

Mobility and Aging: New Directions for Public Health Action

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Optimal mobility, defined as relative ease and freedom of movement in all of its forms, is central to healthy aging. Mobility is a significant consideration for research, practice, and policy in aging and public health. We examined the public health burdens of mobility disability, with a particular focus on leading public health interventions to enhance walking and driving, and the challenges and opportunities for public health action. We propose an integrated mobility agenda, which draws on the lived experience of older adults. New strategies for research, practice, and policy are needed to move beyond categorical promotion programs in walking and driving to establish a comprehensive program to enhance safe mobility in all its forms. (*Am J Public Health*. 2012; 102:1508–1515. doi:10.2105/AJPH.2011.300631)

A significant challenge for public health is to develop effective and efficient strategies to promote health and well-being in a growing and increasingly diverse aging population. *Healthy aging*, a term that is used to refer to this public health objective, is defined by the Centers for Disease Control and Prevention as the “development and maintenance of optimal physical, mental and social well-being and function in older adults.”^{1(p3)} Healthy aging is

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.^{1(p3)}

Optimal mobility, defined simply as being able to safely and reliably go where you want to go, when you want to go, and how you want to get there, is a key component of healthy aging. Mobility refers to movement in all of its forms, including basic ambulation, transferring from a bed to a chair, walking for leisure and the completion of daily tasks, engaging in activities associated with work and play, exercising, driving a car, and using various forms of public transport.

Just as negative health outcomes are associated with impaired mobility, health and well-being are enhanced through strategies to optimize mobility. As evidence of the growing interest in the health effects of mobility, the

American Public Health Association recently released *Transportation and Health Toolkit*,² and the Environment and Policy Change for Healthy Aging Initiative, sponsored by the Centers for Disease Control and Prevention Healthy Aging Research Network, produced *Optimal Living: Getting Around*.³

Mobility has significance for research, practice, and policy in aging and public health. Walking and driving are the 2 leading forms of mobility among older adults in neighborhood settings.^{4,5} Here we (1) review the public health burdens of mobility disability as well as some of the key epidemiological findings in this area, (2) identify leading public health interventions to enhance walking and driving in older populations, (3) discuss challenges and opportunities for public health action, and (4) recommend new directions for public health action, including the development of an integrated mobility agenda to guide the examination and promotion of safe walking and driving as part of the everyday lives of older adults. Although the study of mobility among institutionalized older adults is also an important area of research, it is beyond the scope of this article.

MOBILITY DISABILITY

It is well established that the prevalence of functional limitations and disability is associated with aging.⁶ For example, 31.7% of adults aged 65 years and older report difficulty in

walking 3 city blocks; only 11.3% of adults aged 45 to 64 years have similar difficulty.⁶ Another study reported that 20% of adults aged 65 years and older do not drive a motor vehicle.⁷ At least 4 public health burdens are associated with limited or restricted mobility in older populations. First, limitations in walking and driving reduce access to goods and services, which leads to poor health outcomes.^{8–10} For example, older adults with walking limitations and difficulties with driving are less likely to be able to travel to grocery stores and supermarkets, resulting in fewer nutritional options, compromised health, and impaired functioning.^{11–13} Older adults with these limitations are also less likely to obtain health services or to obtain them in a timely manner, including preventive services.¹⁴

Second, limited mobility is independently associated with health problems and injuries. Sedentary behavior, such as restricted or limited walking, is implicated in the etiology of obesity, cardiovascular disease, diabetes, colorectal cancer, breast cancer, poor cognitive function, and depression.^{15–18} Cessation of driving is also associated with an increased risk of depression among older adults.^{19,20} Injuries from falls and motor vehicle crashes, an elevated risk for mobility-impaired persons, are leading causes of disability, nursing home placement, and premature death among people aged 65 years and older. Indeed, falls and motor vehicle crashes represent the 2 leading causes of accidental death among older adults.^{21,22}

Third, older adults with mobility difficulties are less likely to have regular social contacts.²³ Social isolation, in turn, is associated with a variety of health conditions, including all-cause mortality.^{24–26} Finally, older adults without access to different forms of mobility are less able to take part in civic life, adversely affecting both themselves and their community.²⁷ Indeed, the World Health Organization Global Plan for Age-Friendly Societies is based on the proposition that older adults represent

a significant resource and is designed to ensure that older adults can contribute to the well-being of society.²⁸

In light of the public health burdens associated with aging and loss of mobility, it is important to understand why some older adults are less mobile than others. An ecological model characterizes the range of interrelated biological, behavioral, social, and environmental factors associated with patterns of health, function, and longevity over the life course.^{29–34} Various forms of this model guide research on disablement³⁵ and illustrate how environmental factors modify the association between aging and well-being.^{36,37} Ecological examinations of mobility tend to focus on 1 form of mobility at a time, such as walking³⁸ or driving.³⁹ By contrast, Webber et al. examined personal, social, and environmental factors that affect a range of different types of mobility.⁴⁰ The relationship between place and complexity of mobility is also addressed in this ecological model.⁴⁰ Impaired mobility is associated with a constricted life space.^{41,42} This comprehensive depiction elucidates the diverse set of factors associated with mobility and helps to distinguish between factors that operate within and across specific forms of mobility.

EPIDEMIOLOGY

Studies of mobility take the form of both general population surveys and examinations of the rehabilitation and recovery of older adults recently diagnosed and treated for specific chronic conditions. These studies clearly associate loss of mobility with age, but they also show that mobility disability can be ameliorated through intervention. Loss of independent mobility can be immediate and catastrophic (e.g., following a severe stroke) or can progressively decline (e.g., resulting from gradual loss of muscle strength and lung function).⁴³ This loss also may be caused, in part, by sedentary behavior resulting from environmental barriers to walking and reduced access to goods and services.⁴⁴ This is a dynamic process, with periods of decline and recovery.

Walking is among the most common forms of physical activity engaged in by older adults, as either a leisure-time pursuit or a part of everyday activities.⁴ Driving a motor vehicle is the most frequent and most preferred form of

mobility reported by older adults for trips outside the home, according to the National Household Transportation Survey.^{5,45} The public health benefits of walking, unlike driving, are clear. Driving can improve access to goods and services as well as friends and relatives, but it also contributes significantly to carbon emissions, air pollution, injuries, and associated health conditions such as asthma and lung cancer. In some cases driving may also replace, partially or totally, walking or public transportation use, underscoring the complexity of aging and mobility.⁴⁶

Demographic and Socioeconomic Status

Limitations and disabilities in walking and driving are associated with increasing age, especially among women.^{47–51} The gender difference may be attributable to a variety of interrelated factors, such as differences in functional capacity, perceptions of safety, and cultural norms regarding walking and driving.

Evidence also shows that older adults of lower socioeconomic status and less formal education are less likely to be mobile. These reductions in mobility may be attributable to limited capacity or limited access.^{52–54} Older adults of lower socioeconomic status have worse health and functional status than their age peers who have higher socioeconomic status. In addition, in low-income neighborhoods, walking is often unsafe and transportation options are more limited.

Chronic Health Conditions

The number and types of chronic health conditions and functional limitations are associated with limitations in both walking and driving.^{55–60} In addition to specific health conditions, such as diabetes, cardiovascular disease, and osteoarthritis, limitations in walking are associated with depression, reduced cognitive function, vision problems, and reduced lower-body function.^{55–60} Older persons without disabilities travel greater distances on foot, complete more errands, and most importantly, are better able to circumvent environmental barriers, such as poor street conditions, than disabled older persons.⁶¹

Not surprisingly, older adults with sensory, cognitive, and physical impairments and limitations are less likely to drive than those of the same age who are in better health.⁵⁶ Sensory

limitations of particular significance are vision loss and poor contrast sensitivity.^{62,63} Cognitive impairments encompass limitations in visual–spatial ability, executive function, attention, and information-processing speed (the latter 2 commonly assessed by the useful field of view test).⁶⁴ Examples of physical impairments are reduced head–neck and trunk flexibility and limited upper- and lower-body speed of movement and strength.⁶⁵ Older adults with health and functional limitations of this kind are also more likely to stop driving completely.⁵⁶

Built Environment

Elements of the built environment affect walking behavior, and land-use patterns are especially important. Older adults who are most likely to walk as part of everyday life are more likely to live in mixed-use neighborhoods (i.e., integrated residences, goods, and services) with high density, comparatively short block lengths, and frequent intersections (grid-like street patterns).^{42,66–70} Walkable neighborhoods are also perceived by older adults as free from crime, heavy traffic, and speeding cars.^{71,72}

The built environment also affects driving behavior. Results from a variety of studies indicate that older adults tend to modify their driving practices by driving on roads and at times with lower traffic volume as they cope with health conditions, functional limitations, and safety concerns.^{73,74} The environment affects both walking and driving, but in different ways. The type of neighborhood environment that encourages walking tends to discourage driving among older adults.⁷⁵ Older residents of high-density, mixed-use areas may have more opportunities to walk and greater familiarity with walkable destinations and, as a result, need not drive. It also may be that walkable neighborhoods cause driving to be more stressful and difficult.

ENHANCING MOBILITY

Consistent with the categorical approach used in the epidemiology of mobility disability, public health interventions tend to focus on 1 form of mobility at a time. Most interventions are designed to enhance either walking or driving, not both. Although the epidemiology

of mobility disability focuses on both individual capacity and environmental factors, interventions are designed to enhance individual capacity. Less attention is given to environmental factors.

A variety of interventions promote walking and other forms of physical activity among older adults.^{76,77} Some programs are individualized, such as Active Choices; others target groups, such as Active Living Every Day.^{78–80} Both approaches are very effective in enhancing levels of walking and physical activity.^{78–80} Although *The Guide to Community Preventive Services* recommends minor environmental changes to promote walking (e.g., construction of and access to walking trails, improvement of street lighting, and installation and repair of sidewalks), few community interventions improve both individual capacity and the environment.^{81,82} Despite the growing body of research on the built environment and walking, it is difficult to manipulate environmental variables as part of a public health intervention. However, one pilot study demonstrated the feasibility of developing and distributing walking maps to identify safe walking routes and encourage walking among older adults.^{83,84}

Interventions to promote safe driving are also designed to enhance individual capacity. For example, current programs focus on issues of vision, cognition, head and neck rotation, and lower-body function. Cataract repair is an example of an intervention to address an underlying condition and its functional consequences, which leads to improvement in driving performance.⁸⁵ Interventions that improve information-processing speed enhance performance not only in driving but also in daily activities.^{86–88} Individuals with impairments in range of motion and speed of movement who underwent a physical conditioning program were more successful than control participants in maintaining driving performance.⁸⁹ Programs designed to improve driving performance through classroom instruction alone have had mixed results.^{90–92} By contrast, programs that combine classroom instruction and on-road training to help the older driver move through the environment more safely are more consistently effective in improving driving performance.⁸⁹

The environment generally figures more prominently in driving than in walking

interventions.^{89,93,94} A summary of roadway design enhancements with the best potential to accommodate age-related changes in the driving public is included in the Federal Highway Administration's *Highway Design Handbook for Older Drivers and Pedestrians*.⁹⁴ Recommendations consist of increases in the size, brightness, and contrast of signage; reduction in the complexity of on-road directions; and increase in space and time to make on-road decisions. To our knowledge, the effectiveness of these modifications to promote and extend safe driving in older populations has not been assessed in community settings.

Technological devices represent another area for intervention. These devices are designed to either enhance individual capacity or moderate the effects of environmental challenges; they include assistive walking devices and the automobile itself.^{95–97} As Dickerson et al. report,

Motor vehicle modifications (after vehicle purchase) show promise of helping older drivers compensate for driving-related functional impairments such as reduced strength, flexibility, and range of motion and vision-related deficits. For example, vehicle modifications may help drivers get in and out of the car, fasten and unfasten their safety belt, and exert control in operating the car.^{96(p582)}

States that allow for restricted licensing for older drivers with particular functional limitations (e.g., driving limited to particular places, times, and circumstances) facilitate extended driving for those individuals.⁹⁸ It is argued that this policy is preferable to a complete prohibition on driving for older adults who develop limitations. This policy of restricted licensing aligns with the general principles of gerontology and geriatrics to extend function for as long as possible.

CHALLENGES AND OPPORTUNITIES

Research on walking and driving reveals considerable promise as well as a range of significant challenges. Public health is a multidisciplinary field, but the traditional scientific disciplines and standard approaches in public health, while necessary, appear insufficient to address the scope of this important area. An ecological approach underscores the range of biological, behavioral, social, and environmental factors that affect mobility. In line with

recommendations for advancing the emerging field of place and health is the effort to establish connections with other fields.^{99,100} Application of the ecological model to mobility necessitates an expansion beyond schools and departments of public health to develop the comprehensive agenda that public health action will require. Collaborations should be developed not only with city and regional planning and architecture departments, but also with transportation science researchers, engineers, and designers of vehicular and passenger transport.

This will be challenging. Opportunities for contact across these fields, whether in academic settings or in city, county, or state governments, are still scarce. In most cases, funding streams in public health, city and regional planning, and transportation are categorical and specific to particular fields, resulting in little incentive or opportunity to develop joint projects.^{101,102} Even within the transportation field, funding authorization is primarily restricted to highways and private automobiles. Less money is provided to build and upgrade sidewalks, walking trails, and bicycle routes or for passenger transport projects, such as fixed bus routes and light rail. In addition, training programs in public health typically do not include research, practice, and policy literature from transportation and other related fields.

Just as research tends to focus on 1 form of mobility at a time, policies are unilateral. For example, policies to advance active transportation focus on walking and public transportation and mention driving only as an activity to be reduced or avoided. On the other hand, policies to promote and extend safe driving do not include due consideration to walking and use of passenger transport.

Despite the significant challenges, some programs show promise for collaborations in research, practice, and policy. For example, the Robert Wood Johnson Foundation Active Living Research program takes a multidisciplinary research and policy approach to stimulate collaboration among researchers and practitioners in public health, architecture, and city and regional planning.¹⁰³ This program has contributed significantly to the growing field of place and health. Although most of its work has focused on walking and physical

activity, the program demonstrates that a strategic vision, coupled with grant support, can stimulate research and practice in the field of place and health. The Healthy Aging Research Network has also stimulated research on the built environment, health, and functioning in older populations. Most recently, “mobility and aging” has been identified as a core topical theme.³

Several joint training programs in public health and city and regional planning have been developed (e.g., programs at Columbia University and the University of California, Berkeley), along with transdisciplinary offerings, such as core courses that attempt to integrate elements of different fields.^{104–106} This is a promising trend: training a new generation of researchers, practitioners, and policymakers able to operate at the intersections of public health, planning, and transportation.

A growing number of local, state, and national initiatives aim to stimulate the development of healthy communities, which positively affect all individuals, including older adults. At the local level, programs have been introduced in communities of varying size. For example, in New York City, PlaNYC is designed to enhance the mobility friendliness and walkability of the city through innovative collaborations among local governmental departments.¹⁰⁷ Hendersonville, North Carolina, a rural community of 12 000 residents, developed Walk Wise, Drive Smart, a collaboration between public health practitioners, urban planners, transportation professionals, developers, architects, and other interested parties, to enhance the safety of older pedestrians.¹⁰⁸ In Alameda County, California, the Department of Public Health and other county agencies are collaborating on Place Matters, a program designed to facilitate place-based planning and administration.¹⁰⁹

The National Complete Streets Coalition aims to establish guidelines to ensure that communities are planned for safe mobility for all residents, regardless of age, ability, or mode of transportation.¹¹⁰ In a special report on complete streets, the American Association of Retired Persons outlines the special needs of older adults.¹¹¹ Also at the national level is the Sustainable Communities Project, a collaboration of the US Environmental Protection

Agency, the Department of Housing and Urban Development, and the Department of Transportation.¹¹² This multiagency collaboration is designed to stimulate innovative strategies to establish healthy and sustainable communities in select locations around the United States. As part of the recent US Recovery Act, several communities received support “to put prevention to work,” including collaboration between public health and transportation agencies.¹¹³ Mobility and Aging, an initiative of the Canadian Institutes of Health Research Institute of Aging, is designed to stimulate research and practice collaborations across agencies and disciplines to foster mobility-related projects.¹¹⁴

NEW DIRECTIONS

Rather than focusing exclusively on 1 form of mobility at a time, we should establish an integrated mobility agenda that is based on the lived experience of older adults. Older adults do more than 1 thing.^{3,115} It is reasonable to assume that most adults walk and drive. Specific patterns of mobility, particular combinations of walking and driving, may have unique implications for health and well-being. As Yang et al. write,

Different transportation modes may also affect each other in complex ways. For example, those who regularly walk long distances to work may not be inclined to walk in their neighborhood. Conversely, it is plausible that traveling by car to work or shopping may leave more free time to walk in the neighborhood.^{116(p3359)}

An integrated agenda should lead to a stronger foundation for more comprehensive research programs and more effective practices and policies to establish a range of mobility options for persons throughout late life. This agenda incorporates examinations of whether different patterns of mobility can be maintained or adapted in the face of decreasing capacity and frailty with aging and whether healthy aging could be a specific part of mobility-related practices and policies. Of course, the inclusion of driving as one of several key components of an integrated plan depends on continuing efforts to design safe, efficient, and affordable vehicles that are powered by alternative sources of fuel that will reduce or eliminate carbon emissions. Research of this kind could help to expand the set

of objectives for promotion of healthy communities, outlined in *Healthy People 2020*, to include a new objective of increasing access to a diversity of mobility options over the life course.¹¹⁷

Research and Surveillance Needs

Establish a longitudinal cohort study of mobility patterns. We need a comprehensive set of key variables (e.g., health, function, and mobility), as well as detailed information on walking and driving, from the same population over time. The National Household Travel Survey, the most comprehensive national report on mobility,⁵ provides valuable information on different types of mobility, such as walking, biking, driving, and passenger transport, but not detailed information on age-related health and function. By contrast, national health surveys, such as the National Health Interview Survey, provide detailed information on health status, function, and walking but not on mobility patterns, such as driving and the use of other forms of passenger transport.¹¹⁸

It is necessary to move beyond disparate studies of walking and driving in different populations. We should consider the feasibility of developing a longitudinal study patterned after the National Institute on Aging’s Established Populations for Epidemiologic Studies of the Elderly.¹¹⁹ Begun in the early 1980s, this longitudinal study collected a comprehensive set of information, including direct measures of physical performance, on samples of older residents from East Boston, Massachusetts, New Haven, Connecticut, and selected counties in Iowa and North Carolina. Just as that study represented the most comprehensive study of the epidemiology of aging for that time, it is necessary to conduct a new study for our time that addresses the biological, behavioral, social, and environmental factors that affect patterns of health and well-being in diverse populations. This study should also include detailed consideration of land-use patterns and policies, which affect residential location, access to goods and services, and different modes of transportation.

Beyond driving and walking, the leading forms of mobility, a comprehensive study must include biking and the use of passenger transport. Older adults should be recruited from a set of representative locations that reflect the

climatic, demographic, socioeconomic, and geographic diversity of the country. Only a few attempts have been made to examine the relationships among health, walking, driving, and other modes of mobility in the same population.¹²⁰ A study could incorporate recent technology, such as geographic information systems and devices with global positioning satellite capabilities, and other new sources of information to examine the effects of natural and built environments in each geographic site on mobility outcomes.¹²¹ Global positioning devices can provide an objective assessment of the timing, distance, and use of different modes of mobility. Not only will this type of study advance research on aging, health, and functioning, it will also provide a necessary foundation for public health action.

Explore the utility of computerized simulations. Simulations could address the complexity of dynamic associations across multiple levels (biological, behavioral, and environmental), affecting multiple outcomes, such as walking, and involving reciprocal associations.^{116,122,123} Simulations can serve as an important complement to field studies and may provide insight into the pathways and workings of complex systems. As Green writes, “The challenging question for public health is which aspects of their practice can be understood best with linear models, which with nonlinear, and which with simulation.”^{123(p408)}

Expand and refine methods in health impact assessment. A promising strategy for clarifying the health effects of different forms of mobility, health impact assessment requires new methods and expanded sources of data to enhance its utility. Collaborations with practitioners and policymakers are critical to developing strategies to assess the health effects of ongoing programs and policy initiatives, such as Complete Streets.¹¹⁰ The existing community-based initiatives to enhance mobility have not yet been evaluated for their efficacy in enhancing safe walking and safe driving among older adults.

Expand surveillance of best practices in mobility and aging. Of particular interest are collaborations among professionals in public health, planning, and transportation. In line with the work of Stokols et al. in the ecology of science and team science,¹²⁴ studies should identify the most effective and efficient local,

county, and state organizations that support collaborations, defined as transdisciplinary action research,¹²⁵ among professionals in public health, planning, and transportation.¹²⁶ This information could be made available online to encourage sharing of information and the establishment of future collaborations among public health professionals at the local, state, tribal, and federal levels. This could be either a complement to or a component of *Transportation and Health Toolkit*.²

Workforce and Training Needs

Expand the curriculum in schools of public health. Training is needed to advance an integrated, transdisciplinary agenda in mobility and aging. In addition to an expanded tool kit in research methods, training should include strategies to better integrate research, practice, and policy. Specific programs should be developed from the undergraduate to the post-doctoral levels. Joint-degree programs in public health, planning, and transportation should be refined and further encouraged.

Establish collaborative professional development programs. Programs should be established in conjunction with local, state, tribal, and federal health departments to expand the reach of public health into the development and refinement of sustainable communities. In addition, an integrated mobility approach could be used to expand current public health resources (e.g., State Legislative and Regulatory Action to Prevent Obesity and Improve Nutrition and Physical Activity¹²⁷). Special attention should be given to how this integrated agenda could help to achieve public health objectives in other areas, such as more effective strategies for the evacuation of older adults as part of emergency preparedness planning.^{128,129} Representatives from organizations such as the American Association of Retired Persons should be encouraged to collaborate in this effort.¹³⁰

Engage senior centers. Community senior centers should play an active role in stimulating integrated mobility. As frontline organizations, senior centers can play an important role in comprehensive mobility programs.^{131,132} These programs could train older adults and their family members in the effective, efficient, and safe use of multiple modes of mobility as part of everyday life. This could also include

coordination with police departments and other community agencies in crime prevention and community policing. Concern about safety is a leading barrier to mobility in older populations.⁷¹ Senior centers could also recruit older persons for special training as senior leaders and advisers to enhance mobility and other healthy aging programs.

Incorporate policy into research and practice strategies. Research and practice strategies should be developed with due consideration to their policy implications. Communication and collaboration with residents and policymakers at the local, state, tribal, and federal levels must continue to advance public health objectives.

CONCLUSIONS

Mobility, especially walking and driving, is central to healthy aging. Reduced functional capacity, stemming, for example, from lower-body impairments, is associated with limitations in both walking and driving. The built environment also affects both types of mobility, but in different ways. New sources of information, such as longitudinal studies and computer simulations, are required to provide the evidence base to develop more effective, integrated public health strategies to enhance mobility in older populations. This will require transdisciplinary approaches, including training and organizational innovations, to develop the public health workforce.

An integrated mobility agenda, based on the lived experience of older adults, can serve as the foundation for future research, practice, and policy. If the objective is to achieve optimal mobility for an aging population, we must develop an integrated agenda to guide the work that objective requires. ■

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