

Understanding the role of technology for meeting the support needs of older adults in the USA with functional limitations

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C.N. Harrington, T.L. Mitzner, W.A. Rogers. *Understanding the role of technology for meeting the support needs of older adults in the USA with functional limitations. Gerontechnology 2015;14(1):21-31; doi:10.4017/gt.2015.14.1.004.00* **Issue** Research shows that for the quickly growing older adult population, sustaining independence in everyday activities is a prevalent challenge, often as a result of functional limitations. Along with pre-existing impairments, physical and sensory age-related changes contribute to older adults experiencing difficulties in functional limitations in performing basic, instrumental, and enhanced activities of daily living. Since many older adults elect to compensate for these challenges through the use of assistive technology, there is a need for technological support solutions that facilitate autonomy and independence among older adults, and relieve the burden of formal and informal caregivers. **Method** In this paper we extract pertinent information from survey data in studies that examined the challenges faced by older adults in the USA and we provide direction for the use of appropriate technological solutions. We explore the associated existing assistive technology solutions as well as the acceptance of these technologies by older adults including major barriers to their usage. **Results** There is very little recent data available to speak to the current needs of older adults with functional limitations. While several technological support solutions exist, there are issues of acceptance and adoption that deem these solutions ineffective, leading to low usage rates. As a result, we discuss the potential of accessible everyday technologies to meet unfulfilled needs. **Conclusion** However, our review highlights the need for more recent data on functional limitations of older adults and provides a call to action for more research to understand older adults' support needs.

Keywords: assistive technology, disability, everyday technologies, support needs

Older adults aged 65 and older represented 11.7% of the world's population in 2013, and should reach 21.1% by 2050¹. In the US, adults over the age of 65 numbered 43.1 million in 2012, which is approximately 13.7% of the U.S. population and projected to be nearly 20% by 2030. Currently, about one in every seven Americans is aged 65 and older, leading to greater demands on Medicare, assistive aid, and caregivers².

The shift in the world characterized by delayed mortality and longer lifespans, leads to a greater number of individuals with deficits in sensory, cognitive, and motor functions³. These deficits can have a negative impact on the overall quality of life for older adults, affecting their ability to function independently.

Although technology has great potential to enhance and improve independent functioning for older adults⁴⁻⁷, there is much left to be understood about the interaction between older adults with functional limitations and the assistive technologies that are intended to compensate

for these limitations. To develop better technological solutions that can aid people in aging successfully, details are needed regarding the range, frequency, nature, and distribution of functional limitations that older adults face.

OVERVIEW OF ARCHIVAL ANALYSIS

To that end, we conducted an archival analysis to determine the needs for technological interventions to support routine activity performance of older adults. It is important to understand the causes of functional limitations and the effects that pre-existing impairments have on older adults' ability to function in the home. In this article we define functional limitations as the challenges experienced during daily activities. We examined the available information regarding functional limitations faced by older adults reported by various USA longitudinal and cross-sectional surveys: the Women's Health and Aging Study⁸; the National Health and Aging Trends Study⁹; the National Long-Term Care Survey¹⁰; and the American Community Survey². We also consulted information provided by institutes

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concerned with aging such as the National Institute on Aging, the Federal Interagency on Age-Related Statistics, and the US Census Bureau. This review was confined to information found in these databases as they dealt with large sample surveys of older adults and examined the nature, frequency, and range of functional limitations associated with everyday activities.

We then framed the various methods that older adults elect to address these activity challenges. From the methods identified, we extracted and organized existing data on the use of technological solutions across activity challenges, as well as contributing factors to the usage rates of traditional assistive technology. Next we assessed the application of everyday technologies to support the technological needs of older adults with functional limitations. Our overall goal in this analysis was to determine the availability of up-to-date archival information regarding older adults and the functional limitations that they face. This analysis helps to understand the current unmet needs for assistance felt by the older adult population, and suggests an approach to identifying effective technological solutions for everyday functional limitations.

CAUSES OF FUNCTIONAL LIMITATIONS

Normative aging is associated with declines in hearing, vision, and cognition¹¹. However, some older adults experience these changes in addition to a pre-existing impairment, thereby leading to added challenges. Impairment is defined by the National Center for Medical Rehabilitation Research as the loss or abnormality at the tissue, organ, or body system level^{12,13}. Although most literature may use the term 'impairment' interchangeably with 'disability', there is an important difference between them. Various research areas apply different definitions that range in their level of specificity, but often these definitions include one or both terms. For instance, the Americans with Disabilities Act defined disability as someone having a physical or mental impairment that substantially limits one or more 'major life activities'¹⁴. According to the Bureau of Labor Statistics' *'Persons with a Disability: Labor Force Characteristics'* published in 2012¹⁵, a person with a disability has at least one of the following conditions: is deaf or has serious difficulty hearing; is blind or has serious difficulty seeing even when wearing glasses; has serious difficulty concentrating, remembering, or making decisions because of a physical, mental, or emotional condition; has serious difficulty walking or climbing stairs; has difficulty dressing or bathing; or has difficulty doing errands alone such as visiting a doctor's office or shopping because of a physical, mental, or emotional condi-

tion. This definition of a disability incorporates the idea that a person has difficulty due to the impairment and is used as our concept of disability throughout this review.

The combined effects of pre-existing impairments and secondary age-related changes are often precursors to disabilities experienced by older adults^{12,13,16}, either by resulting in a newly experienced disability or causing greater disability. In fact, the Survey of Income and Program Participation conducted by the US Census Bureau in 2010¹⁷ found that 35% of adults over the age of 65 reported some form of disability, with 6.9% of this population requiring assistance to complete basic activities of daily living. Among adults over the age of 80, the prevalence of disability rose to 70.5%, with 30.2% reporting a need for assistance to complete activities of daily living¹⁷. The prevalence and risk of disability increases with age, leading to a need to differentiate older adults aging *with* pre-existing disabilities from those who are aging into disabilities.

According to the 2008 Health and Retirement Study¹⁸, approximately 44.4% of older adults in the USA reported no impairments, whereas 7.2% reported aging with three or more impairments, and 25.4% reported a disability onset in later adulthood in the domain of basic or instrumental activities¹⁸. Impairments caused by decline of the basic functional abilities (balance, strength, cognitive abilities, visual and hearing acuity) tend to increase with age, making independent living difficult. Adults who are aging with a pre-existing impairment may experience newly acquired and pervasive age-related functional losses, comorbidities, and secondary age-related conditions in addition to their long-term disability¹⁹. Whereas younger individuals with impairments may be able to compensate for their functional losses through use of technologies and alternative techniques over time, additional age-related functional losses can reduce the effectiveness of compensatory approaches and severely restrict activities essential to remaining in the home.

MEASURING FUNCTIONAL LIMITATIONS

Daily activities are defined as tasks that enable self-maintenance, as well as maintenance of one's life-space and routines^{20,22}. Most commonly, activities are divided into three categories: self-maintenance, productivity, and leisure¹⁹. These categories most readily correspond to the domains of basic activities of daily living (ADLs), instrumental activities of daily living (IADLs), and enhanced activities of daily living (EADLs). We discuss each category in terms of the prevalence of limitations for older adults as well as the support needs that correspond to these limitations.

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Activities of Daily Living (ADLs) are defined as the basic activities necessary to maintain independence and are often used as a baseline assessment of functional capabilities²¹. The core self-care tasks that comprise the basic ADLs are bathing, eating, dressing, toileting, functional mobility, and hygiene. Additional sources also incorporate the care of assistive and therapeutic devices as being a part of these basic self-care tasks²². Functional limitations, challenges, or the inability to perform these activities have been used in various surveys and longitudinal studies to indicate status of disability⁸. For example, individuals can be categorized as: (i) requiring help to perform one or more ADLs; (ii) no help required but difficulty with one or more ADLs; or (iii) moderate disability. Oftentimes, these are the self-maintenance tasks that determine the disability status of an individual⁸, as well as whether they can continue to independently reside in their home without assistance²⁰. These definitions have been adapted herein to interpret data in its appropriate context.

Many older adults report experiencing difficulty and challenges with the basic subtasks of ADLs (eating; getting in and out of bed; getting in and out of chairs; walking around inside; going outside; dressing; bathing; getting to the bathroom; using the toilet; and controlling bowel movements)². Of these challenges, the most prevalent support need among older adults relates to difficulty in getting in and out of bed (18%), and bathing or showering (11%)⁹. When assessing functional limitations of older adults with disabilities by sex and age group, similar patterns of difficulty prevalence were seen for getting in and out of bed, and bathing or showering². Adults over the age of 85 present a higher support need with more reported functional limitations due to disability. These findings were congruent with a study assessing the functional limitations of female older adults with disabilities⁸. Within the self-care domain, bathing and showering, and getting in and out of chairs presented the most difficulty and required the most support in terms of assistive aid or caregiver assistance⁸. Assessing the need for technology support here is considerably important to the concept of successful aging in the home as these tasks are vital to older adults living independently.

Instrumental Activities of Daily Living, or IADLs, require a seemingly higher level of physical and mental functional capacity than do ADLs²²⁻²⁵. IADLs refer to the tasks that allow an individual to remain independent in the home in addition to those basic activities of self-care. These tasks are also important for aging in place (preparing meals; doing laundry; light housework; shopping

for groceries; managing money; taking medicine; making telephone calls; and driving or other forms of transportation). Older adults aging both with and without disabilities reported limitations, in doing laundry, housework, and traveling outside the home to shop for groceries, at a seemingly high frequency¹⁰. Tasks related to mobility and ambulatory impairments were associated with higher percentages of reported challenges and difficulties, and were considerably more physically demanding than management tasks and communicating⁹. Many studies assessing these limitations reported that most older adult participants required some type of assistance (caregiver or special equipment) to complete these activities^{9,10}. Approximately 79% of older USA adults assessed in the National Health and Aging Trends Study reported requiring consistent aid in completing IADLs⁹.

Enhanced Activities of Daily Living (EADLs) are defined as those activities that involve social and enriching participation for individuals²⁶, such as recreational hobbies, new learning, volunteering, physical leisure, social engagement, travel, and religious activities. Challenges experienced by older adults with or without disabilities in performing EADLs may be similar to challenges with ADLs and IADLs. For example, mobility and access to transportation may be limiting factors in an individual's ability to maintain involvement in socially enriching activities. In addition, sensory impairments may limit enjoyment of recreational or leisure activities such as difficulty watching TV due to contrast sensitivity, visual field size detection, and hearing thresholds²⁷.

The largest percentages of limitations in ADL, IADL, and EADL performance are related to mobility and gait (for instance, bathing and showering, getting in and out of bed or chairs, walking, grocery shopping, light and heavy housework, transportation to and from activities). Although the highest prevalence of existing solutions is associated with these activities, this is also where there is the most need for assistance and technology support.

It is important to note that the data that exist on functional limitation of older adults are considerably out of date, yet they are the most thorough surveys completed in this topic area. Analyzing the available data is a necessary first step to understanding the support needs of this population. However, for researchers in both aging and technology fields of study to better understand how to approach the design of effective assistive solutions it is critical that research be conducted to collect more recent data.

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SOLUTIONS TO FUNCTIONAL LIMITATIONS

Solutions to functional difficulties may be present in different ways for older adults. Oftentimes, new methods of task performance are seen through adopting assistive aids or workarounds to complete routine tasks, reducing frequency of engaging in a particular task, or abandoning a task by no longer attempting to perform it.

Baltes' Selection, Optimization, and Compensation (SOC) Model described successful aging as a process of many different pathways and successful outcomes^{28,29}. Older adults react to losses (sensory and physical) related to the aging process by electing other ways to be successful in their activities. As they age and find that typical everyday activities become increasingly more difficult to perform, people need to select which activities can be performed as usual; which activities will no longer be done; and which may require aid through caregiver assistance, or assistive technologies.

Based on the SOC model we have framed both difficulties and solutions of older adults with disabilities in the ADL, IADL, and EADL domains.

'Selection' refers to one's ability to choose the goals one wants to pursue whether based on losses such as sensory function, or electing to focus on goals that appear to be more attainable. In reference to a range of activities, older adults may choose to no longer perform certain components of an activity due to disability. Selection specifically in reference to IADLs includes not performing activities such as doing laundry, shopping, or preparing meals.

The term 'Optimization' in this context is applied to choosing to perform a task based on the resources that are available in a particular domain and making the most of current abilities. The use of new technologies and assistive aids may help augment current abilities, for example the use of grabbers or support bars to optimize task functionality in a particular area of the home.

'Compensation' describes the process by which individuals seek new methods of performing a task based on loss of a particular resource. An example of compensation is supplementing a behavior with technology in light of function loss. Most commonly, compensation for functional limitation or difficulty performing an activity is seen in the form of assistance provided by caregivers or technological solutions (i.e., assistive technology devices). Compensation might also involve services in residential living facilities such as meal plans, transportation vans, and personal helpers or caregivers⁹.

TRADITIONAL ASSISTIVE TECHNOLOGY SOLUTIONS

Technologies intended to address the challenges and limitations faced during completion of daily activities are most commonly referred to as assistive aids or assistive technologies (AT). These technologies can be as simple as combining several homemade items to create a customized eating utensil, or as complex as specialized computer equipment for reading. In this context we incorporate both portable assistive aids and environmental modifications in our definition of assistive technologies. We will use AT as a collective term.

AT can help individuals to either maintain or improve their functional capabilities in one of two ways: performing the function for the user (for instance, motorized wheelchairs, grabbers, reachers, stair climbers), or assisting the user in performing the task on their own (for instance, grab bars, reading magnifiers). Most assistive technologies can be directly mapped to any one of the basic, instrumental, or enhanced activities that older adults perform daily and thus it is imperative to development efforts to identify which are routinely used and for what activities.

Currently there are over 23,000 devices considered as AT³⁰. These technologies include adaptive tools for meal preparation (for instance, weighted and strapped handle utensils), medication consumption management devices (for instance, organizers, alarms, reminders), and nursing personnel³⁰ all aimed toward helping older adults with functional limitations to complete IADL tasks. In addition, AT such as low-vision playing cards, dominoes with raised dots, reading aids, workout equipment for wheelchair users, and telephone, memory and communication aids are available to assist older adults with leisure activities.

Prevalence in the homes of older adults

Of the datasets reviewed, only three descriptive studies reported the prevalence and use of AT and home modifications of older adults with or without disabilities. Unfortunately, these datasets are considerably outdated, and vary in their method of reporting, sample size, participant disability status, and the content of survey items. Among the findings, an average of 3 to 9 ATs were reportedly available in the homes of older adults³¹⁻³³.

The most up-to-date data concerning AT used for ADLs was reported by the National Health and Aging Trends Study (NHATS) (*Table 1*). There was a higher emphasis on AT use in the bathroom setting compared to other areas of the home, possibly indicating greater need for

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Table 1. Percentage of adults 65 yrs and older in the USA who added modifications and assistive technologies to their home within the last year⁹; no specification is available of whether individuals sampled had any form of sensory or physical disability

Home modification	%
Shower grab bar	6.71
Raised toilet seat	6.30
Bath seat	6.20
Toilet grab bar	2.94
Ramp	1.34
Stair lift	0.21
Elevator	0.04

support in this environment. Although the self-report data on the prevalence of AT in the home seem to vary across datasets, literature does support a relationship between type of impairment and the number of ATs found in the home. Older adults with mobility impairments are more likely to have AT in their home, followed by those with visual impairments, and cognitive impairments³³.

Usage data

Several studies established that the use of AT increases with age³⁴⁻³⁸. Between 14% and 18% of community-dwelling older adults utilize some form of AT³⁹. According to the 'Assistive Technology and Information Technology Use and Need by Persons With Disabilities in the United States' report⁴⁰, persons over the age of 65 are more likely to use mobility aids (61.5%), hearing devices (68.6%), and vision aids (51%) when compared to younger adults. Survey data suggest that the use of AT is most common for ADL tasks. According to the Centers for Medicare and Medicaid Services⁴¹, 23.4% of individuals over the age of 65 with ADL limitations utilize some combination of personal assistance and assistive equipment to aid in tasks of bathing, getting dressed, using the toilet, eating, and getting in and out of the bed⁴⁰. The most common use of AT for older adults is seen with toileting (Table 2). This table also broadly identifies a higher re-

Table 2. Percentage of adults 65 yrs and older in the USA who used assistance in their home within the last year⁹; no specification is available of whether individuals sampled had any form of sensory or physical disability

Assistance	%	
Raised toilet seat	24.62	
Caregiver	Bathing/showering	16.00
	Getting dressed	15.67
	In eating	9.16
Grab bars for toileting	15.17	
Assistive aid to get dressed	3.73	
Adapted utensils when eating	1.16	

liance on assistive support for activities that require physical mobility and maneuvering around.

Research findings of self-care aids as the most common ATs are also supported across various geographic regions. Technologies for self-care were the most common AT reported across five European countries with an average of 24% use, following 49% use of mobility ATs⁴². Several studies also suggested that there is a shift in the use of AT with increase in age^{33,43}. After age 85 most AT used by older adults support mobility and hygiene as found in a Swedish study assessing the change in assistive technology use among participants 76 and 85 years of age. Therefore activities in these areas are readily identified as requiring more support in the forms of AT and caregiver assistance.

Data regarding breakdowns of AT usage by other demographic factors such as sex is slightly less clear. Some studies have found that among the older adult population, women are more likely to utilize AT than men⁴¹, whereas other studies concluded the inverse reporting men have a higher prevalence of AT usage^{44,45}. In one USA survey of non-institutionalized older adults, men reported a higher prevalence of non-use compared to women despite having relatively equal limitations in ADLs⁴¹. Although this information seems less critical to the development of technological support in comparison to the nature of these limitations, it may prove beneficial to understand some of the associated factors of physiological need and AT use. It may be equally important to understand the components that lead to AT usage versus non-use or even task abandonment.

Electing task abandonment

Although various technological solutions exist to help older adults compensate for physical and sensory impairments, many older adults elect to alter their method and frequency of activity performance due to limitations encountered during completion. Given the methods available to complete ADLs, many older adults elect non-performance and abandonment due to task difficulty, with some of the highest prevalence seen in bathing and showering, along with eating and preparing meals⁹. The Women's Health and Aging Study found that female older adults reported a high prevalence of activity abandonment in the self-care and high-functioning domains. Approximately 90% of participants reported abandoning heavy housework (for instance, washing windows, floors), 75% reported no longer shopping for their own personal items, and 74% reported abandoning meal preparation⁸.

In general, older adults report going without meals, the ability to buy groceries, or clean laun-

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dry due to difficulty in being able to complete these activities on their own⁹. Nearly 2% of older adults surveyed by the National Health and Aging Trends Study reported going without bathing due to task difficulty, and 1.8% reported going without hot meals⁹. Oftentimes the necessity of the activity dictated the likelihood of abandonment. Although these numbers seem statistically small, there is great meaning in any task abandonment or non-performance as this may affect the health and well-being of an individual.

IADL and EADL tasks are more likely to be done less often or not at all if older adults experience difficulty in completing these tasks due to them being less vital to self-care. ADLs, however, are most often attempted through alternate methods of optimization or compensation. The greater availability of alternate methods to complete ADLs signifies that older adults' election to abandon these activities is more severe, bringing greater question to whether current technologies are actually effective and if not, how developers can work towards better solutions.

Assistive technology acceptance

AT adoption is particularly important to the sustained independence of older adults, increasing the feeling of autonomy compared to reliance on a formal or informal caregiver. For older adults with impairments, AT has been proven to have great potential in enabling activity, increasing safety, and improving access to society and the community^{46,47,56-58}. One of the key characteristics of these technologies is their ability to be customizable to the individual seeking to use them. Allowing an individual to alter a technology dependent on their particular needs has the initial appeal of satisfying the unique purpose of the user. This factor plays a major role in the current prevalence and adoption of AT in the homes of older adults.

However, in comparison to the numbers of reported limitations and challenges experienced with performing ADLs and IADLs in the home, the reported AT use, particularly by older adults with impairments, is alarmingly low. Discontinued use, or the non-use of AT can be attributed to various factors, including lack of awareness that many of these technologies exist, and a limited perceived usefulness, or minimal benefit, of the intervention when compared to caregiver support. Research examining the use of AT has highlighted that many of these devices see high rates of abandonment or inconsistent use due to such factors as low perceived efficiency, discomfort in use, lack of training, or lack of knowledge^{33,48,56}. For example, in a study conducted with 127 older adult veterans following their dis-

charge from the hospital, 72.7% of participants felt that they never needed the help of the AT, 9.1% preferred the assistance of a caregiver, and 6.8% reported experiencing difficulty in using a particular device. This study concluded that the most common causes of discontinued use and non-use of ATs were perceived short-term need and participants feeling as though they could perform a task more efficiently on their own³².

Lack of instruction or proper training may also contribute to device abandonment^{33,49}. Technologies that leave users feeling confused or embarrassed are more likely to see discontinued use due to frustration or even safety concerns in operating equipment the wrong way. Proper training and guidance, however, can lead to better adherence to AT use, with more successful users being those who learn within the contexts of their own home³¹. Older adults tend to benefit from training sessions where they are given the opportunities to practice and modify their personal AT device⁴⁹.

Older adults may feel that some technologies that are designed to aid them in completing tasks may in fact make the tasks harder to complete. ATs that require more exertion than they eliminate have shown to rate rather low in their frequency of use, and even lower in their perceived usefulness in aiding older adults with impairments³². For example, in a study assessing the effectiveness of AT for older adults with varying disabilities, several participants commented that AT designed to help users get dressed increase task duration compared to if the participant were to do it on their own or with the help of a caregiver³². These findings support that perceived usefulness is an important factor in the adoption and routine usage of AT by older adults.

Additionally, there is a common trend of older adults reporting certain AT as no longer meeting their needs as their capabilities decline. Worsening disability status indicates a greater support need which is most commonly correlated with age. When older adults no longer find their current technological support to be efficient in compensating for a functional deficit, or even that the efficiency of the device is minimal compared to the assistance of a caregiver, it is more likely to be abandoned^{33,50}. Low rates of acceptance corresponding to these factors leave many older adults with a significant need for assistance in their home⁴³.

There are many factors, or characteristics, of AT that determine their use or non-use by older adults. Those outlined here indicate that there is still a need to address AT solutions for older

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adults with disabilities. Although many AT solutions currently exist and are even present in some homes of older adults with disabilities, there is still an unmet need for facilitators that enable individuals to successfully complete ADLs and IADLs independently and without additional stress and physical exertion.

There is also a need to collect more in-depth and recent data pertaining to the difficulties older adults are having with these technologies.

Many ATs are seen in the form of specialized equipment designed particularly for the needs and functions of a specific task. Although these technologies have proven to be an appropriate approach in addressing functional limitations for older adults, there is also viable potential in these needs being addressed by everyday technologies found in the home.

EVERYDAY TECHNOLOGY SOLUTIONS

Everyday technologies may provide viable solutions to functional limitations associated with ADLs, IADLs, and EADLs. Everyday technologies are currently found in an individual's home, and something that easily integrates into their everyday life. Everyday technologies are readily available in comparison to traditional AT. The benefit of the development of such technologies is to make all aspects of everyday life easier and not just specifically for the performance of certain activities for disabled individuals.

Ubiquitous computing has allowed for the access and mobility of technologies that have otherwise been seen as static. Current trends in mobile application development allow users to easily access information and monitor their health, in addition to providing certain accessibility features that may make activities associated with ADLs, IADLs, and EADLs easier to perform. Mobile phones may address communication barriers⁵¹, or even aid individuals with visual impairments to navigate unfamiliar environments⁵². For instance, accessible features of these phones such as text-to-speech, or voice-over command, allow users with hearing, vision, and physical impairments to perform daily activities such as shopping, managing finances, and arranging transportation with the aid of digital assistants⁵³. Additionally, these technologies have the ability to automate basic activities through the use of personal robotics and in-home smart systems⁵⁴. Many of these technologies can be customized and individualized, leading to higher autonomy and more independence among those who use them. Current capabilities of these technologies have the potential to surpass older AT solutions, and allow for older adults to adopt a newer – and

perhaps more flexible – approach to performing self-care activities.

Looking to the future technological needs of older adults with functional limitations it is imperative to move beyond traditional AT and consider technologies that may already be utilized by a user. Moving away from more traditional AT may deter the non-use or abandoned use commonly seen due to stigma and negative perceptions they represent. Utilizing technologies that are not readily identifiable as assistive in nature may help older adults to feel more confident in using them and therefore increase usage rates.

Making everyday technologies more accessible would also allow for a greater range of use by more individuals who come in contact with a particular technology. Current technologies such as smart phones and tablets are now primarily application based, and therefore have the capability to provide customized support for specific disability groups, in addition to being used by a larger population of older adults. Seventy-seven percent of USA adults over the age of 65 own mobile phones⁵⁵, although only 18% of this ownership is associated with smartphones. Additionally, 27% of USA older adults own a tablet or e-book reader device. These figures indicate the availability of everyday technologies to the older population, showing potential for the adoption of these technologies to address functional limitations.

There is great potential for mobile computing devices to serve as solutions for functional limitations. These devices provide an extensive range of functionalities from monitoring health conditions, to providing gentle reminders for medication consumption. Although the goal of many of these technologies is to support activity performance, there are still barriers to their use. Older adults report such limitations as physical challenges, inexperience, and perceived ineffectiveness as being barriers to adopting newer everyday technologies⁵⁴. In essence, these hurdles can be addressed by a more accessible design approach for these technologies in addition to better training and information dissemination on the capabilities of these technologies to aid in the completion of ADLs, IADLs, and EADLs.

SUMMARY AND CALL-TO-ACTION

Older adults may need support for a variety of reasons whether to enhance remaining capabilities or to compensate for functional deficits and limitations caused by impairments and age-related changes. Technology support for ADLs, IADLs, and EADLs may come in the form of AT or through accessible everyday technologies. Our review of the available data revealed that, al-

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though AT is meant to support older adults with functional limitations, the actual usage of AT is minimal. This analysis highlights a significant unmet need for support, despite the current availability of AT. This phenomenon presents an opportunity for intervention in the approach and implementation of AT design. Understanding the factors contributing to the usage of existing technology support is critical to develop truly effective technological interventions for older adults with functional limitations. Given that much of the existing research lacks in-depth information regarding the causes of AT non-use and abandonment, this understanding is an essential first step in developing more effective and accepted AT.

Our assessment highlights the critical need to understand technology support needs for older adults in more depth. Researchers must identify exactly what about the reported functional limitations is difficult for these populations. Most of the data we reviewed was not reported at a descriptive level but designers would benefit from such qualitative detail. For example, surveys asked older adults how they elected to perform an activity instead of using an existing AT device but did not collect data on why. To appropriately evaluate and design technologies to support older adults, researchers and developers must map the difficulties and nature of functional limitations to the specific design components of technologies used.

Comparing the high prevalence of reported ADL or IADL limitations to the low usage rates of available technologies reveals a major gap in the support needs of older adults with functional limitations. This highlights the need for assistive aid in the form of technology to support daily activity completion. Better designed technologies and products can compensate for the difficulties experienced during aging²⁶. As adults with or without disabilities age into their late 70s and early 80s, data show that there is an increasing prevalence of functional limitations, primarily with activities that require physical strength and mobility, whether inside or outside the home^{8,41}. Resources that define disability as being measured by functional limitations also highlight that many older adults choose to avoid performing a task, or perform it less often as opposed to utilizing caregiver assistance that is provided to them⁹. Therefore AT development represents an area of opportunity to increase quality of life for these individuals by allowing them to be able to perform these tasks on their own and more efficiently.

Technology has much potential to ameliorate functional limitations faced by older adults by facilitating autonomy in activity completion.

Enabling older adults to perform more activities on their own reduces the burden on formal and informal caregivers, and contributes to the development of independence and ultimately longer self-maintenance in the home. Although such technologies designed to foster autonomy and independence exist, they are not always adopted or fully supportive of individuals' needs. Data from various surveys and longitudinal studies illustrate that often these technologies are either not present at all in the home or seldom used. Barriers such as lack of awareness, perceived ineffectiveness, and greater needs due to worsening condition can all affect the adoption and continued use of AT. Perceptions of minimal benefit can cause AT to never be utilized at all.

Much of the data we presented here suggests that there is a particular support need in the self-care domain for bathing and toileting activities, along with a need to enable easy and independent maneuvering around the home. Everyday technologies have the potential to be a solution due to their advantage of being currently present in the home and their familiarity.

The data presented in this review provide an initial overview of the most prevalent domains in which technology support is needed and some of the associated technologies commonly utilized. These data illustrate prominent areas of unmet needs despite the existence of technologies, signifying a gap between technological support needs and current AT solutions. From this analysis, researchers can identify which subtasks of activities have an outlying need for support and the factors leading to users deeming current solutions ineffective. This affords designers and technology developers the ability to better work towards solutions more inclusive of current and projected future needs of older adults with disabilities, and to ultimately develop technologies that are more widely used. Although the analysis presented here is an appropriate first step in this research direction, there is still a need for more detailed and comprehensive information.

Understanding the technology support needs of older adults with functional limitations is an important step in developing effective AT solutions. Future research should more closely examine the details of AT acceptance by older adults with functional limitations. Many of the data sets reviewed did not specify whether participants were aging with or into disabilities at the time of evaluating their technology usage. By identifying factors associated with acceptance, technology developers can be better informed and able to integrate components that appeal to the needs of future users.

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In sum, meeting the needs of older individuals with disabilities is a societal issue that will increase with time. Our goal was to identify cat-

egories of need, potential solutions, and directions for future research and development efforts.

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