For example, among persons with spinal cord injury, cardiovascular disease has replaced urinary complications as the leading cause of death [10].

3.2.1. Health Benefits. Generally, the health benefits of an active lifestyle among persons with disabilities appear to be similar to populations without disability. Research conducted on individuals with disability has shown physical activity to positively affect hypertension, manage cardiovascular disease and osteoarthritis, and reduce spasticity [47, 49, 50]. There is moderate evidence that physical activity reduces secondary conditions prevalent in persons with mobility disabilities, including pain and fatigue [20]. Mortality in people with CHD is related to low fitness [23].

Due to a lack of studies, evidence is limited that physical activity improves healthy weight and metabolic health among persons with mobility disabilities. There is some evidence that physical activity improves weight and metabolic factors among persons with SCI [51] and arthritis [52]. One difficulty in examining relationships between physical activity and weight among persons with disabilities is that BMI is not always obtained or BMI calculations are not straightforward (e.g., persons with amputations where the weight of the missing limb must be accounted for to determine current BMI). Few studies have collected weight status or BMI information and physical activity data among populations with mobility disability.

3.2.2. Physical Functioning Benefits. Research conducted on individuals with disability has shown physical activity to increase overall fitness and prevent functional decline [47, 49, 50]. In particular, research suggests moderate to strong evidence that aerobic exercise improves cardiorespiratory fitness in persons with lower limb loss, MS, stroke, and SCI, and walking speed and distance in persons with stroke and MS [3]. Exercise also was noted to improve physical function and delay disability among those with osteoarthritis and rheumatic conditions [3]. There is moderately strong evidence that resistance training improves muscular strength in persons with stroke, MS, and SCI [3]. Motl recently reviewed studies on MS and physical activity showing that exercise training improved walking mobility with a weighted mean effect size of (.19), similar to that of medical interventions [53]. A Cochrane review of physical fitness interventions for stroke found that cardiorespiratory interventions that included walking resulted in improved walking speed, endurance, and reduced dependence while walking [54]. Another review found that physical rehabilitation programs were effective in improving physical state, including functioning with ADLs, flexibility, and strengthening [55].

3.2.3. Mental Health Benefits. Research conducted on individuals with disability has shown physical activity to improve quality of life and reduce depression [3, 47, 49, 50].

3.2.4. Cognitive Health Benefits. Research shows that exercise interventions can improve cognitive functioning among people with existing mild cognitive impairment [56]. A promising avenue of future research is to examine whether exercise interventions can improve cognitive function among persons with mobility disability who are at risk for cognitive impairments as they age, such as those with MS. There is some cross-sectional evidence that people with MS who are more active report fewer cognitive deficits [57].

3.2.5. Other Findings. The committee report from the 2008 Physical Activity Guidelines [3] summarized evidence for the health benefits of exercise for persons with disabilities. A main finding was that physical activity is safe and effective for people with disabilities. Few adverse outcomes were reported. The report concluded that research evidence is lacking regarding: (1) the dose of physical activity needed to confer health benefits, and (2) longitudinal studies on the health benefits of physical activity among persons with a variety of disabling health conditions.

An understudied area of concern is the health effects of prolonged sedentary behavior in persons aging with mobility disabilities. Even when adults meet physical activity guidelines, sitting for prolonged periods can compromise metabolic health. Television time, even after adjustment for physical activity, is independently associated with increased risk for obesity, type 2 diabetes, CVD mortality, and all-cause mortality [58, 59]. This has not been studied among populations with disability. Further evidence of the relationship between television watching and health outcomes among persons with disabilities is needed. There is evidence that adults over 60 spend more time watching television than other age groups [60, 61]. Greater television use was related to lower life satisfaction among older adults in one study [60].

Overall, there is a dearth of research on the health benefits of physical activity among persons aging with mobility disabilities. Larger studies, focusing on specific diseases (e.g., MS) and cross-cutting conditions (e.g., mobility disability related to cardiovascular disease, diabetes, etc.), can better elucidate the health benefits of physical activity. Additionally, more focus on the health effects of light intensity activities [62] and their relationship to health outcomes is needed among those aging with mobility disability. More research is needed on specific health benefits of physical activity, which are under-examined among persons aging with mobility disability and may show promising relationships (e.g., variables such as weight status, progression of illness, mental health, and cognitive functioning).

3.3. Factors That Influence Participation in Regular Physical Activity. Few cross-cutting studies address correlates of physical activity among people aging with mobility disability. We discuss the studies that have examined the demographic, physical health, psychological, social, and built environment variables that are correlated with physical activity among various groups with mobility disability.

3.3.1. Demographic Correlates. Sociodemographic correlates of physical activity have been understudied among persons with disabilities. Younger age has been related to less physical activity among people with SCI [25]. People with MS have been shown to be less active if they had a disability pension and children to care for [63]. Among people with arthritis, relationships with sociodemographic variables have been inconsistent or nonexistent [64, 65]. Among those with CHD, age, BMI, education, income, and insurance coverage were not related to physical activity while being Caucasian, male, and employed were associated with higher levels of exercise [23]. The lack of studies may be due to the use of study samples that are not diverse with respect to various sociodemographic indicators.

3.3.2. Physical Health Correlates. Common health-related correlates include pain and fatigue for those with SCI (shoulder pain; [66]), MS [67], arthritis [64], and stroke (fatigue [68]). Among people with SCI, independent predictors of greater physical activity were less time since injury, being a manual wheelchair user, and having motor complete paraplegia [25]. Predictors of greater physical activity in people with MS were less severe disease [63] and less difficulty walking [69, 70]. Controlling for disease severity, greater MS-related symptoms predicted less physical activity cross-sectionally [69] and longitudinally over a three- to five-year period [70]. In one study, the relationship between greater symptoms and lower physical activity was through greater fatigue [71]. Illness-related barriers limited physical activity in a sample of women with arthritis and included pain, stiffness, and arthritis limitations on the body's ability to do activity [72]. In a different sample of persons with arthritis, those who were more active had fewer medical comorbidities and less obesity [52]. Arthritis, fatigue, and discomfort were the largest barriers to exercise among the total sample but affected those with lower physical activity levels more [52]. In an arthritis physical activity program, disease exacerbations were a barrier to exercise [73]. High rates of fatigue impacted participants with COPD undergoing pulmonary rehabilitation [74]. In those with CHD, higher functional status and better health status including fewer comorbidities and less severe illness were related to higher levels of physical activity [23].

3.3.3. Psychological Correlates. There are several common psychological correlates of exercise. Higher self-efficacy has been related to higher physical activity among people with SCI [75], MS [28], arthritis [52, 64], CHD [23], and diabetes [76]. Exercise enjoyment, outcome expections, and sense of personal accomplishment have been found to be related to more physical activity among those with MS [28, 77]. The benefits of exercise and positive attitudes were found to be related to more PA among persons with arthritis [64]. Higher previous physical activity level, greater intentions to exercise, positive attitudes, and benefits were related to more exercise in CHD [23]. Emotional distress including depression has been an important barrier to exercise among persons with SCI [78], MS [67], stroke [68], CHD [23], and arthritis [64]. Physical exertion was the greatest barrier to physical activity among both exercisers and nonexercisers with MS [79]. Other barriers that have been cited among older adults with functional limitations or physical disabilities include mistaken beliefs that exercise must be vigorous and uncomfortable to afford health benefits [80]. Barriers to exercise in persons with arthritis have included time constraints, boredom, lack of knowledge, and lack of motivation [64].

3.3.4. Social Correlates. Social isolation has been shown to be a barrier to physical activity among persons with stroke [68]. Encouragement to be active from others, including family, friends, and medical providers, has been related to physical activity in persons with arthritis [52, 64]. More social support resulted in higher exercise during and after cardiac rehabilitation for those with CHD [23].

3.3.5. Environmental Correlates. The ICF framework states that the environmental context includes products and technology, natural environment and human-made changes, support and relationships, attitudes, and services, systems, and policies [7]. The built environment, including human-made structures (e.g., sidewalks, street crossings) in cities, landscapes, and buildings [81], may be particularly important in shaping physical activity as those with existing impairments can become more disabled by limiting conditions in the built environment [82, 83].

Research on built environment features shows that having access to public transportation is important for promoting recreational physical activity among those with physical disabilities [84], MS [85], CHD [23], and knee osteoarthritis [86]. Having low-cost programs has been shown to be important for those with physical disabilities [84], MS [85], CHD [23], and arthritis [64, 72]. Additional important built environment variables are having convenient access to destinations and fitness programs for physical activity [64]. Studies have shown that destinations and accessibility are important for promoting physical activity. Specifically, destinations for those with MS [85], arthritis-specific exercise programs at local fitness facilities as well as parks and trails among women with arthritis [72], parks and walking areas for those at high risk or who had knee osteoarthritis [86], distance and accessibility of cardiac rehabilitation programs for those with CHD [23], and accessibility to stores and buildings among people with SCI [78]. Specific built environment barriers to exercise have included weather, poor sidewalk conditions, lack of streetlights, and safety concerns among women with arthritis [64, 72]. Weather was not associated with exercise in people with CHD undergoing cardiac rehabilitation [23]. Crime rates have been associated with lower physical activity among persons with SCI [87]. Additional environmental barriers to physical activity among persons with physical disabilities include lack of curb cuts, inaccessible access routes, narrow doorways, slippery floors, lack of handrails on stairs, lack of adaptive or accessible equipment in fitness facilities, lack of information on facilities and programs that are accessible, and unfriendly environments at fitness facilities [84].

There are few studies that measure both the environmental context for physical activity and physical activity levels among persons with disabilities. Few detailed self-reported measures of the built environment are validated for use among those with disabilities. Some have related environmental features to participation, activity ability, and quality of life among persons with SCI [88] and general rehabilitation populations [89]. Relationships were observed between home and community environment and participation as well as quality of life. One study suggested that over time the relationships diminish as people adapt to or modify their environment [89].

One methodologic issue in these studies is that many built environment features (e.g., walkability, transit access, nearby destinations) are expected to more highly relate to active transport (e.g., walking or wheeling to get to useful destinations like stores or a bank) rather than the more commonly studied recreational physical activity (e.g., walking or wheeling for leisure) [90]. Features expected to be more related to recreational physical activity include aesthetics and traffic safety. Studies to date have not examined relationships of these specific types of physical activity and built environment features in persons with mobility disabilities.

Environmental avoidance can also affect mobility among persons aging with disabilities [91]. Fear of going outdoors can interact with the local built environment features in ways that further inhibit activity (e.g., barriers in the built environment) [92] or help people overcome their fears (e.g., presence of facilitators in the built environment). The importance of addressing multiple levels of influence on physical activity in future studies is highlighted by these results.

More research is needed describing individual, psychological, social, and built environment correlates of physical activity among persons aging with mobility disability. Perhaps one reason for the dearth of research in these areas relates to the focus of medical rehabilitation on remediation of physical impairments and regaining the ability to carry out activities of daily living, a focus that is largely driven by insurance reimbursement. Outcomes measurement in rehabilitation has reached beyond measuring impairment and disability to encompass environmental determinants of societal participation. However, it is telling that measures of environmental factors within rehabilitation, such as the Craig Hospital Inventory of Environmental Factors, have not been widely used [93]. Medical rehabilitation research has also been limited by an over-emphasis on individual and condition-specific levels of analysis rather than on population-based perspectives and issues that transcend disability types, such as problems attributable to inactivity and sedentary behaviors. This is understandable given that rehabilitation often deals with complex and relatively rare conditions such as spinal cord injury and multiple sclerosis. Increased awareness of environmental barriers to mobility with the aging of the population and renewed interest in the health benefits of physical activity may benefit disability populations indirectly through policy changes and research on universal health promoting activities.

While research on physical activity is increasing among populations with disability, particularly those with MS, there are many cross-cutting conditions (e.g., mobility disability) and specific conditions (e.g., spinal cord injury) that are understudied in terms of physical activity correlates and determinants. Correlates of physical activity among persons with mobility disability may include a combination of general barriers faced by the general population (e.g., lack of time) and barriers specific to the condition or disability (e.g., arthritis-related pain). Among those with the various disabilities described, common correlates include pain, fatigue, depression, and self-efficacy. Some research suggests that mental health and built environment variables are related to physical activity but more data are needed, and interventions will need to target these barriers.

3.4. Interventions and Policies to Promote Physical Activity in Older Adults with Mobility Impairments. Interventions can target individuals, either one-on-one or in group settings, to promote changes. Another intervention approach, however, is to change the built environment and create policies to make healthy choices, including active living, the default option (e.g., walking to the store rather than driving there) [94]. We briefly review current research on each of these areas.

3.4.1. Individually Focused Physical Activity Interventions. Maximizing mobility in older adults has been the focus of multiple intervention projects. Much of the focus has been on preventing mobility disability in otherwise healthy older adults (e.g., [95]). However, some interventions have been specifically developed to increase physical activity among those who have mobility disabilities.

The research that has been done among older adults with chronic disease or low fitness has indicated that multicomponent programs (including endurance, strength, flexibility, and balance) focusing on physical activity only (versus multiple behavior targets such as activity, nutrition, and medication), building exercise slowly over time, and using behavior change principles (e.g., social support, health contracts, self-monitoring, goal-setting) help promote physical activity [96–100]. Effective physical activity programs among older adults target moderate intensity activities, are inexpensive, are convenient [80], can be done independently though with some instruction [101], and are tailored [102]. For women, particularly, inclusion of a social component can be important [80]. It is likely for older adults with mobility disability that these program characteristics are also important although there may be differences due to the higher rates of illness, pain, fatigue, and depression among those with mobility disabilities.

Rimmer and colleagues conducted a review of exercise interventions specifically for individuals under age 65 with physical and cognitive disability [6]. MS and stroke were the most common conditions studied. The 32 randomized controlled trials involved aerobic, strength, or combined exercise but no two trials offered the same dose across 11 different disability groups, making comparison difficult. The primary outcomes were functional, musculoskeletal, cardiorespiratory, mental, and metabolic health. Although many of the exercise trials showed positive benefits, the lack of replication and often small sample size makes conclusions difficult. The authors suggest that exercise interventions need to be developed that focus on groups with the same functional impairment or activity limitation (e.g., inability to walk) and varied doses of exercise [6].

It can be difficult to evaluate whether exercise interventions result in increases in exercise. Motl's review of studies on MS and physical activity showed the largest effect sizes were for studies with supervised exercise and shorter duration programs [103]. Petter et al.'s review on physical activity programs for CHD showed that exercise levels did not vary whether the program was home or hospital based [23]. Several limitations of the rehabilitation research literature are (1) lack of measurement of physical activity and (2) use of time-limited structured programs such that the benefits likely end when the programs stop. Studies are needed that focus on improving lifestyle activity and participation in on-going exercise programs that can be maintained once research ends.

Barriers to activity can be much higher than for populations without disabilities, stemming from both increased internal struggles (e.g., motivation, pain, depression) and environmental constraints (e.g., lack of access to exercise facilities). Strategies to improve self-efficacy for continuing to exercise as well as self-efficacy to overcome barriers to exercise (symptoms, social environment, and physical environment) may merit specific attention in trials to promote physical activity in people with MS and other mobility disabilities [104, 105]. Social support has been identified as an important component of adapting to chronic conditions [89] and could be a means for encouraging a physically active lifestyle.

Pacing of activity may be important to promoting physical activity among persons aging with mobility disability. Brawley et al. noted that in one large intervention for knee osteoarthritis, those who exercised more often but for shorter durations per session had less pain and better ADL performance than those who did more exercise [80]. This suggests that for persons with disabilities, doing shorter bouts of exercise regularly could be more beneficial than pushing oneself to do more at one time. Additionally, the physical activity guidelines state that activity can be accumulated with three 10-minute bouts throughout the day and health benefits can still occur [20].

An important issue is assuring older participants of the safety of exercise. Older adults or those with mobility disability may not believe that exercise is safe for them or they may not consider activities they can do (e.g., slow walking with an assistive device) a valid form of exercise [80]. Risk of falls and fear of falling need to be addressed via education and specific intervention targets. Additionally, falls prevention among people aging with mobility disabilities is important due to higher rates of falls among those with disabilities [106]. Fall rates for those with disabilities may be twice the rate of community-dwelling older adults [106]. A potential cause and consequence of falls is activity restriction which can lead to a decrease in quality of life [106]. Physical activities consisting of balance training, strengthening exercises, and gait training are important elements of falls prevention programs. However, there are few falls prevention interventions geared towards those with mobility disabilities [106]. Programs developed in the general aging population, such as Matter of Balance and Stepping On, could be tested to determine whether they are effective for persons with mobility disabilities [106]. Some attempts at modifying fall prevention programs for populations with disability, such as stroke, have begun [107]. A review of interventions to prevent falls in those aged ≥80 found that the most cost effective intervention included strength and balance retraining [108].

Evidence-based physical activity programs do exist for some populations of adults aging with mobility disability. The EnhanceFitness program, for example, has been offered to adults over age 65 in community-based settings, and many participants have chronic illnesses that make them susceptible to disability [109]. The program promotes social support for a healthier lifestyle and involves supervised moderate intensity aerobic exercise, strength training, and flexibility and balance training. Involvement in the program was found to decrease health care costs over the long term [109]. Fit and Strong is an evidence-based program for people with arthritis consisting of 8 weeks of aerobic, flexibility, and resistance training exercises. Because maintenance of physical activity is a problem when structured programs end, Fit and Strong tested the use of a maintenance contract plan according to individual preferences and telephone contacts twice monthly for months 3 through 6 and monthly between months 7 and 18 [110]. This approach was shown to promote physical activity, decrease lower extremity pain, stiffness, improve function, and improve strength and aerobic capacity as well as decrease depression at 18 months [110]. For those with arthritis, other evidence-based programs include the Arthritis Foundation Aquatic Program [111], People with Arthritis Can Exercise (PACE) [73], and Walk with Ease [112]. A problem is that participation in such structured programs has been noted to be low, around 1% of the target population in one instance [73]. Several reasons why people may not attend such programs are lack of interest in group-based exercise programs, inability to access programs due to transportation and lack of knowledge the programs are offered in close proximity to ones' residence. Improving the reach of such programs and expanding them to include those with various types of mobility disability should be a target.

The Chronic Disease Self-Management Program is an empirically supported program teaching self-confidence to manage chronic conditions for those with hypertension, arthritis, heart disease, stroke, lung disease, and diabetes [113]. Exercise is one component of the program and has been shown to improve for those that participate. While those with mobility disabilities could be included in such programs, further translating this type of approach for those specifically with diverse types of mobility disabilities could be a promising strategy.

Some studies have sought to provide cognitive-behavioral self-regulation skills to aid participants' transitions from rehabilitation to independent lifestyle activity [80]. Programs comparing facility-based programs to home-based independent exercise programs have shown no difference in improvements in functional capacity, suggesting that a lifestyle, home-based approach can be as effective as facility-based treatments. Lifestyle physical activity programs, which incorporate routine activity as part of usual life, may be more acceptable to a larger population [114]. Some researchers are beginning to investigate the utility of such approaches [114].

Notably, while Internet-based and technology-based interventions are becoming increasingly popular to use among many populations [115], including some with chronic illness (e.g., diabetes [116]), these approaches are under-studied among persons aging with mobility disability. Exergame (i.e., active video games) interventions are being used for rehabilitation purposes [117], including balance training [118] and upper limb strengthening among persons with stroke [119], but have not been empirically tested as a physical activity promotion tool among persons aging with mobility disability. Virtual reality and exergames are promising because they can promote social engagement as well as improvements in mental health, cognitive health, specific rehabilitation needs, and physical activity [120, 121]. Additionally, interventions to decrease sedentary behaviors such as television viewing among persons with mobility disability are nonexistent.

In sum, based on evidence with older and less active populations and those with general disabilities, programs for those with mobility disability will likely need to target multiple components. To address risk of falls, lifestyle physical activity interventions may not be enough and specific exercises to improve strength and balance may be needed. In this case, structured, community-based exercise programs are needed for people aging with various types of mobility disability. However, issues such as pain, fatigue, and depression may make it more difficult to engage persons with mobility disability in such programs. Therefore, promoting low-intensity, unstructured, lifestyle activity, although underutilized, may be a viable strategy among individuals with mobility disability coping with barriers to moderate to vigorous activities. Researchers need to focus on participation in community-based programs as well as lifestyle activity changes and decreased sedentary behavior.

3.4.2. Environmental and Policy Interventions. Intervention approaches to physical activity recommended by the *Guide to Community Preventive Services* include enhanced access to places for physical activity combined with informational outreach, community-scale urban design, and street-scale urban design (e.g., street crossings, traffic calming, sidewalks) [122]. Research now acknowledges the effect of the built environment on persons with mobility disability [123], but no intervention research focuses on addressing the neighborhood built environment barriers among persons with disabilities. Yet, to promote healthy aging, it is important that environments and communities support the integration of people aging with mobility disability to enhance opportunities for active living.

Longitudinal evidence shows that street conditions affect mobility more among persons with mobility disability than those with mild or no physical impairments [82]. Improving street quality could lead to more use of the local neighborhood for utilitarian and recreational activities. This could slow or reverse the disablement process among adults with the greatest risk for disability in outdoor mobility [82].

Another relevant neighborhood characteristic relates to safety and neighborhood deprivation. Lang et al. [124] conducted a prospective cohort study with a two-year follow-up and found that older people living in deprived neighborhoods (based on income, employment, education, living environment, health deprivation, and crime) are significantly more likely to experience incident mobility difficulties than those in less-deprived neighborhoods. Persons with disabilities may feel less safe ambulating around their communities due to believing that they are perceived as easier targets for crime. Crime reduction efforts should explicitly focus on improving safety concerns among persons aging with mobility disability.

Beyond neighborhood-level environmental considerations, home environments can either support or hinder mobility [89]. Accessible features allow for people, regardless of functional status, chronological age, or use of mobility devices to have easy access to and use of their home. The home can be an important source of physical activity through the ability to do exercise or activities of daily living and to limit time spent being immobile. Research has examined home modification but more towards preventing injury and falls and increasing functioning and activities of daily living [125] rather than with a view towards promoting physical activity (e.g., by providing exercise equipment).

Some studies have used interventions that combine cognitive behavioral approaches and address the environment. Cognitive-behavioral strategies, finding supportive environmental solutions, exploring motivation postinjury, and capturing new frames of reference were found to help promote physical activity after SCI in a qualitative study [126]. Similarly, the Personalized Exercise Program for predominantly African American women with mobility disabilities and obesity included a focus on individual and cultural preferences for activity, equipment adaptations, and access to community resources and resulted in improved physical activity, reduced weight, and decreased barriers to activity [127]. Such interventions are encouraging that more work is needed to address multiple levels of influence on physical activity (e.g. individual, social-cultural, and built environment) [127].

With the advent of the Americans with Disabilities Act (ADA), newer construction and retrofitting of older construction can lead to improved mobility in public buildings and spaces but has yet to reach our private homes. The opportunity to use universal design (UD) features in the design of homes as well as communities will be increasingly important as the population ages. UD features are intended to be accessible, attractive, and acceptable to everyone [128]. It will be important for urban planning policies to promote new housing designs and developments that are accessible to all as the population ages and rates of disability increase.

The Environmental Protection Agency (Building Healthy Communities for Active Aging [129]), World Health Organization (Global Age Friendly Cities [130]), and AARP (Planning Complete Streets for An Aging America [131]) sponsor initiatives encouraging communities to be designed for healthy active aging that each touch on issues related to persons aging with disabilities. The Federal Administration on Aging, Evidence-based Disease, and Disability Prevention Program has provided over $23 million since 2003 to support community-based healthy aging programs in 24 states [132]. The programs include physical activity and falls prevention programs. These programs have served over 44,000 seniors and the number benefitting each year has been increasing. Despite the success of these programs, it remains unclear whether they will be sustainable either by creating an adequate business model or by convincing states to commit to long-term funding.

Because states depend on funding from the federal government to support these programs, securing policies that provide investment at the federal level should be a target. Promising policy avenues that could lead to improved federal funding include the emphasis on prevention and wellness in the 2010 Patient Protection and Affordable Care Act. There will be opportunities for grants to provide funding for programs that deliver evidence-based services. As part of healthcare reform, Medicare and Medicaid beneficiaries will be incentivized to complete behavior modification programs. Promoting dissemination of physical activity programs targeting people with disabilities and those that use Medicare and Medicaid should be an important objective for these funds.

There are increasingly more technical assistance opportunities available targeting cross-sector groups related to environmental and policy change for mobility. One such initiative is the Environmental and Policy Change for Healthy Aging [133] (http://agingfriendly.org/), a novel online initiative of on-demand presentations, archived webinars, a clearinghouse for mobility resources, and an active online community. The initiative focuses on the challenges amenable to environmental and policy change, the evidence that supports specific approaches and their outcomes, and promising strategies for practice.

Overall, there are few physical activity interventions from which to draw conclusions on the most effective ways to promote activity among persons aging with mobility disability. It is likely that the best approaches to promoting physical activity will use an intervention framework that incorporates both the physiologic process involved in disability, psychosocial barriers (e.g., self-efficacy), as well as the role of the environment. Several frameworks are available to guide intervention approaches. A widely used model in physical activity and public health research is the ecological model, which promotes intervention at the intrapersonal (biological/psychological), interpersonal/cultural, physical environment, and policy levels of change (i.e., multilevel approaches) [90]. Additionally, Webber et al. [134] created a mobility framework for older adults meant to bridge various disciplines. The model incorporates the seven dimensions of lifespace (e.g., room, home, outdoors, neighborhood), mobility determinants (including cognitive, psychosocial, physical, environmental), and gender, culture, and biographical influences.

There are many models of disability which are also important to consider including the the biopsycho-ecological paradigm [135], Nagi's disablement model [9], the International Classification of Functioning [7], and Verbrugge and Jette's disablement process model [9]. These frameworks all embrace a biopsychosocial view of disability and acknowledge that disability is not only determined by impairments or functional limitations within an individual, but rather an interaction between individuals and contextual factors [7–9].

Several relevant frameworks of disability have been reviewed elsewhere [9, 136].

Regardless of the model used, the built environment appears to be an important barrier to mobility and physical activity in persons with mobility disability. Thus, interventions will need to address built environment influences. Making changes to the built environment, by retrofitting and encouraging policies that use UD for new developments, is a promising approach to helping people stay active as they age with a mobility disability.

4. Discussion

The population of individuals aging with mobility disability is increasing and current research on physical activity to promote health and reduce secondary conditions is limited. In this review, we provide several recommendations that will help build a research agenda targeting physical activity promotion among persons aging with mobility disabilities (see Table 1). Our review, while not systematic, is intended to provide a broad overview and address limitations and barriers of research to date so that future endeavors can further the field of research.

Evidence shows that physical activity levels among persons with mobility disability are lower than the general population though information on subgroups of disability type is lacking. Improved surveillance system assessment of various disability types as well as improved measures of self-reported and objective physical activity assessment will help researchers better understand patterns of physical activity among those aging with mobility disability. Several new technologies can help guide measurement and understanding of physical activity and mobility patterns, including GPS and sensor technology.

Evidence illustrates that even among those with disabilities, physical activity can reduce secondary chronic conditions, reduce pain, and improve physical function [2]. Research on the benefits of physical activity among persons aging with mobility disability has lacked longitudinal studies and examination of important potential health benefits such as cognitive function. Correlates of physical activity among persons aging with mobility disabilities are also understudied. There are no review studies that comprehensively address correlates of physical activity for persons aging with mobility disabilities. Little is known regarding the interaction of gender, ethnicity, socioeconomic status, and mobility disability as people age. Particularly important individual barriers to exercise include pain, fatigue, and depression; the community built environment is an additional barrier. Physical activity interventions will need to target each of these concerns and multilevel approaches should be used.

There are several special concerns for a research agenda targeting persons aging with mobility disabilities that crosscut each of the four areas covered here. One issue is that there is a lack of clear prevalence and trend data on physical activity patterns in this population, making it difficult to fully understand the scope of the problem, identify relevant correlates, and develop effective interventions. Healthy People 2020 contains an objective related to including identification of people with disabilities in datasets [16]. The report notes that only 2 of 26 datasets identified persons with disabilities in Healthy People 2020, and the objective is to double the number of datasets that identify persons with disabilities. Indeed, in datasets from Healthy People 2010, data are not available for persons with disabilities regarding relevant outcomes including television viewing and walking for transportation [22].

Another problem is that clear physical activity objectives and guidelines are lacking for persons aging with mobility disability. Such specific guidelines can be useful for tracking physical activity patterns and developing intervention targets which could include provider-based recommendations. Due to a lack of research focus on those aging with mobility disability, determining adequate doses and types of physical activity necessary to confer health benefits has not been possible. One promising step forward is that Healthy People 2020 includes a physical activity objective for older adults with reduced physical or cognitive function [16].

A theme observed in the research described here is that community-based exercise programs targeting persons with various types of mobility disability are lacking. There is evidence that rehabilitation programs may effectively increase physical activity levels among participants, but once the programs end, levels decline. It would be helpful for rehabilitation practitioners to refer their discharged patients to relevant community-based physical activity programs, but these programs are not widely available, with the possible exception of those for persons with arthritis. However, even these empirically validated programs are underused. Research can help improve our understanding of what program characteristics will be effective in promoting physical activity for persons aging with mobility disability. More knowledge is needed regarding preferred settings for doing exercise (e.g., home, general group, or group of persons with the same impairments), modes of exercise (alone or with others), and types of exercise (e.g., walking, chair-based aerobic). Physical activity programs and interventions will need to include safeguards that address the fluctuations in activity due to illness or other setbacks. Other under-examined intervention targets relevant to promoting physically active lifestyles include reducing sedentary behaviors such as television watching.

An additional research difficulty is that physical activity research on people with mobility disability has often been discipline and disease specific [134]. Generally, there is a need to focus away from specific conditions (e.g., amputation) and toward broader categories of impairment (e.g., lower extremity mobility impairment). Larger studies can then be conducted and the population of persons aging with mobility disability can be a growing target for larger-scale public health surveillance, prospective studies, and interventions [137]. Many older adults have more than one chronic illness or disability, so disease-specific research is less useful, and often those with comorbid conditions are excluded from research studies. Cutting across conditions would allow research to keep individuals with comorbid conditions in research studies rather than exclude them. In order to prepare for an aging society, we need to learn more

Table 1: Recommendations for research priorities related to promoting physical activity for adults aging with mobility disabilities.

Topic Area	Recommendations
(1) Prevalence of physical activity among older populations with mobility disability	(i) Define mobility disability and employ standard definition across sectors and research studies. Include specific categories of disability (e.g., mobility disability, sensory disability) in surveillance (ii) Conduct studies on best means for measuring physical activity among persons aging with mobility disability, including objective (pedometers, accelerometers) and subjective measures (iii) Incorporate newer technologies to better understand physical activity patterns among persons aging with mobility disability (Global Positioning Systems; home-based sensors)
(2) Health benefits of physical activity and consequences of sedentary behavior in older adults with mobility disability	(i) Conduct research on ways physical activity benefits persons with mobility disabilities as they age, including larger samples, more rigorous methods, and prospective studies (ii) Conduct studies that use the same measurement tools, capture data on frequency, intensity, duration, and modality of exercise so that recommendations for people with mobility disability can be developed (iii) Include understudied health outcomes such as weight status, mental health, and cognitive functioning (iv) Examine the effects of sedentary behaviors among those aging with mobility disability (v) In rehabilitation-oriented, supervised or structured physical activity interventions, include explicit measurement of physical activity among populations with mobility disability (versus assessment of only ability)
(3) Correlates and determinants of physical activity participation among older adults with mobility disability	(i) Expand studies on the correlates of physical activity participation in this population to include demographic, societal, mental health, and built environment variables (ii) Develop measures of individual, social, and environmental facilitators and barriers of physical activity common among persons aging with mobility disability (iii) Conduct studies that include both specific disability groups (e.g., aging with spinal cord injury) and broader groups with the same activity limitation (e.g., aging with mobility disability)
(4) Interventions to promote physical activity in older populations with mobility disability	(i) Develop and test interventions that use multilevel approaches (which aim to target individual, interpersonal, and built environment factors) to promote physical activity among persons with mobility disability (ii) Interventions should address symptoms such as pain, depression, and fatigue that are common among persons aging with mobility disability and that are barriers to being physically active (iii) Conduct technology-based interventions (e.g., using Web-based approaches, exergames, feedback from GPS and other technologies) to promote physical activity (iv) Conduct studies assessing the effectiveness of lifestyle-based, lower intensity activity programs that address features of the home design and built environment in conjunction with structured programs (v) Develop community-based physical activity programs for persons aging with mobility disability (vi) Further develop and continue policies and funding at the local, regional, and national level to support evidence-based environmental enhancements and universal design

about populations with comorbid chronic conditions and disabilities [138].

The importance of the built environment, both in the neighborhood and the home environment, as a barrier to activity among persons aging with mobility disabilities is clear and needs to be further elucidated and measures of these constructs are needed. Employing ADA standards and UD principles will be important so that an aging society can find acceptable housing and communities that allow them to stay active as they become unable to drive. Healthy People 2020 targets both persons with disabilities and older adults as important populations that need supportive built environments [16].

In sum, there is a dearth of research on promoting physical activity among persons aging with mobility disability. Due to a population that is aging with more disease and disability [14], there is a need to better understand preventive health behaviors including physical activity in aging populations with disability. Promoting physically active lifestyles to enhance mobility, even among those with disability, as a preventive and control strategy is imperative. Individuals with disabilities have traditionally been treated by medical professionals in rehabilitation medicine, but with the aging demographic and associated increase in disability, public health approaches will likely be necessary due to cost restraints [2]. Public health research efforts should attempt to learn from rehabilitation research and vice versa, forming a new field of public health rehabilitation. Developing effective physical activity interventions and designing our communities to support active aging for all is vital.

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Review Article

The Urban Built Environment and Mobility in Older Adults: A Comprehensive Review

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Mobility restrictions in older adults are common and increase the likelihood of negative health outcomes and premature mortality. The effect of built environment on mobility in older populations, among whom environmental effects may be strongest, is the focus of a growing body of the literature. We reviewed recent research (1990–2010) that examined associations of objective measures of the built environment with mobility and disability in adults aged 60 years or older. Seventeen empirical articles were identified. The existing literature suggests that mobility is associated with higher street connectivity leading to shorter pedestrian distances, street and traffic conditions such as safety measures, and proximity to destinations such as retail establishments, parks, and green spaces. Existing research is limited by differences in exposure and outcome assessments and use of cross-sectional study designs. This research could lead to policy interventions that allow older adults to live more healthy and active lives in their communities.

1. Introduction

Mobility limitations are defined by impairment or dependence in movement and affect between one third and one half of adults aged 65 or older [1]. Mobility limitations can affect an individual's health through a number of pathways. Lack of physical activity in older individuals can lead to loss of muscle mass (sarcopenia), loss of bone density (osteoporosis), and an increase in fat mass (obesity) [2, 3]. Isolation and loss of social ties resulting from reduced mobility can lead to depression and other adverse mental health outcomes [4]. A lack of access to resources such as fresh foods and medical care which can result from limited mobility can also have negative impacts on health [5]. Individuals with mobility limitations are also at higher risk of health service utilization [6–8] and institutionalization [6, 9, 10]. Ultimately, further frailty and disability and an increased risk of premature mortality can result from restricted mobility [1, 11].

Methods of assessing mobility limitations vary [1]. In assessment of mobility, it is important to distinguish between capacity to function—what an individual *could* do—and enacted function—what an individual *does* do [12]. In this way, assessments of an individual's walking behavior represent an enacted form of mobility while questions that assess an individual's perception of their ability represent functional capacity. Both may be relevant measures of mobility.

Mobility restrictions are not typically the result of a single cause, but arise from an interaction of risk factors in various domains, both individual and environmental [1]. Traditionally, disability research had been based on the medical model in which the focus is on the individual and pathology [13]. More recently, following on the work of Lawton [14, 15], Verbrugge and Jette [16], and the World Health Organization's International Classification of Functioning, Disability, and Health (ICF) [17], disability models have focused on the interaction of the individual with their environment. Lawton stressed the importance of the environment in determining the well-being of older adults where an individual's competence to deal with their environment combines with the stresses, or press, that the environment places on that individual [14]. Thus, Lawton's model adds the possibility that mobility may be enhanced through environmental buoys as compared to the medical model that assumes decline [5]. Both the ICF and Verbrugge stress the importance and bidirectionality of environmental as well as personal factors on individual health [16, 17]. Environmental characteristics are hypothesized to limit or promote an individual's ability to complete purposeful actions and fulfill role expectations, affecting physical functioning and disability (see Figure 1).

Older adults may be more vulnerable to influence of their residential environment as they tend to travel outside their own neighborhoods less often than do younger adults and children who travel for work and school and tend to have a longer duration of exposure to neighborhood influences than younger individuals [5]. Declining physical and mental health, shrinking social networks, loss of social support, and increased fragility may also reduce the ability of older individuals to cope with environmental demands [5, 19, 20]. Therefore, neighborhood environment likely has a greater impact on the elderly than on those in other age groups and evidence suggests that supportive environments improve quality of life in older adults [21]. Lawton proposed several dimensions of environment that are important for older adults: personal environment (family, friends), suprapersonal environment (i.e., neighborhood racial or age composition), social environment (norms or values related to society or culture), and physical environment (e.g., built environment) [14]. The built environment is defined as the human-made or human-altered space in which individuals live out their daily lives [22] and is the focus of this paper.

Much of the existing research regarding neighborhoods and health has been conducted in younger or middle-aged adults and has focused on aspects of the environment other than the physical or built environment [19, 20, 23]. The built environment's effect on health has been conceptualized into three domains: transportation systems which include street networks and transit systems, land use patterns which includes density and land-use mix, and urban design which includes safety, attractiveness, and site design [18]. Transportation systems are defined as the network of physical infrastructure, such as its street network, transit systems, and trails (e.g., for jogging or biking,). Transportation systems influence how easy it is to travel through a neighborhood and get to places a person wants to go. Land use patterns reflect where and how residential, commercial, and industrial uses are distributed in a neighborhood. Density of land use represents an increased compactness of neighborhoods with easier access to pedestrian destinations. Urban design characteristics—such as number and width of traffic lanes, size and extensiveness of sidewalks, traffic calming devices—influence safety and attractiveness and ultimately decisions about whether or not to walk. Pleasant pedestrian environments that promote feelings of belonging to a neighborhood and trust in ones neighbors can be created through positive urban design [18]. In contrast, evidence of decay, such as vandalism and poorly maintained vacant lots, can reduce mobility by creating feelings of discomfort in one's neighborhood. All three of these domains can potentially impact mobility in the elderly (see Figure 1).

Use of self-reported measures of the environment is common in the existing literature but relies on participant's perception of problems rather than actual presence of barriers. Evidence consistently shows differences between objective and perceived measures of the local environment [19, 24]. The two measurement types are likely capturing different constructs both of which are important in determining mobility of older adults. We focus on objective measures here in an attempt to summarize the direct effects of built environment factors as these can be ideal targets for public policy interventions.

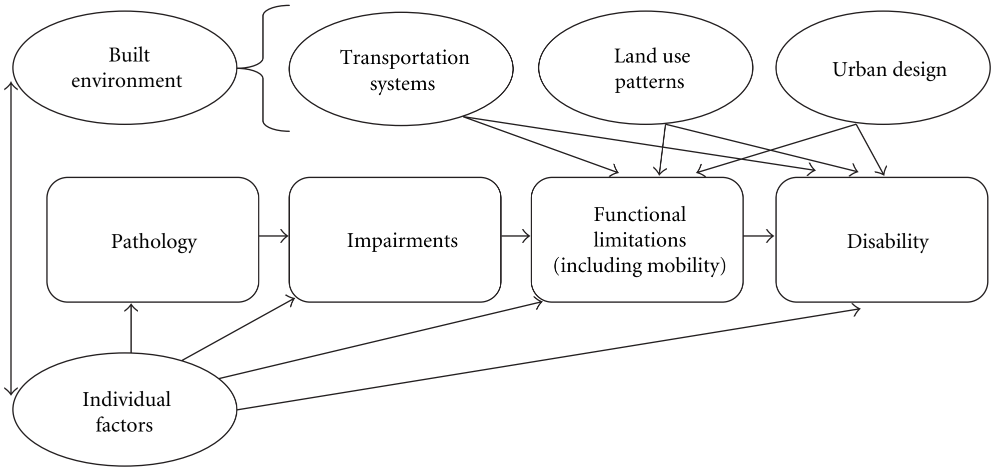
The goal of this paper is to summarize the recent published literature on objective measures of the built environment and mobility or disability in older adults and provide a critical analysis of the limitations.

2. Methods

Searches of Medline and Web of Science were conducted for English-only articles published between 1 January, 1990 and 7 December, 2010 with the following keyword search terms: neighborhood, built environment, or physical environment and elderly, older adults, aging, mobility, disability, walking, or physical function. Additional articles were identified through consultation with experts and review of reference lists of included articles. Inclusion criteria were (1) the study population consisted of community-dwelling adults aged 60 years or older or if no range was provided, the average age was ≥65 years, (2) built environment was objectively measured either through use of administrative datasets or research rater assessments, (3) outcomes included measures of mobility or disability and physical functioning as described in Verbrugge's disablement model [16]. Articles were excluded if they were a review or commentary or if they provided qualitative data only.

3. Results

We reviewed 31,596 abstracts for relevancy to this paper. Of these, 28 articles were reviewed for inclusion criteria, with seventeen articles meeting our criteria. Details of these studies are provided in Table 1. Four studies were longitudinal [25–28]; the remainder assessed cross-sectional associations. One study used nationally representative data from the USA [25] and one was conducted outside the USA [29]. Seven of the studies (41%) were conducted in the Pacific Northwest [28, 30–35]. Enacted function, or walking in some form, was the most commonly assessed outcome, though there was little overlap in the way in which walking was assessed. Walking has been measured as specifically for exercise [35], for utilitarian purposes [30, 36], by frequency of neighborhood walking on a Likert scale [32–34], by whether individuals met physical activity recommendations for walking (>150 hours/week) [27, 29, 37], and by other measures of walking frequency [3, 28, 31]. One study used accelerometers to directly measure the number of steps taken by participants in a day [38]. There were also a wide range of definitions for neighborhood, including specified



Built environment
Transportation systems: street network, transit systems
Land use patterns: density, land-use mix
Urban design: safety, attractiveness, site design
Disablement pathway
Pathology: disease or injury
Impairments: dysfunction in body systems
Functional limitations: restrictions in purposeful actions including mobility and enacted forms of walking
Disability: difficulty performing expected activities and roles
Individual factors: gender, age, health conditions, financial resources, etc.

Figure 1: The role of the built environment in the disablement process (adapted from Verbrugge and Jette, 1994 [16] and Frank et al., 2003 [18]).

distances from an individual's home (i.e., quarter-mile radius), census tracts, and other administratively defined neighborhoods. Subgroup analyses were completed in only 5 studies, including gender [35], lower body functional status [37, 39], age [25], and neighborhood socioeconomic status [28]. Fewer than half of the studies explicitly stated the theoretical framework or causal model that guided their research in the article [26, 28, 30, 34, 37–39]. Effect sizes tended to be small: approximately three-quarters of the statistically significant estimates had relative risks or odds ratios below 2.0 (range was 1.08 to 4.12).

3.1. Transportation Systems. Traffic-related street characteristics have been assessed in relation to mobility, with high-traffic volume positively associated with walking [31]. However, presence of through routes, representing high-traffic volume, was not associated with disability [40]. A high percentage of car commuters, indicating a greater reliance on driving rather than walking for transportation, was positively associated with increased walking difficulty among those aged 75 and older, but not among younger age groups [25]. Living within a specified area of Bogotá, Columbia in which streets are closed to vehicular traffic on Sundays and holidays, creating a pedestrian corridor, was positively associated with walking among older residents [29]. Proximity to walking paths and trails was associated with amount of daily walking [38] but not with frequency of neighborhood walking [32]. Finally, presence of nearby transit stops, providing access to areas outside the immediate neighborhood via public transit, was not associated with walking in two studies [29, 31]. Street connectivity, indicating shorter blocks with more intersections and resulting in easier pedestrian links between two points, have been studied in relation to walking in older adults with mixed results. Nagel and colleagues and Satariano and colleagues found no association [31, 37], Li and colleagues found a positive association [33], and Gomez and colleagues found an unexpected negative association [29]. Differences in study site, neighborhood definitions, and operationalization of walking likely accounted for some differences in results for street connectivity. Neighborhoods were specified differently in the four studies: those studies finding no association, Nagel et al. [31] and Satariano et al. [37], used a specified distance from homes, Li et al. [33] used city-defined neighborhoods, and Gomez et al. [29] used neighborhoods defined by socioeconomic status. Two discordant studies were conducted in the same city (Nagel et al. [31] and Li et al. [33]) and another two discordant studies both assessed walking as meeting physical activity recommendations (Satariano et al. [37] and Gomez et al. [29]).

3.2. Land Use Patterns. Housing density was associated with greater levels of walking [33] and with less disability among those with lower body functional limitations [39]. However, population density was not associated with increased walking difficulty over 15 years [25]. Mix of land use, representing proximity to a variety of destinations such as places of employment and retail establishments, has been assessed in

Table 1: Details of reviewed articles of built environment characteristics and mobility in those aged 60 years and older.

Reference	Sample Size	Location	Age range or mean (SD)	Neighborhood definition (n units)	Built environment measures[a]	Outcomes	Associations[b]: Expected direction	Associations[b]: Unexpected direction	Associations[b]: Null
Beard et al., 2009 [40]	937,857	New York, New York	65+	Census tracts (2,138)	Mixed land use	Disability			X
					Neighborhood decay	Disability			X
					Through routes	Disability			X
					Poor street characteristics	Disability	X		
Berke et al., 2007 [35]	1967	Seattle, Washington	65–97	100, 500, or 1000 meters from homes	Walkability index including residential and commercial density	Walking	X[d]		
Brown et al., 2008 [26]	273	Miami, Florida	Mean = 78.5 (NR)	Participant's block	Front entrance characteristics[c]	Physical functioning after 24 months	X		
Clarke & George, 2005 [39]	4154	North Carolina	Mean = 73.55 (6.72)	Census tracts (95)	Housing density	Disability	X[e]		
					Land use diversity		X[e]		
Clarke et al., 2009 [25]	1821	USA	Results for: 65–74 and 75+	Census tracts (1821)	Population density	Increase in walking difficulty over 15 years			X
					Non-automobile commuters		X[f]		
Fisher et al., 2004 [34]	582	Portland, Oregon	64–94; Mean = 73.99 (6.25)	City defined neighborhoods (56)	Parks	Walking	X		
Frank et al., 2010 [3]	1970	Atlanta, Georgia	65+	1 kilometer from homes	Walkability index including land use mix, residential density and street connectivity	Walking	X		
Gomez et al., 2010 [29]	1886	Bogotá, Columbia	60–98; Mean= 70.7 (7.7)	Researcher defined by SES (50)	Lives in weekend pedestrian-only corridor	Walking	X		
					Transit stops				X
					Parks				X
					Connectivity			X	
Hall & McAuley, 2010 [38]	128	Illinois	Mean = 69.8 (5.89)	1 kilometer from homes	Paths	Walking	X		
					Parks				X

Table 1: Continued.

Reference	Sample Size	Location	Age range or mean (SD)	Neighborhood definition (n units)	Built environment measures[a]	Outcomes	Associations[b] Expected direction	Unexpected direction	Null
					Recreation areas				X
					Exercise/gym facilities				X
					Schools				X
King, 2008 [36]	190	Denver, Colorado	Mean = 74.2 (5.8)	City defined neighborhoods (8)	Sidewalk functionality[c]	Walking			X
					Safety from traffic[c]		X		
					Aesthetics[c]		X		
					Destinations[c]				X
Lee et al., 2009 [27]	4997	USA	Mean=70 (NR)	County (448)	Sprawl	Walking—cross-sectional analysis	X		
						Increase in walking over 5 years			X
Li et al., 2005 [33]	582	Portland, Oregon	Mean = 74 (6.3)	City defined neighborhoods (56)	Residential households	Walking	X		
					Places of employment		X		
					Street intersections		X		
					Green space and recreational facilities		X		
Michael et al., 2006 [32]	105	Portland, Oregon	Mean = 75.1 (6.3)	City defined neighborhoods (10)	Shopping mall	Walking	X		
					Trails				X
					Sidewalk presence[c]				X
					Sidewalk condition[c]				X
					Graffiti/vandalism[c]				X
Michael et al., 2010 [28]	422	Portland, Oregon	Median = 74	1/8, 1/4, and 1/2 mile from homes	Parks	Increase in walking over 3–6 year follow-up	X[g]		
					Trails		X[g]		
					Recreational facilities				X
Nagel et al., 2008 [31]	546	Portland, Oregon	Mean = 74.5 (6.3)	1/4 or 1/2 mile from homes	Automobile traffic volume	Walking		X	
					Sidewalk coverage				X

Table 1: Continued.

Reference	Sample Size	Location	Age range or mean (SD)	Neighborhood definition (n units)	Built environment measures[a]	Outcomes	Associations[b] Expected direction	Unexpected direction	Null
					Intersection frequency				X
					Public transportation access				X
					Retail establishments		X		
					Park/green space				X
Patterson & Chapman, 2004 [30]	133	Portland, Oregon	70–92	Census tract (6)	New Urbanism Index including mix use, connectivity and aesthetics	Walking	X		
Satariano et al., 2010 [37]	884	4 USA locations[h]	65+	Within 400 meters of homes	Common destinations	Walking			X
					Street connectivity				X
					Commercial/mixed use neighborhood			X	

[a] From administrative databases unless otherwise indicated.
[b] From fully adjusted models when multiple results provided.
[c] From rater assessments.
[d] Among those living in same residence for ≥2 years, positive association was found only among women.
[e] Positive association was found only among those with lower body impairments.
[f] Positive association was found only among those aged 75 and older.
[g] Positive association was found only among those in high socioeconomic neighborhoods.
[h] Locations include Alameda County, CA; Allegheny County, PA; Cook County, IL; and Wake and Durham Counties, NC.
NR: not reported.

several studies with inconsistent results. More mixed land use was negatively associated with walking in one study [37], negatively associated with disability among those with lower body limitations in another [25], and unassociated with disability in a third [40].

Proximity to particular destinations has been widely assessed as a promoter of mobility among older adults. Presence of destinations may increase mobility by providing locations for recreational walking or by providing access to needed services such as grocery stores. No associations have been found between walking and presence of recreational facilities [28, 38], gyms [38], or schools [38]. In contrast, shopping malls and overall retail destinations have been associated with walking [31, 32]. More general measures of destinations have been used, including a measure of total places of employment which was positively associated with walking [33] and two separate measures of select destinations, including places such as retail businesses and parks, neither of which was associated with walking [36, 37].

3.3. Urban Design. Front entrance characteristics that promote social interactions, such as presence of a stoop and a shallow housing setback, were positively associated with physical functioning among older adults in a Hispanic neighborhood [26]. Neighborhood decay, represented by presence of graffiti or vandalism, was not associated with disability [40]. Graffiti or vandalism was associated with less walking in one study [36] but not associated in another [32]. Differences in results for the two walking studies cannot be attributed to size of the studies or to assessment of neighborhood as these were similar for both studies. However, the study finding no association evaluated walking as frequency of any neighborhood walking and the one reporting a positive association measured walking for errands only. Neither presence nor condition of sidewalks was associated with walking in several studies [31, 32, 36] but presence of safety measures for pedestrians against traffic was associated with walking [36]. Presence of parks has been positively associated with walking in two studies [33, 34], but no association was found in three others [29, 31, 38]. These inconsistencies may be a result of different localities, differences in neighborhood definitions, or differences in outcomes assessments as these all differed between those with positive findings and those with findings of no association. Michael and colleagues demonstrated a positive association between proximity to parks or paths and increases in walking over a 3–6-year period among men living in neighborhoods classified as having high socioeconomic status but not among those living in low socioeconomic status neighborhoods [28].

3.4. Composite Scores. For some study questions, a theoretical framework was used to guide the development of a built environment summary score. If the items in the summary score are similarly correlated with mobility, it may provide a more robust exposure than a single measure. Urban sprawl represents density of land use with more sprawling areas often having poorer accessibility and greater reliance on automobiles for transportation. Urban sprawl measured by census data was negatively associated with walking in cross-sectional analysis, but no association was found between movement to an area classified as more or less sprawling and change in walking behavior [27]. Neighborhood walkability scores have included land use mix, residential density, street connectivity, park and trail presence, and vehicular traffic information. Frank and colleagues demonstrated a positive association between their walkability score and walking [3], whereas Berke and colleagues found a positive association only among women [35]. Patterson and Chapman developed a scale that combines elements of urban sprawl and walkability and found it was positively associated with walking among older adults in their study [30]. Another study reported negative street characteristics, defined as low density of intersections, few shade trees and few transit stops, were associated with greater disability [40].

4. Conclusions

The evidence provides empirical support for an association between aspects of the built environment and mobility in older adults. This paper suggests that built environment characteristics from three domains (transportation systems, land use patterns, and urban design) can impact both functional limitations and disability in positive and negative directions. However, it is still unclear if these associations represent direct influences on the disablement process. The most promising evidence points to high density of intersections, street and traffic conditions, and proximity to select destinations and green space as the most likely factors to impact mobility, though results have been inconsistent. These inconsistencies are likely due to differences in methodology. There are many differences between studies regarding neighborhood definition, exposure measurements, and outcome assessment.

Theoretical and methodological limitations are present in much of the existing literature on this topic. A number of papers lacked an explicit theoretical framework to guide determination of which neighborhood factors may impact mobility, at what spatial resolution effects should be assessed, and which individual and neighborhood level factors should be considered as confounders or mediators [19, 23, 41]. A majority of the existing literature is cross-sectional, making causal inferences impossible [19, 20, 22, 24]. It is unknown whether individuals adapt their mobility based on environmental presses and buoys or whether they choose neighborhoods with fewer environmental demands as their potential mobility decreases. However, there is some evidence that an effect of built environment on walking persists even after accounting for selection factors [42].

It is unlikely that built environment characteristics affect all neighborhood residents in the same manner [19, 24]. Assessing subpopulations among older adults may prove important as the socially disadvantaged among them—women, minorities, and those with low income—may be more vulnerable to environmental factors and have a higher propensity to live in disadvantaged neighborhoods [5, 20].

In addition, results should be replicated in different localities as the existing research has been limited in its geographic scope and it is unclear if differences may be due to unique characteristics of a locality. Greater use of nationally representative data may help to confirm results and assess effect modification by location, although these studies may suffer from less detailed measures of the built environment.

Finally, this research field would benefit from use of broader measures of enacted mobility. This paper has identified walking measures as the primary measure of mobility; however, general mobility may be more important than walking, specifically. Use of assistive devices, public transportation, and personal automobiles allow for increased mobility and access to services such as healthcare and healthy foods [1]. General mobility assessments are available, such as the University of Alabama Birmingham Life-Space Assessment [43, 44]. Life-space is defined as the spatial area traveled by an individual in their daily life over a specified period of time. The Life-Space Assessment assesses extent of movement in the past month, how frequently that movement occurred, and whether assistance was used [43]. New technologies are also allowing objective measures of mobility through use of individual global positioning system (GPS) monitors [45]. GPS monitors do not rely on individual recall, allow assessment of individual trips into the community, and can provide information on specific location and speed of movement [45].

The current review is limited in that it addresses only objective measures of the built environment. While objective characteristics are more relevant to policy interventions [19], perceived measures capture important information about an individual's relationship with their environment. Perceived environmental measures can more easily assess quality and access to resources within the built environment that are often not apparent from objective data (e.g., residents underreport neighborhood parks because they are not safe to use). However, perceptions bundle psychosocial and behavioral factors with objective features of the environment [46]. Studies using perceived measures face a number of methodological challenges and bias issues that complicate their interpretation [47]. Perceived and objective measures are known to capture different conceptual aspects of many environmental factors [24]. Only five articles included in this review assessed perceived as well as objective measures, though only two included comparable variables [29, 32, 34, 37, 38]. More research is needed that allows direct comparison of the two types of measures and allows evaluation of independent and combined effects on mobility. An additional limitation was the use of broad search terms resulting in a large number of abstracts. The lack of dual review may have resulted in missed articles, but the use of reference lists as an additional review should have at least partially addressed this.

For this field to advance, research must have a strong theoretical framework, identify associations of the built environment with incident mobility restrictions, assess how changes in the built environment affect mobility, and characterize subpopulations among which these associations are strongest, areas that have not been adequately addressed in previous research. In general, effect sizes of associations between built environment characteristics and functioning in older adults are small to moderate. However, a large percentage of the population is exposed to these conditions, indicating that the potential public health impact of policy interventions could be great [48]. The advantage of population level interventions over those that target only high-risk individuals has been demonstrated [49, 50]. In general, older adults wish to age in place, remaining in their homes rather than moving to potentially more accommodating locations [51]. In order to facilitate aging in place and maintaining quality of life as people age, it is important to understand the role of the built environment on mobility limitations and disability while addressing the limitations of the current body of evidence.

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Review Article

Ensuring Mobility-Supporting Environments for an Aging Population: Critical Actors and Collaborations

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Successful aging takes on an array of attributes, including optimal health and community participation. Research indicates that (1) persons with disabilities, including age-related disabilities, report frequent barriers to community participation, including unsuitable building design (43%), transportation (32%), and sidewalks/curbs (31%), and (2) many seniors report an inability to cross roads safely near their homes. This paper attempts to define mobility-related elements that contribute to optimal health and quality of life, within the context of successful aging. It then examines the impacts of community design on individual mobility, delving into which traditional and nontraditional actors—including architects, urban planners, transportation engineers, occupational therapists, and housing authorities—play critical roles in ensuring that community environments serve as facilitators (rather than barriers) to mobility. As America ages, mobility challenges for seniors will only increase unless both traditional aging specialists and many nontraditional actors make a concerted effort to address the challenges.

1. Introduction

The elderly population in the United States has grown from 3 million in 1900 to 39 million in 2008, with a projected growth to almost 90 million by 2050 [1]. Older age has been associated with increased prevalence of chronic diseases [2] and sensory impairments [3]; changes in cognitive processing time [4]; alterations in balance and stamina [5]; increases in falls, fall-related injuries, and death [5, 6]. Mobility can mitigate some of the negative health consequences of aging and promote social interactions critical to aging successfully; therefore, it is essential to create environments that encourage safe mobility.

Unfortunately, current research indicates that many older Americans live in communities that hinder rather than facilitate safe mobility. Analysis of data from the Centers for Disease Control and Prevention's (CDC's) 2002 National Health Interview Survey indicates that the largest proportion of persons with disabilities, including age related, reported that their most frequent barriers to community participation included unsuitable building design (43%), transportation (32%), and sidewalks/curbs (31%) [7]. Similarly, a recent AARP study found that between 40% and 50% of seniors reported inadequate sidewalks in their neighborhoods and an inability to cross main roads safely near home [8].

Beginning in 2011, 10,000 people will turn 65 every day, and this rate of achieving senior status will continue for 20 years [9]. Moreover, physical activity rates and community engagement level off or decline with increasing age—potentially bringing on declines in health [1]. These patterns could have a significant impact on healthcare and long-term care in the future, since the use of formal and informal health-related services is strongly correlated to increasing age [10]. If we as a society are to respond successfully to these implications, as well as others, we must ensure that the aging population remains healthy, vital, and engaged in their communities as long as possible.

CDC's healthy aging research network (HAN) defines healthy aging as "the development and maintenance of optimal physical, mental and social wellbeing and function in older adults. It is most likely to be achieved when physical environments and communities are safe, and support the adoption and maintenance by individuals of attitudes and behaviors known to promote health and well-being; and by the effective use of health services and community programs to prevent or minimize the impact of acute and chronic disease on function" [11]. These statements indicate that in order to maintain optimal health during aging, an individual must be able safely to take advantage of health-promoting behaviors such as physical activity and social interaction, and the individual must be able to access health-promoting resources such as nutritional food, clinical preventive services, and other medical care. Exercising such behaviors and gaining access to such resources is difficult, if not impossible, if an individual's mobility is seriously impaired.

Avoiding mobility impairment during aging is not necessarily something that an individual can accomplish alone, however. The World Health Organization's International Classification of Functioning, Disability, and Health (ICF) defines disability, including such functional limitations as mobility impairment, as an outcome of interactions between health conditions (diseases, disorders, and injuries); contextual factors—such external environmental factors as architectural characteristics, legal and social structures, and so forth; internal personal factors, including age, coping styles, and other factors that influence how disability is individually experienced [12].

The purpose of this paper is to describe a model of the different levels at which the physical environment can influence mobility and to list some of the key individuals or professions that can be most effective in helping to create livable communities that promote optimal mobility throughout the lifespan.

2. Methodology

We searched the HAN Database of Environmental and Policy Change Resources [13] and the CDC Healthy Community Design Initiative's resource list [14] to identify a framework on which to base our analyses of key social and environmental elements related to mobility and successful aging. We also did so to identify key fields that are crucial in creating supportive environmental changes. Using the previously referenced definitions and the HAN social ecological model of healthy aging, we examined the physical environments within which mobility occurs (or is constrained) at each of the levels beyond the individual—interpersonal, institutional, community, and public policy. We then listed some of the main actors responsible for mobility-impacting decisions at each level and described the responsibilities and potential actions these individuals/groups could assume and take to ensure optimal mobility for older adults.

2.1. The Model. HAN created the social ecological model of healthy aging (see Figure 1) [15] by merging two separate but related models to reflect the interplay of individual- and community-level factors related to successful aging. This model considers the behavioral impact and connections between people and their environments. For this purpose, environments can be natural or manmade. A major principle of this framework is to emphasize that there are multilevel interventions that can influence healthy behaviors.

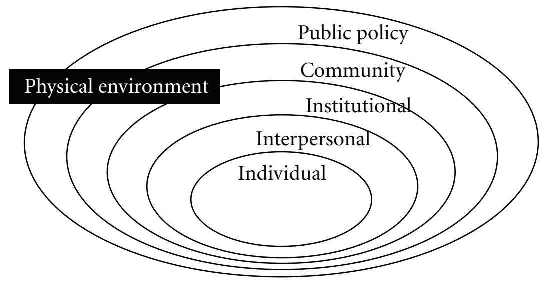

Figure 1: Healthy aging research network social ecological model of healthy aging [15].

For the purposes of this paper, we will focus on the physical environments connected to each level in the model, rather than on such issues as societal norms or behavioral choices. The *individual* is at the core of this model. He/she is surrounded and influenced by multiple relationships and environmental levels. The closest domain to the individual in this model is the *interpersonal* environment. It encompasses personal environments or spaces in which individuals should be able to interact effectively with family, friends, and coworkers in such locations as homes and workplaces. The next level is *institutional*, encompassing an individual's larger neighborhood environment or the spaces in which individuals access needed resources and services, as in grocery stores, neighborhood parks, and healthcare settings. The *community* level includes community-wide or regional environments or systems in which individuals engage in the larger community and gain access to less regularly needed resources and services. And finally, the *public policy* domain includes the policies that affect spaces, environments, or systems at all levels, as exemplified by building codes, zoning and land use regulations, and healthcare system policies [16].

3. Results and Discussion

3.1. Key Professional Fields. Our paper revealed many and varied professional fields that can influence the social ecological environment to promote safe mobility for successful aging (see Table 1).

Several professions play a key role in multiple domains of our model. We, however, will focus on the most engaged professions, the ones that affect the individual most significantly.

3.2. Professional Roles by Model Domain. The professions and organizations in Table 1 currently have initiatives to influence the environment of aging Americans. We reviewed the current initiatives and have organized them by model domain.

Table 1: Social ecological model for healthy aging domains and their most influential key professions or organizations.

Social ecological model for healthy aging: core domain	Key professional fields	Representative organizations
Interpersonal	Architects	American Institute of Architects (http://www.aia.org/)
	Building inspectors	Nat. Academy of Build. Inspect. Engineers (http://www.nabie.org/)
	Home builders	Nat. Association of Home Builders (http://www.nahb.org/)
	Housing authorities	Public Housing Authorities Directors Assoc. (http://www.phada.org/) Nat. Council of State Housing Agencies (http://www.ncsha.org/) Nat. Assoc. of Housing & Redevelop. Officials (http://www.nahro.org/)
	Injury prevention specialists	Safe States Alliance (http://www.safestates.org/)
	Occupational therapists	American Occupational Therapy Assoc. (http://www.aota.org/)
Institutional	Gerontology/aging studies	Gerontological Society of America (http://www.geron.org/)
	Housing and community development planner	American Planning Association (http://www.planning.org/)
	Landscape architects	American Society of Landscape Architects (http://www.asla.org/)
	Law enforcement	International Assoc. of Chiefs of Police (http://www.theiacp.org/)
Community	Aging services specialists	Nat. Association of Area Agencies on Aging (http://www.n4a.org/)
	Healthcare services and facilities administrators	American Hospital Association (http://www.aha.org/)
	Urban and regional planners	American Planning Association (http://www.planning.org/) Assoc. of Metropolitan Planning Organizations (http://www.ampo.org/)
	Public health professionals	Nat. Assoc. of County & City Health Officials (http://www.naccho.org/)
	Parks and recreation specialists	Nat. Recreation and Park Assoc. (http://www.nrpa.org/)
	Transportation/transit planners and engineers	Institute of Transportation Engineers (http://www.ite.org/)
Public Policy	Policymakers and elected officials	Nat. League of Cities (http://www.nlc.org/) U. S. Conference of Mayors (http://www.mayors.org/) Nat. Assoc. of Counties (http://www.naco.org/)

3.2.1. Interpersonal/Microlevel Environments (Interior of Homes, Commercial Facilities, Workplaces, and So Forth)

Architects. The *American Institute of Architects (AIA)* works to ensure that the built environment meets the reasonable needs of people with disabilities. The AIA focuses on the mission of providing those with a disability, including an age-related disability, the means to participate in society to the extent possible through the elimination of physical barriers in a manner that balances the interests of the physically disabled, the public good, and cost effectiveness [17].

To accomplish this work, AIA calls for its members to adopt ten specific principles for livable communities [18], including

(i) designing in such a way as to create compact, pedestrian-friendly communities that allow residents to walk to shops, services, cultural resources, and jobs, thereby reducing traffic congestion and benefiting residents' health;

(ii) providing choices by creating variety in housing, shopping, recreation, transportation, and employment, all to accommodate residents throughout the lifespan;

(iii) creating a variety of transportation options by giving people the option of walking, biking, and using public transit, with the effect of reducing traffic congestion, protecting the environment, and encouraging physical activity.

Architects such as Mace and Maisel et al. have contributed to the pursuit of these goals by creating and implementing such design concepts as *universal design* [19] and *visitability* [20]. Universal design calls for the design of products and environments usable by all people to the greatest extent possible, without the need for adaptation or specialized design. Visitability is the use of design and construction practices to ensure that all new homes, not merely those built for those who have disabilities, offer key features that make the home suitable for visitors with impairments and residents who later develop mobility impairments.

Building Inspectors. The *National Academy of Building Inspection Engineers* encourages its members to adhere to the principles of sustainable development—meeting human needs for food, transportation, and shelter while protecting the environment and its ability to meet the needs of future generations [21]. Members conduct plan review; participate in construction and project design; inspect residential, commercial, and retail buildings. Board-certified building inspection engineers are required to pass a written examination to demonstrate competence in building codes and standards, including compliance with the Americans with Disabilities Act, as well as an ability to ensure the safety and health of building occupants [22].

One specific example of the contribution of building inspectors to improved mobility for older adults is the *Homes for Life* program in Johnson County, Iowa [23], a voluntary home certification program for new home building and renovation. *Homes for Life* assures that homes certified by the program will continue to meet occupant needs and be welcoming abodes for visitors for many years. In order to receive certification, applicants must submit construction drawings, including, for instance, a site plan drawn to scale showing an easily navigable route from parking location(s) to an accessible building entrance.

Home Builders. The *Fair Housing Amendments Act of 1988* (Fair Housing Act) requires new multifamily buildings constructed for first occupancy after March 13, 1991, and consisting of four or more units to be accessible to disabled persons. In response to the *act*, the *National Association of Home Builders (NAHB)* cooperatively developed building code language along with the US Housing and Urban Development (HUD), the International Code Council, and disability advocates. In addition, NAHB policy encourages its members to

(i) actively participate in ongoing education and training efforts to inform builders about accessibility requirements under the Fair Housing Act;

(ii) support adoption of model accessibility building codes endorsed by HUD as providing a safe harbor for complying with the accessibility requirements of the *Fair Housing Act;*

(iii) work with other interested groups, including building product manufacturers, disability advocates, real estate, and multifamily design and construction groups to promote education, outreach, and compliance with the accessibility requirements of the *Fair Housing Act* [24].

Reinforcing these organizational policies, NAHB provides support for its membership by (1) helping to create what are known as local 50+ Housing Councils and (2) maintaining what is known as the Aging-in-Place Specialist certification program. The Certified Aging-in-Place Specialist (CAPS) designation program teaches the technical, business management, and customer service skills essential to home modifications for the aging-in-place—including conducting needs assessment to identify and prioritize the needs, wants, and wishes of the aging-in-place client and recommending specific design solutions [25].

Housing Authorities. Housing authorities vary, and they are managed by both elected and appointed staff. The *Public Housing Authorities Directors Association,* representing a segment of this professional continuum, challenges its members to consider their professional role as an opportunity to serve their communities by providing decent, safe, and sanitary homes and suitable living environments for all citizens, regardless of race, creed, sex, or age [26].

Another segment of this continuum, represented by the *National Council of State Housing Agencies,* has set itself and its members the goal of protecting, expanding, and increasing the effectiveness of affordable housing programs responsive to the wide range of housing needs—including supportive housing for persons with special needs. Supportive housing achieves the highest level of quality in a number of dimensions, including the following [27].

(i) Physical environment: the design, construction, appearance, physical integrity, and maintenance of the housing units all provide an environment that is attractive, sustainable, functional, appropriate for the surrounding community, and conducive to tenants' stability.

(ii) Access to housing and services: initial and continued access to the housing opportunities and supportive services is not restricted by unnecessary criteria, rules, services requirements, or other barriers.

A final segment of this continuum, represented by the *National Association of Housing and Redevelopment Officials*, has embraced the mission of creating affordable housing and safe, viable communities that enhance the quality of life for all—including meeting the needs of vulnerable populations. The association addresses the living environment of public housing seniors and the disabled by supporting increased resources and by assisting housing authorities in creating state-of-the-art building improvements, including the option of converting housing to assisted living facilities [28].

Injury Prevention Specialists. Injury prevention specialists come from a wide range of professional backgrounds. They include allied health professionals, social workers, therapists, researchers, instructors, and city planners. One professional organization of injury prevention specialists is the *Safe States Alliance (SSA),* which engages in activities that increase awareness of injury and violence throughout the lifespan as a serious public health problem. The Safe States Alliance (formerly known as the State and Territorial Injury Prevention Directors Association, or STIPDA) embraces several core values, including multidisciplinary collaboration to build a safer America through a culture of inclusion, openness, and accessibility [29]. Among the professional fields vital to Safe States Alliance's efforts are health care services, environmental health, community design, traffic safety, and law enforcement.

SSA has found growing evidence that collaborating with transportation agencies is important, for a strong link exists between transportation policies and the health of communities [30]. In fact, SSA purports that Americans expect their community design to support active transportation, access to public transit and commercial centers, and aging in place. SSA supports such efforts as engineering design changes to roadways, adaptations of vehicles for accessibility, and the provision of alternative transportation options. The organization suggests that communities adopt "Complete Streets" policies [30] to

(i) make streets inclusive and safer for pedestrians and bicyclists;

(ii) require health impact assessments during transportation and land-use planning processes;

(iii) develop transportation and land-use practices that encourage mixed-use communities;

(iv) provide training to community design practitioners to promote land use and infrastructure development that promotes safe mobility throughout the lifespan.

Occupational Therapists. Occupational therapists often play a vital role in helping people develop, maintain, or regain independence through support, training, and resources throughout the lifespan. The main professional organization for occupational therapists is the *American Occupational Therapy Association (AOTA).* AOTA believes that community mobility in the United States throughout the lifespan is critical for independence, spontaneity, and personal identity. According to AOTA's practice framework, the concept of community mobility includes moving around in the community and using public or private transportation, including driving, or accessing buses, taxi cabs, or other public transportation systems [31].

AOTA members employ a number of tools to support safe mobility for older people. For example, many seniors have a goal of "driving safer longer," and therefore occupational therapists offer education programming, evaluations, and safe driving strategies for those who can still drive safely, while it offers other resources to those for whom safe driving is no longer possible. Additionally, AOTA offers programs to help caregivers provide transportation options for those with special needs, as in the case of people with dementia, and it can provide instruction in wheelchair mobility, accessibility, and environmental modifications when such instruction is necessary.

3.2.2. Institutional/Intermediate-Level Environments (Exterior Neighborhood Areas)

Gerontology/Aging Studies. The main professional organization of gerontologists is the *Gerontological Society of America (GSA)*, a multidisciplinary organization [32] that includes medical professionals (physicians, nurses, dentists, pharmacists, and nutritionists), educators, researchers, practitioners, and policymakers. GSA works to foster collaboration among biologists, health professionals, policymakers, and behavioral and social scientists, believing that the intersection of research from diverse areas is the best way to achieve the greatest impact and promote healthy aging.

GSA has created a special interest group focused on physical environments and aging [33]. This group enables the society to promote multidisciplinary research on the relationship between the design of physical environments and successful aging. Additionally, a special interest group formed by GSA focuses on the topic of transportation and aging [33], and one section of the society deals with social research, policy, and practice to enhance collaboration in delivering community-based services, including transportation, nutrition, and housing [34].

Housing and Community Development Planners. For a majority of Americans, housing costs (along with transportation) exceed 50% of household expenses. The *American Planning Association (APA),* representing many housing and community development planners, challenges its members to create new models of housing that increase mobility through an emphasis on livability, choice, and access to economic opportunity [35]. The association recognizes that zoning, land-use law, and building codes can all create barriers that make community-based housing for the elderly more difficult to obtain.

Considering alternatives in housing and community development planning can facilitate or even encourage aging-in-place. These alternatives include zoning for accessible dwelling units, creating elder cottage ordinances, and employing various shared living strategies. In some communities, whole developments have been created to tap into such existing entities as universities (called ULRCs or university-linked retirement communities). Another option is to plan for continuing care retirement communities (CCRCs), which provide a range of services and support for community members as they age [36]. CCRC developments, such as John Knox Village in Florida, often include free-standing single-family houses, high-rise condo buildings, and medical facilities with skilled nursing care, so that residents can remain in a community with family and friends as they age and still have access to whatever level of social or medical support they need [37].

Landscape Architects. The vision of the *American Society of Landscape Architects (ASLA)* is of a world in which the built and natural environments coexist in harmony and sustainable balance, where all peoples can express their diverse heritage and their individual desire to grow and thrive [38]. ASLA believes that

(i) communities are more livable when they strive for social equity and provide places for positive social interaction [39];

(ii) all people should have equal and appropriate physical access to their surroundings through the principles of Universal Design [40];

(iii) design, construction, and management of streets and highways should preferably enhance interconnected transportation options, particularly for pedestrians, bicyclists, transit riders, and people with disabilities [41].

ASLA encourages mixed-use land use that incorporates housing to offer residents the ability to live, learn, work, shop, and play in a healthy, affordable, and walkable setting. ASLA also encourages the development of communities designed to be cohesive and multimodal, with well-connected, universally accessible transportation systems that provide attractive, safe, comfortable, and cost-effective access to convenient mobility options [41].

Law Enforcement. Law enforcement officials play a key role in ensuring safe and independent mobility for aging Americans. The perception of safety is extremely important to encouraging community mobility. For example, people are less likely to walk and bike in areas where they feel the traffic is too heavy or fast, where roads are too wide to cross safely [42], or where the risk of crime is too great [43].

A professional organization for local police chiefs that has begun to address the issue of neighborhood safety for older people is the *International Association of Chiefs of Police (IACP)*. IACP has recognized the growing elderly population, the unique protection challenges such a population may bring to law enforcement, and the fear of crime and victimization experienced by many older people. In response, IACP has resolved to encourage and promote cooperative, coordinated, and multidisciplinary approaches to address criminal victimization of the elderly [44].

3.2.3. Community/Macrolevel Environments (Exterior Community-Wide or Regional Areas)

Aging Services Specialists. Most communities in the United States have resources and services specifically tailored to the needs of their aging population as a means of supporting successful aging. These services are usually specific to a particular need, such as nutrition (nutrition centers, meals on wheels), resource dissemination (local commissions on aging), or transportation (dial-a-ride).

An association that helps link organizations for older people is the *National Association of Area Agencies on Aging (n4a)*. The n4a recognizes that providing services to seniors must be considered broadly to include multiple sectors and disciplines, including the built environment. Therefore, n4a promotes the concept of livable communities, in which people can live safe, healthy lives throughout the lifespan. The organization believes that public policy must support housing opportunities, transportation systems, and land-use regulations that support active lifestyles, provide access to healthy foods, and encourage social participation as community members age [45]. The organization recommends that communities consider improvements to roadway design, including large-print road signs, dedicated left turn lanes, and extended walk times at pedestrian crosswalks to accommodate older drivers and pedestrians [46].

Healthcare Services and Facilities Administration. Access to healthcare and healthcare facilities is imperative for successful aging. Often, the phrase *healthcare accessibility* refers only to financial accessibility, but there is a growing body of research indicating that physical access to healthcare services and facilities is also a concern for older Americans. Healthcare services and facilities cannot be physically accessible if buildings are poorly designed so as to make movement in and around them difficult or if equipment is inaccessible, as in the case of equipment or examination tables that do not adjust for people who use wheelchairs [47, 48].

The *American Hospital Association (AHA)* represents hospitals, allied health networks, their patients, and their communities. AHA has a model aging-in-place initiative [49] that has been adopted by several hospitals in the United States. This initiative strives to keep seniors independent longer by helping them manage their chronic conditions and care while remaining in their homes, rather than in long-term care. According to AHA, this initiative has resulted in improved blood pressure, diet, exercise, and medication compliance for participating community members and has instilled a sense of community support and trust within the community.

Urban and Regional Planners. As previously stated, for a majority of Americans, transportation costs and housing combine to exceed 50% of household expenses. The *American Planning Association (APA)* challenges its members to create new models of transportation and metropolitan planning to increase mobility through an emphasis on livability, choice, and access to economic opportunity. APA states that US transportation networks must serve all users equitably [35].

According to APA, holistic strategies for community transportation planning can make significant contributions to lowering health care costs and increasing economic output. Increasingly, however, there is a need to think of access in terms of good transit service to connect regions, downtowns, major activity centers, and the people who will work there. Providing direct, safe, and comfortable pedestrian and bicycle facilities can help people of all ages and abilities acquire the knowledge and income they need to be productive members of society [35].

Another organization, the *Association of Metropolitan Planning Organizations (AMPO),* serves the needs and interests of metropolitan planning organizations (MPOs) nationwide. As a condition for spending federal highway or transit funds in urbanized areas, federal highway and transit statutes require the designation of MPOs, which have responsibility for planning, programming, and coordination of federal highway and transit investments [50].

One example of how planners on a regional level can pursue these mobility-related goals is the Lifelong Communities project in Atlanta, which involves collaboration between the Atlanta MPO, the Atlanta Regional Commission (ARC), and Atlanta's Area Agency on Aging. The Lifelong Communities project focuses on achieving three major goals: promoting housing and transportation options, encouraging healthy lifestyles, and expanding information and access to services. This collaboration has resulted in the creation of ARC Guidelines for Promoting Housing Options for Older Adults through Zoning and in improvements to the Atlanta Region's Coordinated Human Services Transportation Plan [51].

Public Health Professionals. The *National Association of County and City Health Officials (NACCHO),* representing local health departments (LHDs) across the country, affirms the fundamental role of LHDs in identifying and responding to health inequities. NACCHO addresses the social determinants of health and the barriers to full participation in society. NACCHO supports a holistic approach in public health and disabilities, an approach that considers not only medical health, but also physical, social, emotional, and spiritual health. The organization regards full and meaningful participation in society as an essential ingredient of health. NACCHO advocates for increased research on best practices to create healthy environments, increased societal participation, and improved health and functional status of individuals living with disabilities [52].

A concrete example of public health system actions to address mobility issues in aging is the Maryland Access Point (MAP) of Worcester County, which targets elderly residents and disabled citizens age 18 or over. MAP addresses the need for elderly, vulnerable, and disabled adults to receive consolidated quality care that is efficient and effective in supporting full quality of life. To simplify access to and increased use of appropriate services, three agencies (Worcester County Health Department, Department of Social Services, and Commission on Aging) colocate service delivery efforts at a single site to increase accessibility of services for aging adults in Worcester County. This program is fairly unique in the range of services it provides (including nursing assessment, social support, information and referral, and behavioral health assessment and counseling) and in the colocating of three agencies [53] to provide a range of services.

Parks and Recreation Professionals. Community parks and recreational facilities have long been used throughout the lifespan as social gathering places, as areas where people relax and play, and as locations where people can interact with nature and green space. Parks and recreational facility accessibility in older age can have important public health benefits. These health benefits include increased physical activity that results in reduced rates of heart disease, hypertension, and diabetes; improved psychological well-being, such as reduced symptoms of depression and anxiety; increased quality of life from social interactions and access to open space and nature [54].

The *National Recreation and Park Association (NRPA)* is a nonprofit organization dedicated to the advancement of public parks and recreation opportunities. NRPA has demonstrated its commitment to inclusion of older people by partnering with AARP to organize the AARP/NRPA Walking Program. This is a 10-week free program intended to promote the benefits of walking for people over the age of 50. It also highlights the benefits of parks and recreation in helping people find safe places to walk, and it provides tools and resources for older people as they choose to get active in their communities [55].

Transportation/Transit Planners and Engineers. Transportation planners and engineers play a crucial role in community mobility. They greatly influence the safe and independent mobility of older people by community design decisions these professionals make on a daily basis. Transportation planners and engineers design the systems and physical environments by which people move around in their communities.

The *Institute of Transportation Engineers (ITE)* is a professional organization that has a Safety Action Plan. The plan states that the purpose of the organization is to enable transportation engineers, planners, and other professionals with knowledge and competence in transportation and traffic engineering to contribute individually and collectively toward meeting human needs for mobility and safety [56]. ITE recognizes that more people are living longer and that therefore it is important to provide resources, information, and road design consideration for older drivers and pedestrians to reduce the risk of motor vehicle injuries and fatalities.

ITE specifically strives to take the following actions [56]:

(i) identify and promote methods to enhance the driving environment for older road users, including providing traffic control devices, highway geometric features, and illumination;

(ii) promote the Federal Highway Administration (FHWA) Older Driver Handbook and Workshop;

(iii) promote the application of FHWA's Older Driver Handbook in the design, operation, construction, and maintenance of road facilities.

3.2.4. Public Policy That Affects All Spatial Levels

Policymakers and Elected Officials. The *National League of Cities (NLC)* regards public transportation as an essential public service that provides mobility for all people, including the disabled, elderly, and economically disadvantaged, in all places. To the NLC, public transportation does not exist solely for those who can afford to pay for the service. While recognizing that human resources policy relates to all citizens, NLC supports giving special emphasis and priority to social service funds for the problems of the nation's most vulnerable, including the physically challenged and the elderly. NLC believes that such economic assistance can help people attain their highest level of independent living [57].

Similarly, the *U. S. Conference of Mayors (USCM)* strongly supports the formulation of a national elderly housing strategy that allows elderly residents to age in place in all forms of subsidized housing. Furthermore, USCM encourages support for programs that bring together shelter, supportive services, healthcare, and social services to help elderly residents remain independent [58].

Finally, the *National Association of Counties (NAC)* supports a continuum of care for the elderly. The care includes supportive services to assist older persons in remaining active, productive, and independent. These services include appropriate transportation options (including public transit), housing alternatives, and in-home support services [59].

4. Conclusions

The aging population in coming years demands that professionals from multiple sectors change their methods of practice to meet the needs of a growing number of seniors. An expanding body of literature highlights the need for a multidisciplinary approach in the planning and service delivery to support successful aging, including safe and independent mobility. Optimal mobility translates into healthy, active lives in which older adults are supported and encouraged to engage in social participation. It is this multidisciplinary approach that will bring a more complete and cohesive practice of mobility-supporting community design.

We have identified several professional fields that play a key role in creating mobility-supporting environments for the aging population. It is essential that these professionals pursue and value collaborations with other key players. Professionals interested in such collaborations have many tools and models available for creating environments that support successful aging. One such tool is the Prevention Institute's Spectrum of Prevention [60]. The Spectrum of Prevention is a systematic tool that identifies multiple levels of intervention and helps professionals develop collaborative relationships and strategies to effect change. It has been used nationally in prevention initiatives targeting traffic safety, violence prevention, injury prevention, nutrition, and fitness. A related tool often used with the Spectrum of Prevention is the Collaboration Multiplier, in which collaborative groups "add" to each other's information pool, "average" definitions by agreeing to a common language, "multiply" capacity through training, and "divide" up responsibility for the overall work [61]. This *collaboration math* typically plays out as dialogue among groups about how they, collectively, can make best use of their diverse backgrounds and resources. The benefits of collaboration grow exponentially as more professionals are added and more projects explored.

The Institute of Medicine (IOM) points out that the "public [health] sector at the community level encompasses local government officials and agencies traditionally seen as having health-related responsibilities, as well as many others that have important but sometimes less obvious roles in health but whose policies and objectives may have potential health consequences…includ[ing] city councils, public schools, colleges and universities, police and fire departments, zoning boards, housing authorities, parks and recreation agencies" [62]. By teaming with other disciplines and fields, groups can use their time and effort to achieve maximum results in creating mobility-supporting communities. For example, when public health, transportation engineering, optometry, community planners, and law enforcement work together, traffic safety can be maximized by

(i) identifying at-risk individuals (public health);

(ii) making roads and sidewalks safer (transportation engineering);

(iii) providing guidance on traffic sign/signal visibility (optometry);

(iv) creating infrastructure that minimizes encounters between pedestrians and motor vehicles (community planning);

(v) enforcing speed limits (law enforcement).

The result is a safer, more supportive mobility environment.

As the implications of these evolving concepts have become clear, a consensus has developed that the responsibilities for health promotion are not just those of the traditional health sector; rather, the responsibilities rest in the hands of many nontraditional actors as well. It is this dynamic that, in part, motivated the IOM to define public health as "what we, as a society, *do collectively* [emphasis added] to assure the conditions in which people can be healthy" [62]. This aspirational definition places the responsibility for health promotion not only on the individual but also on society as a whole.

Disclaimer

The findings and conclusions in this paper are those of the author(s) and do not necessarily represent the views of the Centers for Disease Control and Prevention.

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Case Report

Federally Qualified Health Centers Minimize the Impact of Loss of Frequency and Independence of Movement in Older Adult Patients through Access to Transportation Services

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Loss of mobility in older adults (65 and older) is associated with falling, loss of independence, and mortality. This paper, which to the author's knowledge is the first of its kind, summarizes findings of Federally Qualified Health Center (FQHC) case reports and how FQHCs minimize the impacts of mobility loss in older adult patients (who would not receive primary services without these transportation programs) by providing access to primary care services through transportation programs. This paper features the transportation programs of four FQHCs located in both urban and rural United States areas: LifeLong Medical Care (Oakland, CA); Hudson Headwaters Health Network (Queensbury, NY); North End Community Health Center (Boston, MA); Aaron E. Henry Community Health Services Center, Inc. (Clarksdale, MS). This paper is beneficial to primary care providers and public health officials in outlining how transportation may be used to minimize the effects of mobility loss in older adult patients.

1. Introduction

Recent research defines mobility as "where people move or travel, (while) taking into account the frequency of movement and degree of independence during such movement" [1]. Mobility is critical to the physical and mental health, as well as independence, of older adults, 65 and older [2, 3]. Healthy People 2020 recognizes the impact of mobility loss through its inclusion of older adult objectives reducing the proportion of older adults who have moderate to severe functional limitations [4]. Loss of mobility is a predictor of physical disability and is associated with falling, institutionalization, and mortality [5, 6]. A majority (68%) of adults, 50 years of age and over, experience some mobility limitations [7]. This loss of mobility not only affects physical health directly, but also indirectly—older adults experiencing a loss of mobility may be less able to access primary care and other health services [7–9]. Loss of mobility and other forms of impeded access in older adults "can lead to underutilization of primary care and preventive care services, which in turn may result in unnecessary hospitalizations, increased morbidity, and higher costs to the healthcare system than necessary" [10].

As older adults age, they are at greater risk for functional impairments that may hinder their ability to drive to primary care appointments [8, 11]. Poor elderly, who are 50% more likely to experience a loss of mobility, have the added barrier of having more difficulty affording public transportation services in order to get to their primary care providers [7]. Elderly living in rural areas may not have access to public transportation services, or their communities may lack those services altogether [12, 13]. Furthermore, older adults with access to a public transportation system may not possess the physical ability or stamina necessary to endure long bus rides or the mental acuity to follow route directions or learn transfer points [11].

To minimize the impact of mobility loss (i.e., frequency of movement and degree of independence during such movement) in older adults as it relates to access to quality health care, some Federally Qualified Health Centers (FQHCs) have turned to including enhanced transportation services as part of their primary care service delivery to older adult patients [1]. FQHCs are supported by the Health Resources and Services Administration (HRSA).(While the term “FQHC” is a CMS designation, the term is also used to refer to FQHCs that receive a HRSA-supported grant, which is authorized under Section 330 of the Public Health Service Act.) FQHCs provide community-based and patient-directed primary care services, as well as necessary enabling and support services, to medically underserved communities and vulnerable populations regardless of individuals’ ability to pay for care [14]. There are 1,200 FQHCs delivering care through almost 7,500 service delivery sites nationwide [15]. FQHCs currently serve 20 million patients, and through provisions passed as part of the Affordable Care Act (including $11 billion in dedicated funding for FQHC operation and construction), FQHCs stand to double in capacity to serve 40 million patients by 2015 [16, 17].

FQHCs are required to provide high-quality, cost-effective health care to people of all ages residing within their service areas [14]. Currently only 7% of their current patient population nationwide is aged 65 and over [14]. However the number of older adult patients at FQHCs is expected to grow over the next five years as the total number of patients doubles in size from 20 million to 40 million patients [16, 17]. Over one-third of the 1,200 FQHCs nationwide serves a larger older adult patient population relative to that of the national average; some of these FQHCs provide primary care specifically to older adults. Although FQHCs are statutorily required to provide transportation as a “required primary health service” to all patients regardless of their ability to pay, (Public Health Service Act. Section 330(b)(1)(A)(iv)) this paper explores case reports of four FQHC transportation service models that are tailored specifically for older adults affected by mobility loss and that would not have access to primary care without the FQHCs providing transportation services. These services range from free taxi cab rides, to partnerships with local public transportation authorities, to FQHC-owned-and-operated transportation services. By providing these transportation services to their older adult patients, FQHCs minimize effects of mobility loss on their older adults’ abilities to access high-quality primary care [8].

2. Materials and Methods

These case reports investigate the impact of access to primary health care through FQHC-affiliated transportation programs on older adults living with mobility loss in medically underserved areas. The case reports were drawn from in-depth, one-hour interviews with staff of the four featured FQHCs. The first interview consisted of questions surrounding the history of the FQHC and its transportation program; the program’s structure and organization, costs associated with the program and ways in which the program is financed; affiliations and partnerships with local public and private entities; patient satisfaction with the program. If necessary a follow-up interview was conducted in order to clarify or otherwise fill gaps in the information.

The case report participants were self-selected by responding to an e-mail sent out on behalf of the National Association of Community Health Centers (NACHC) to all FQHCs that were members of NACHC at the time and/or members of NACHC’s Health Policy Committee’s Subcommittee on Elderly. This ensured that all the respondents would serve a relatively large percentage of older adult patients as compared to FQHCs nationwide. Four FQHCs responded to the e-mail alert and were also selected for the interview: LifeLong Medical Care (San Francisco, CA); Hudson Headwaters Health Network (Queensbury, NY); North End Community Health Center (Boston, MA); Aaron E. Henry Community Health Services Center, Inc (Clarksdale, MS). The four FQHC participants represent different geographic regions, both in urban and rural communities, and their patients reflect varying racial/ethnic backgrounds and socioeconomic status.

The following case reports are focused on transportation programs owned, operated, or coordinated by an FQHC and utilized primarily by the FQHC’s older adult patients. These four case reports are not intended to be representative of all FQHCs and their transportation programs; instead, they offer insight to policymakers and researchers about the ground-level experience of running an enhanced transportation program for older adult patients at an FQHC. While this report focuses on transportation programs, FQHCs participate in other kinds of social service programs that reduce the effects of mobility loss in seniors that are not detailed in this paper, including enhanced case management, food delivery, home health programs, and senior public housing.

3. Results and Discussion

3.1. Case Report 1: Lifelong Medical Care (Oakland, CA). LifeLong Medical Care has provided a healthcare home for seniors since 1976, when community advocates from the Gray Panthers, a senior citizens’ advocacy organization, founded its first clinic: the Over-60 Health Center in Berkley, CA. In 1996, Over-60 Health Center merged with another clinic borne of citizen activism, Berkeley Primary Care Access Clinic, to become the FQHC now known as LifeLong Medical Care. The FQHC operates out of 6 sites. One of those sites has retained the Over-60 focus, and another focused on adult health is located in East Oakland—a low income, high crime area. LifeLong Medical Care also operates two Adult Day Health Care (ADHC) centers for frail seniors and adults with disabilities in East Oakland and Novato. About 30% of LifeLong Medical Care’s patients are of age 55 and over; about 21% of the patients are of age 65 and over.

When LifeLong founded its ADHC center in Oakland in 2004, it provided transportation to and from the ADHC center by purchasing vouchers from East Bay Paratransit, a public transit service for people unable to use regular city buses due to a disability or a disabling health condition, such as poststroke complications or memory loss. Paratransit provides door-to-door service by specially trained drivers using sedans and wheelchair-accessible vans. However, the service has several significant limitations: there is an application process to qualify, so rides are not available to new clients immediately; rides must be scheduled in advance, precluding last-minute trips; rides are typically shared by several people (with multiple pick-up locations and destinations), so even traveling short distances can take a long time; strict rules regarding "no shows" can cause particularly frail, disorganized, or otherwise compromised clients to lose access to the service. For these reasons, LifeLong Medical Care also contracted with a private taxi company to bring ADHC participants to and from the center.

In addition to transportation services for ADHC participants, LifeLong Medical Care also provides limited transportation assistance in the form of taxi vouchers to primary care patients who otherwise would not be able to make their medical appointments. The vouchers are available upon request for those who cannot arrange their own transportation to appointments at one of the FQHC sites or who need to visit the emergency room. LifeLong Medical Care also contracts with a community-based social services organization to provide rides for its elderly and disabled patients. Older adults, including those who are experiencing mobility loss, are more likely to utilize high-cost ambulance services [18, 19]. By offering vouchers to older adult patients for emergency room visits, LifeLong Medical Care is able to control costs to the local health delivery system.

3.2. Case Report 2: Hudson Headwaters Health Network (Queensbury, NY). Hudson Headwaters Health Network is a system of 13 FQHC sites in the frontier Adirondack, Lake George, and Glens Falls areas of upstate New York. Founded by a physician in 1974, Hudson Headwaters serves about 60,000 patients each year; over 20% of those patients are low-income older adults at least 65 years of age. As it relates to median age, the Adirondack area is one of the oldest in the United States; by 2020, only the west coast of Florida will exceed the Adirondack area as the oldest region in America [20]. It is also one of the most isolated, characterized by natural geographic boundaries formed by the Adirondack Mountains.

For the thousands of older adults living in the rural Adirondack, accessing primary care requires serious effort. Rugged terrain and long distances are common obstacles, especially for older adults with physical mobility limitations. Therefore in 2002, Hudson Headwaters began providing transportation services free of charge, to its low-income, older adult patients. The program consists of a wheelchair-accessible bus that Hudson Headwaters uses to bring older adult patients to and from their medical and dental appointments at the FQHC's sites. The bus also transports patients to the hospital and to subspecialty services in upstate New York and neighboring Vermont.

The "Bus Program" at Hudson Headwaters is a demand service and does not operate a daily schedule like a public transportation system. Patients call the Bus Program in advance of their need for a ride, and designated staff schedules the rides and dispatches the bus. There is no cost for patients 60 and over to ride the bus. To fund the program, Hudson Headwaters collaborates with Adirondack Rural Health Network, which is a community partnership of public, private, and nonprofit entities in upstate New York that funds rural providers to improve access to care. Hudson Headwaters also collaborates with Inter-Lakes Health, another healthcare provider, to provide older adults with access to the Bus Program. Hudson Headwaters also receives funding from HRSA and private donations to operate the Bus Program, which currently has an annual budget of $47,000.

Although Hudson Headwaters has not completed a formal satisfaction survey of its program, the FQHC believes the numbers speak for themselves. Since 2002, the Bus Program has offered rides to 5,200 patients 60 years of age and over; approximately 2,000 rides have been given to patients that utilize wheelchairs. Since 2002, the bus has travelled 160,456 miles to take patients to and from their health care appointments, with an average round trip of 44 miles. Hudson Headwaters occasionally receives small, private donations from current and former riders who would not have access to primary care without the Bus Program.

3.3. Case Report 3: North End Community Health Center (Boston, MA). North End Community Health Center was founded 40 years ago with a focus on providing outpatient medical care to adults. Over the past 20 years the FQHC has added dental and behavioral services, as well as optometry, ophthalmology, podiatry, neurology, and obstetrics/gynecology to patients of all ages. North End also operates a pediatric department and provides child day care. Even with its expanded services, North End, still retains a focus on older adult patients. Over 20% of its patients are 65 years of age and older, and seniors comprise 40% of the FQHC's total patient visits. North End also operates an Adult Day Health Care (ADHC) center and provides primary care services to older adult residents of senior public housing.

The North End transportation program was initially developed as part of the ADHC center (transportation is a required service under Medicaid regulations for ADHC) [21]. The ADHC center serves older adults in four urban Boston neighborhoods: East Boston, Charleston, South End and North End (for which the FQHC is named). The transportation program started with one van servicing the four neighborhoods and only taking ADHC patients to and from the center. The transportation program has since expanded to include all older adults who are patients of North End Community Health Center, not only those who utilize ADHC. North End currently has three vans and two drivers, which take patients to and from primary care appointments at the FQHC and the ADHC center, to the hospital, and even to run errands. About 98% of the patients who utilize the transportation program are older adults.

In an urban area like Boston, public transportation is readily available. However, older adults experiencing mobility loss may not possess the stamina necessary to map out a route on public transit, walk to and from bus stops, stand for long periods of time waiting for connections, and so forth. Because public transit operates on a schedule, direct routes both to and from locations is uncommon and increases total travel time. In addition, public transportation options for those with disabilities and other mobility losses are difficult to access. These are a few of the reasons why North

End opted to not only expand its transportation program to all older adult patients in the area, but also operate the transportation program as an "on-demand" service. North End's vans respond to requests made at least 24 hours in advance (with same-day requests acknowledged if the schedule is permitting) and transport older adult patients door to door. Because the neighborhood of North End is so small, many patients end up needing to go to the same places. For more common destinations, North End Community Health Center does coordinate scheduled rides. For example, North End Community Health Center worked with Massachusetts General Hospital to provide three scheduled trips to the hospital each day through the hospital's shuttle service. North End's van also makes one morning trip to Massachusetts General Hospital each day; the van stops at all the FQHC's senior housing sites and takes older adult patients to their hospital visits. The FQHC also provides one weekly trip to the local grocery store and scheduled service from the FQHC to the ADHC center.

Funding for the transportation program comes from North End's budget and also from patient revenues; North End does charge its patients a nominal fee to ride the vans, but will still provide the service even if the patient is unable to pay. North End does not require payment at time of service; the patients are billed, and if they are unable to pay, North End does not refuse them the transportation services. Generally the fee to ride the bus to a health care appointment at the FQHC is $7 round trip. To get to Massachusetts General Hospital or another health care provider, the fee is $15. Social workers and case managers work with North End to coordinate the rides to the ADHC center on behalf of patients who may live outside of North End's immediate service area; Medicaid reimburses North End for rides to the ADHC center.

North End's transportation program has many consistent riders. According to North End, older adult patients feel safe and comfortable on the vans, which is in contrast to how they feel when utilizing other public transportation. The patients know the drivers by first name, and the drivers maintain good relationships both with the patients and with their family member and caregivers. This comfort level has been especially important for frail elders.

3.4. Case Report 4: Aaron E. Henry Community Health Services Center, Inc. (Clarksdale, MS). Aaron E. Henry Community Health Services Center provides primary care services to 7 rural counties stretching from southeast Mississippi to the base of Tennessee. About 15% of Aaron E. Henry's patients are over 65 years of age. The FQHC began its transportation program in 1989 as an effort to provide older adult patients living in very rural Mississippi with access to subspecialty care. These patients would often need to travel 20 miles or more to receive more specialized care than was available at the FQHC. Before the transportation program started, older adult patients would secure rides from neighbors in order to make it to their specialty appointments—neighbors would charge between $15 and $30 for these rural seniors to make the trip.

When Aaron E. Henry became aware of their older adult patients' inabilities to pay their neighbors for rides, the FQHC applied for a grant from the Health Resources and Services Administration (HRSA) to purchase two 15-passenger vans to transport older adult patients to and from their specialty appointments. Soon the FQHC was permitting patients of other primary care providers in the area to access the vans. In 1993, Aaron E. Henry received a grant from the Mississippi Department of Transportation (MDOT) to expand the FQHC's transportation services and assist with costs; many of the riders were low-income individuals and could not afford to pay what it costs to ride the vans. However the MDOT grant came with the following condition: rides would need to be opened up to the general public.

Aaron E. Henry seized the opportunity to provide transportation services not only to its own older adult primary care patients with the need to access specialty care providers, but also to nonpatient members of its large, rural service area who needed transportation to and from work, shopping centers, and even schools. Although some riders are not primary care patients at Aaron E. Henry, the FQHC chooses to provide rides to whoever may need one, regardless of that person's ability to pay. However, almost all of the riders are able to pay the full cost of a local trip, which is between $2 and $5. Trips to Memphis (Tennessee) are more expensive—about $25 round trip—and occur less often.

Now known as the Delta Area Rural Transit System (DARTS), the transportation program at Aaron E. Henry serves individuals of all ages and mobility levels. The FQHC is the largest transportation provider in the area with 28 multipassenger vehicles booking over 99,000 one-way trips in 2009; over 58% of those trips were for low-mobility riders. DARTS currently operates an annual budget of $1.5 million and recently received funding through the American Reinvestment and Recovery Act of 2009 (ARRA, also known as the "Stimulus") to cover the costs of purchasing and operating new vehicles.

4. Conclusions

This paper explored transportation programs in four FQHCs that are reducing the effects of mobility loss in their older adult populations and summarized results of these case reports. It is the author's understanding, after a review of the literature, that this report is also the first of its kind. This paper concludes that by providing elderly patients access to primary care services, these FQHCs are increasing their patients' access to affordable primary care services, increasing their patients' independence and affording their older adult patients' the opportunity to remain in the community rather than be institutionalized. Only 7% of the 20 million patients FQHCs currently serve are over the age of 65. However as the population ages and FQHCs double their current capacity to serve 40 million patients by 2015, the number of older adults receiving primary care services at FQHCs will increase, and there will be a greater need for strategies to increase primary care access for older adults through transportation programs.

These case reports are also examples of how FQHCs continue to be responsive to the specific needs of their communities while potentially bending the cost curve in primary care service delivery. Other studies have found that by providing access to primary care services to their older adult patients, FQHCs reduce the need for unnecessary hospitalizations and emergency department utilization in this population, which greatly decreases costs to the health care system [22–24].

A limitation to this report is that these four FQHCs are not representative of FQHCs nationwide. While all FQHCs are required by law to provide transportation to the patients within their service areas, the FQHCs featured in this report provide transportation services both to their own patients and to patients of other providers. These FQHCs have also tailored their transportation programs to meet the specific needs of older adults experiencing mobility loss, which is not reflective of FQHCs nationwide. However, these case reports shed new light on how FQHCs with transportation programs can reduce the effects of mobility loss in older adults by providing access to primary care services. Also the case reports featured in this paper are only examples of how FQHCs are able to use their resources and build collaborations with external partners in an effort to reduce the effects of mobility loss in the older adults that utilize their services; FQHCs interested in establishing their own enhanced transportation programs, whether by replicating the case reports featured in this paper or by developing their own innovative models, should obtain legal advice and other expert assistance prior to establishing and implementing their own programs.

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