

Critical Opportunities for Assisting Older Adults as a Function of Living Environment

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Executive Summary

As the older adult population grows and becomes more diverse, so will their needs and preferences for living environments. Many adults over 65 years of age require some assistance in their living environment (Administration on Aging, 2009), however it is important for their feelings of well-being that the assistance does not restrict their autonomy (e.g., Barkay & Tabak, 2002). Moreover, autonomy enhancement may improve older adults' functionality (e.g., Greiner et al., 1996). This report provides an overview of older adults' diverse living situations and an assessment of their needs for assistance with activities of daily living (ADLs), instrumental activities of daily living (IADLs), and medical conditions when living independently or in a long-term care residence, such as assisted living or skilled nursing.

We also examine older adults' residential mobility patterns to understand potential unmet needs for assistance. This assessment highlights the specific needs of older adults that could benefit from robot assistance. By providing support for older adults, mobile manipulator robots have the potential to reduce undesired moves from homes and independent living residences to long-term care residences and from long-term care residences with lower levels of care (i.e., assisted living) to those with higher levels of care (i.e., skilled nursing).

Older Adults' Diverse Needs and Preferences for Assistance and Housing Environment

In 2009, adults age 65 and older comprised nearly 13% of the U.S. population (Administration on Aging, 2009). These numbers are expected to grow dramatically in the future. For example, adults 65 and older are expected to comprise almost 20% of the U.S. population in 2030 (Administration on Aging, 2009). One of the causes of this growth is an increase in life expectancy at birth, which has risen in the U.S. from 49.2 years at the turn of the

20th century to 77.5 years in 2003 (Library of Congress, 2006). The older adult population is also becoming more culturally diverse. By 2050, the distribution of the ethnic population 65 and older is projected to be Hispanic (20%), African American (16.1%), and Asian American (15%) (Angel & Hogan, 2004). The growth and increase in diversity of the older adult population will likely translate to a wider range of lifestyle needs and preferences.

Lifestyle needs and preferences can impact preferences for different types of housing environments. Housing options for older adults have increased in recent years. Housing types range from the traditional (e.g., remaining in original home, moving in with relatives, or moving to a skilled nursing residence) to the more recent options (e.g., moving to an independent or assisted living residence, or a continuing-care retirement community). Moreover, within each housing type there is often a wide range of care levels. Individuals may be living in their original home with very little assistance or with substantial assistance from informal and formal caregivers. Likewise, individuals residing in a skilled nursing residence may be receiving various types and levels of assistance.

Older adults' diverse needs for assistance are one of the factors driving housing market changes for older adults. About 2.2 million older adults require assistance with only IADL tasks, such as cooking, shopping or going outside of their house (Department of Health and Human Services [DHHS], 1998). Moreover, approximately 37% of adults 65 and older reported having a severe disability (e.g., three or more ADL dependencies or severe cognitive impairment), ranging from difficulty in hearing, vision, and cognition to difficulty with ambulation, self-care, and independent living (Administration on Aging, 2009). Furthermore, the number of people reporting a severe disability increases to 56% for adults over 80 years of age. Some needs for

assistance can be met where older adults choose to live, but other needs may necessitate older adults' relocation to a long-term care residence.

Needs for assistance managing chronic conditions vary, as well. The most common conditions associated with aging are hypertension, stroke, heart disease, arthritis, cancer, and diabetes (Centers for Disease Control [CDC], 2004). Certain acute health conditions are also particularly common for older adults. In one study of hospital discharges, 20% of the acute condition diagnoses were falls and injuries, 18% were conditions related to diseases of the circulatory system, and 15% related to diseases of the respiratory system (Baztan, Galvaz, & Socorro, 2009). The prevalence of health conditions is high for older adults. About 80% of adults 65 years of age and older have at least one chronic health condition and 50% have at least two (CDC, 2003).

Older adults vary in their preferences for housing environments, although most prefer to remain in their own homes as they age (American Association of Retired Persons [AARP], 2000). Nevertheless, some older adults voluntarily relocate to independent or assisted living residences (Kostka, & Jachimowicz, 2010), in anticipation of future needs of assistance or for the convenience of the available amenities. There are also ethnic differences in housing preferences. An AARP (2001) survey found that Asian, African American, and Hispanic seniors are more likely to live in multigenerational homes than Caucasian seniors. Given that the older adult ethnic population is growing, these findings suggest that the number of older adults living in multigenerational homes may increase in the future.

Older Adults' Preference for Autonomy

Regardless of where older adults live, research suggests they prefer to preserve their autonomy and that this preservation has substantial benefits. Autonomy refers to the “experience of choice” (Ryan & Deci, 2006) and is related to perception of control. Nursing home policies supporting autonomy are associated with higher resident well-being, less reliance on supportive services, and more participation in social activities (Barkay & Tabak, 2002; Rodin, 1986); autonomy-restricting policies are associated with mental and physical decline (e.g., Boyle, 2005). Overall, evidence from cross-sectional, longitudinal, and experimental studies on autonomy present a powerful message suggesting that losses in autonomy may have harmful consequences, including increased morbidity and mortality (Schulz & Brenner, 1977), whereas enhancements in autonomy may improve health status, psychological well-being, and activity level (see Sikorska-Simmons, & Wright, 2007, for a review).

Research has shown that even people who reside in assisted living facilities value and prefer to have their personal autonomy facilitated (Ball et al., 2004). However, some older adults may not prefer to preserve their autonomy (Rodin, 1986) and some may not benefit from autonomy enhancement. One study found that greater autonomy was only associated with reduced rates of hospitalization and mortality for nursing home residents with little functional impairment; those with some functional impairment did not experience such benefits (Menec & Chipperfield, 1997). Hence, while the majority of older adults may prefer to maintain their autonomy, there is a subset of older adults whose needs for assistance may surpass or reduce their preference for autonomy.

The aforementioned findings emphasize the importance of accommodating individual older adults' needs for assistance, as well as their preferences for housing and autonomous

living. However, currently, the data reflecting these needs and preferences are not integrated in the literature making it difficult to understand what such accommodations should be made as a function of living environment. Thus, the purpose of this report is to provide an analysis of needs for assistance, taking into consideration changing levels of need and different living environments. These findings can provide guidance for robot designers to develop mobile manipulator robots that support older adults' needs.

Where is Home?

Adults 65 years of age and older live in a variety of housing arrangements (see Table 1). Most live in private homes, with a spouse, however many live alone (approximately 30%). The likelihood of living alone is higher for the oldest age group (i.e., 38.7% of those 85 and older) and for women. Close to 50% of women 75 and over live alone. About 32% of adults 65 and older live with other relatives, such as in a multigenerational household (20%, Pew, 2009). Nearly 11% of adults 65 and older live in the private homes with informal care (U.S. Census, 2005) and almost 5% live in private homes with formal care (DHHS, 1998).

Table 1

Living Arrangements for Older Adults in the United States (% of the U.S. population)

Age	Private Home Alone ^a	Private Home with Spouse ^b	Private Home with Other Relatives ^b	Long-Term Care (Institutional Living) ^c
65-74	21.9	63.0	10.9	1.3
75-84	31.2	48.2	13.4	3.8
85+	38.7	27.3	23.0	15.4

Note. ^aPew (2008), ^bUS Census (2003), ^cAdministration on Aging (2009). Rows do not equal 100 because living arrangement categories are not comprehensive and table includes data from multiple sources.

Some older adults move out of their private home into a long-term care residence, such as one that offers assisted living, skilled nursing, or continuous care. However, it is important to note that some of these transitions may be temporary until the individual is strong enough or receives the assistance necessary to regain independence (Saunders & Heliker, 2008). Assisted living residences offer less assistance than skilled nursing residences. The specific services offered at assisted living residences vary but typically include congregate meals, housekeeping, and personal care assistance. Skilled nursing residences typically offer these same services, in addition to skilled nursing and rehabilitation services.

Assisted living residents typically function more independently than nursing home residents and have greater autonomy in their daily living. However, most older adults who live in long-term care facilities live in skilled nursing residences. There are an estimated 11,500 assisted living residences nationwide with more than 611,000 beds (Hawes, Rose & Phillips, 1999). As a point of comparison, there are an estimated 16,100 nursing homes with 1.7 million beds nationwide (DHHS, 2004). Research has shown that assisted living residents are at a high risk for further functional decline and subsequent nursing home placement (Frytak, Kane, Finch, et al., 2001; Phillips, Munoz, Sherman et al., 2003). In fact, it is estimated that 24% to 40% of assisted living residents are discharged to a skilled nursing long-term care residence annually (Aud & Rantz, 2005). However, findings show that older adults may make multiple moves prior to moving to more supportive residential settings (Litwak & Longino, 1987). For example, an older adult may move from one assisted living residence to another before moving to a skilled nursing residence.

One notable trend in Table 1 is that the likelihood of living in a long-term care residence increases dramatically for those 85 years of age and older. Adults 85 and older are almost 12

times more likely to live in a skilled nursing residence than those less than 85 years of age. The ramifications of this trend are significant given that those aged 85 and over are the most rapidly growing group of older adults (U.S. Census, 1995). However, an increasing number of older adults are choosing to live in assisted living residences. In 1999 it was estimated that 811,000 people 65 and older were living in assisted care residences (U.S. Census, 2005). Moreover, the majority of new housing construction for older adults falls into the assisted living category (American Senior Housing Association, 1998). However, given this is a relatively new type of housing, it has not been well researched or defined well enough to make research possible (e.g., Mitchell & Kemp, 2000).

Assistance Needs Associated with Different Living Environments

Private Homes

Examining the provision and utilization of assistive services can provide insight into older adults' needs for assistance in different living environments. To understand the needs of older adults living in private homes, we explored survey findings regarding assistance from informal caregivers (e.g., partners, adult children, other relatives, friends and neighbors) and formal caregivers (i.e., subsidized or fee-paid professionals). In the U.S., almost 40% of adults 65 years of age and older report having some type of disability (U.S. Census Bureau, 2008). Approximately 96% of those who are disabled (i.e., difficulty in hearing, vision, cognition, ambulation, self-care, or independent living) report receiving some assistance from informal caregivers for an average of nearly 29 hours a week (DHHS, 1998).

Informal caregivers typically provide assistance with ADLs and IADLs. ADLs include eating, bathing, dressing, and getting around inside the home, whereas IADLs include tasks such as driving, preparing meals, doing housework, shopping, managing finances, managing

medication, and using the telephone (Lawton & Brody, 1969). Needs for ADL and IADL assistance increase with age.

In one national survey, 1,002 informal caregivers were asked to identify the ADLs and IADLs for which they provide assistance to older adults living in private homes (Donelan et al., 2002). Many respondents (30%) reported assisting with three or more ADLs. The ADLs that respondents reported assisting with most frequently included dressing (42%), transfer (in and out of bed or chairs; 40%), ambulation (walking across the room; 34%), bathing/showering (26%), feeding (17%), and managing incontinence (17%). The most commonly reported IADLs for which assistance was provided were errands (85%), transportation (76%), housework (71%), making phone calls (59%), preparing meals (59%) and managing medications (39%). The distribution of responses in this survey reflects that informal caregivers assist with IADLs more often than with ADLs, a finding that is consistent with other studies as well (e.g., Hopp, 1999).

Approximately 35% of disabled older adults who live in private homes also utilize formal home care, although only 5.4% rely entirely on formal caregivers. The use of formal caregivers (i.e., home health providers) is greater among older adults with moderate to severe levels of disability (i.e., those requiring assistance with one or more ADL). In fact, approximately half of older adults who require assistance with three or more ADLs rely to some extent on assistance from formal caregivers. Approximately 44% of home health care patients received assistance with personal care, including ADLs and IADLs (DHHS, 2000). Over half of these patients received help with at least one ADL (51%). The most frequent ADLs for which older adults received assistance were bathing/showering, dressing, and transfer (see Figure 1). The most common IADL for which assistance was received was housework (see Figure 2). These data reflect a disparity between the types of caregiving tasks provided by informal caregivers, who

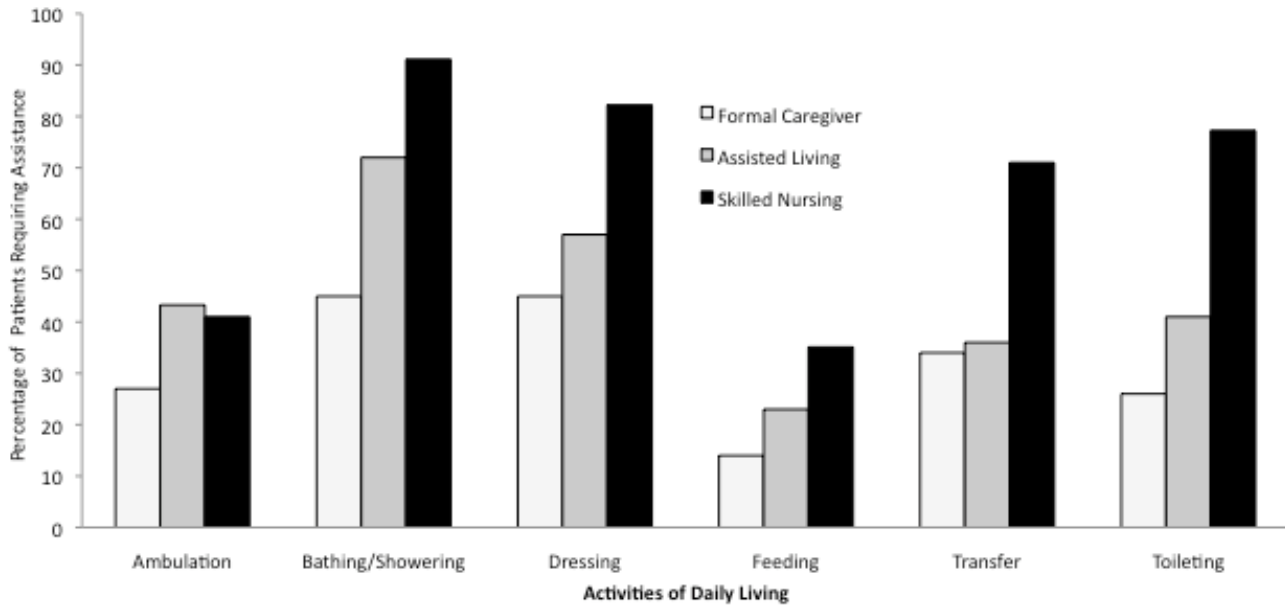


Figure 1. Distribution of support across caregiver type. Percentage of patients requiring ADL assistance.

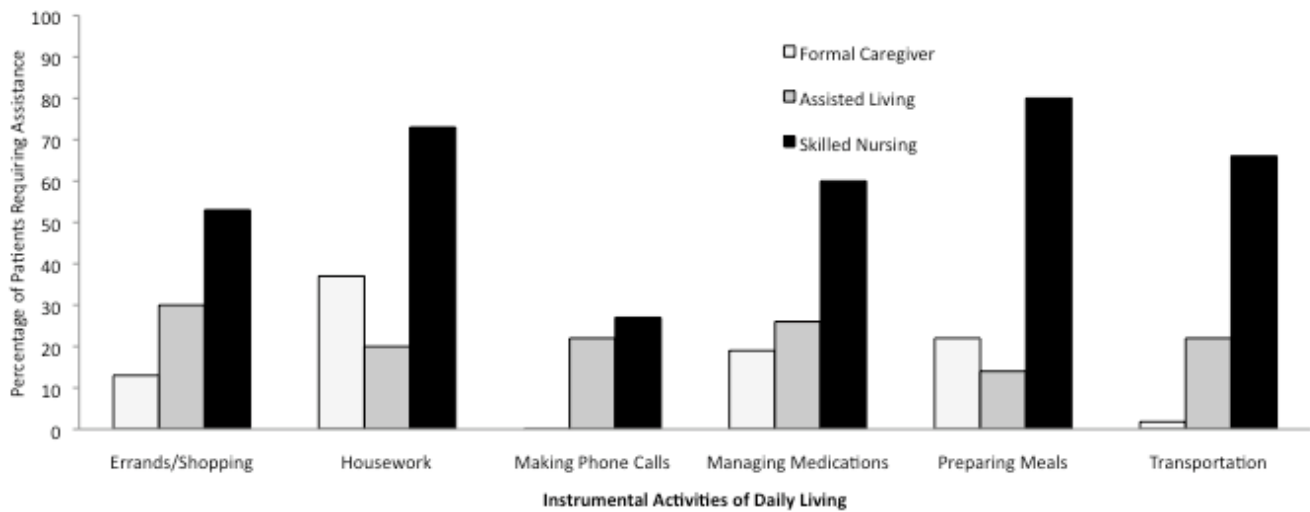


Figure 2. Distribution of support across caregiver type. Percentage of patients requiring IADL assistance.

are more likely to provide assistance with IADLs, versus formal caregivers, who are more likely to provide assistance with ADLs.

For formal care recipients, medical/skilled nursing services are primarily needed for treating and managing chronic health conditions, particularly heart disease (11%), diabetes (8%), cerebral vascular disease (7 %), chronic obstructive pulmonary disease (COPD) (5%), malignant neoplasms (5%), congestive heart failure (4%), osteoarthritis and allied disorders (4%), fractures (4%), and hypertension (3%) (DHHS, 2000). In addition, older adults with depression are more likely to use formal care services than those without depression with similar physical conditions (Badger, 1998; Callahan, Hui, Nienaber, Musick, & Tierney, 1994). Hence, not only do older adults who live in their homes often need assistance with ADLs and IADLs, they need assistance with managing and treating chronic health conditions as well.

Implications for Robot Design in Private Homes: Mobile manipulator robots have the potential to enable older adults to live more independently in their private homes. If robot assistance can enhance older adults' feelings of autonomy, it may provide benefits to their health, psychological well-being, and activity level. Although the efficacy of robot assistance in private homes is in need of further exploration, our review suggests mobile manipulator robots may be most useful and feasible for assisting with the activities listed in Table 2.

Table 2

Robot Assistance Opportunities for Older Adults Living in Private Homes

Activities of Daily Living	Instrumental Activities of Daily Living	Chronic Health Conditions
Ambulation	Errands/Shopping	Heart disease
Bathing/showering	Housework	Diabetes
Dressing	Making phone calls	Cerebral vascular disease
Transfer	Managing medications	Chronic obstructive pulmonary disease (COPD)
	Preparing meals	

Long-Term Care Residences

To understand the needs of older adults living in long-term care residences, we explored data on the provision of assistance in assisted living and skilled nursing residences. There is general agreement that assisted living is a special type of housing (not licensed as a skilled nursing home) that offers supportive and health care services for individuals who require help with daily activities. Other terms used to describe assisted living include personal care and residential care homes, both of which offer assistive services in a homelike environment (Lewin, 1996). As a combination of housing and services, assisted living residences aim to support residents' autonomy (Ball et al., 2004; Utz, 2003), whereas skilled nursing residences offer more medical and rehabilitation services.

The average number of ADL limitations for assisted living residents is 2.8 (Cohen & Miller, 2000), and survey findings show the most common assistance need was for bathing/showering and dressing (NCAL, 2001). Most assisted living residents were ambulatory; some used mobility aids, such as walker (30%), a wheelchair (15%), and a cane (11%). Assistance needs for assisted living residents was more equally dispersed for IADLs. Figures 1 and 2 demonstrate a continued shift toward greater provision/need for ADL assistance as the level and availability of care increases in living environment (i.e., comparing living in a private home with formal care services versus assisted living). Assistance with transfer is an exception to this trend in that the need of assistance for this ADL is comparable across a private home living environment with formal care services and assisted living.

In addition, assisted living residents are in need of medical/skilled nursing services for conditions including bladder incontinence (33%), heart disease (28%), and bowel incontinence (28%) (NCAL, 2001). In another report, which documented the diagnoses of assisted living

residents, it was found that the most common diagnoses were heart disease (24%), diabetes (22%), stroke (14%), and COPD/Emphysema (13%) (Kaiser Family Foundation, 2006). Cognitive/mental conditions were also found to be common diagnoses in assisted living residences: depression (38%), dementia (33%), and other mental disorders (9%; Kaiser Family Foundation, 2006). Additional research has documented similar findings of a high prevalence of cognitive impairment in assisted living facilities (34% had moderate to severe cognitive impairment; Hawes, Rose, & Phillips, 1999).

The average number of ADL limitations increases for skilled nursing residents to 4.7 (Cohen & Miller, 2000), and they most frequently included bathing/showering, dressing, using the toilet room, and transfer (in and out of bed or chairs). Not only do needs for assistance in ADLs increase for residents in skilled nursing residences compared to those in assisted living residences, needs for assistance in IADLs increase as well. The most commonly reported IADLs for which assistance was required in skilled nursing residences were preparing meals, transportation, medication management, shopping/errands, and housework. Making phone calls was the only IADL for which under 40% of nursing home residents were reported to have limitations.

The 2004 National Nursing Home Survey found that the most common skilled nursing home diagnoses were heart disease (38%), diabetes (24%), stroke (24%), COPD/Emphysema (15%) (DHHS, 2004). Cognitive/mental conditions were also found to be prevalent: depression (37%), dementia (23%), and other mental disorders (26%). Moreover, other research has documented even higher prevalence of cognitive impairment (71% had moderate to severe cognitive impairment), more than double what was found in assisted living homes (Hawes, Rose,

& Phillips, 1999). These data reflect the increase in medical and cognitive support needs and/or service provisions for skilled nursing residents.

Implications for Robot Design in Long-Term Care Residences: In the immediate future, it may be more economically feasible to deploy mobile manipulator robots in long-term care residences than in private homes. The data from assisted living and skilled nursing residences show disparate needs in these two types of long-term care residences. Overall, older adults' needs for assistance with ADLs tends to increase as level of care increases (moving from assisted living to skilled nursing), particularly for bathing, dressing, transferring, and toileting. It is important to note that most of these tasks involve significant lifting demands, as well as fine motor skills on the part of the caregiver. These considerations should be considered when developing mobile manipulator robots for assisted living and skilled nursing residences.

Most older adults in assisted living residences did not require assistance with IADLs, and the activity for which most assistance was needed was doing errands and shopping. Most older adults in skilled nursing residences required assistance with all IADLs, except making phone calls. Although individuals residing in assisted living may currently have more limited needs than those in skilled nursing, it would be advantageous to design mobile manipulator robots that have the capability to provide greater levels of assistance to adjust to changing needs. In this manner, mobile manipulator robots may be able to support older adults sufficiently to enable them to continue residence in assisted living rather than having to move to a skilled nursing residence.

Long-term care residents also may require assistance with monitoring and managing medical conditions, particularly heart disease, diabetes, stroke, and COPD/Emphysema. Such

assistance may include biophysiological monitoring (e.g., blood pressure, blood glucose) and medication management. Given the high rate of mental illness (e.g., depression, dementia) in long-term care residences, robot developers should consider the possibility of providing assistance in the form of cognitive support. Moreover, robot designers should take into consideration the probability that older adults who require greater levels of assistance, and therefore who may have the greatest need for robot assistance, may also be cognitively impaired. Although the efficacy of robot assistance in long-term care residences is in need of further exploration, our review suggests mobile manipulator robots may be most useful and feasible for assisting with the activities listed in Table 3.

Table 3

Robot Assistance Opportunities for Older Adults Living in Long-term Care Residences

Activities of Daily Living	Instrumental Activities of Daily Living	Chronic Health Conditions
Ambulation	Errands/Shopping	Heart Disease*
Bathing/showering*	Housework	Diabetes*
Dressing*	Making phone calls	Stroke*
Feeding	Managing medications	COPD/Emphysema*
Transfer*	Preparing meals	Mental Illness (e.g., depression, dementia)*
Toileting		

*Activities in critical need of support in both assisted living and skilled nursing residences; all others are in critical need of support in skilled nursing residences only.

Residential Mobility Patterns

The behavioral model of health service utilization (Andersen, 1995), suggested three mechanisms driving utilization of formal health services: 1) predisposing variables, 2) enabling conditions, and 3) need variables. Predisposing variables include person characteristics correlated with greater use of health services (e.g., age, race). Enabling conditions include

variables that make health services more accessible (i.e., income). Need variables include impairment (e.g., limitations in ADLs and IADLs) and illness-related factors that necessitate the use of formal services. Need characteristics are often the most immediate and strongest predictors of the utilization of formal health services (Bookwala et al., 2004). Below we discuss the need characteristics that are most predictive of transitions to assisted living and skilled nursing care.

Just as older adults who live independently often require assistance with IADLs, some of those IADL needs also precipitate transitions to assisted living. For example, difficulties performing tasks such as walking outside, doing heavy housework, doing laundry, and going shopping may be predictors of transitions to assisted living (Finlayson, Mallinson, & Barbosac, 2005). Difficulty managing medications has also been found to be a significant reason older adults move into assisted living (Lieto & Schmidt, 2005). This finding is understandable given that on average assisted living residents take approximately six medications and 25% take nine or more (Armstrong, Rhoads, & Meiling, 2001). Hence, the need for assistance with IADLs is an important variable that impacts whether a person transitions to an assisted living residence. However, more systematic, empirical research is needed that carefully examines the relative contributions of various need characteristics, including ADL and IADL limitations.

Predictors of transitions to skilled nursing residences have been researched to a greater extent than those of transitions to assisted living. Whereas transitions to assisted living may be precipitated in part by IADL assistance needs, transitions to skilled nursing are often predicted by additional needs for ADL assistance. For example, the percentage of nursing home residents having either complete or partial ADL function dependence may be as high as 97% (Gabriel, 2000). Inability to take a bath independently was the most common dependency in this study.

However, other findings suggest that need for IADL assistance may be a stronger predictor than need for ADL assistance for skilled nursing transitions. In a study of 4,066 older adults, IADL dependence and bowel incontinence independently predicted skilled nursing residence admission, whereas poor cognitive status, number of chronic conditions, ADL deficits, urinary incontinence, behavioral disturbances, and duration of program operation did not (Friedman, Steinwachs, Rathouz, Burton, & Mukamel, 2005). IADL dependence may be more likely to predict skilled nursing admission for older adults who live alone (Black, Rabins, German, 1999). That is, these older adults may be unable to live alone before their ADLs become significantly impaired. Together, these findings suggest that ADL and IADL assistance needs are strongly tied to transitions to long-term care facilities, and therefore may be a significant opportunity for robot assistance.

With respect to chronic and acute medical conditions, cerebrovascular diseases were the strongest disease predictor of skilled nursing admission, and fractures of the ankle or lower leg were also strong determinants of admission (Wong, Elderkamp-de Groot, Polder, & van Exel, 2010). Other research has found that cognitive impairment and incontinence were strong factors, in addition to functional decline, in whether someone entered a skilled nursing residence (Wygard & Albreksten, 1992; Tomiak, Berthelot, Guimond, & Mustard, 2000). Therefore, consistent with Tables 2 and 3, mobile manipulator robot developers should consider older adults' medical service needs, as well as their ADL and IADL needs for assistance.

This needs analysis highlights activities for which older adults receive or require assistance in different living environments. Older adults residing in private homes were more likely to be assisted in performing IADLs, whereas older adults in long-term living residences were more likely to receive assistance in performing both ADLs and IADLs. Furthermore,

declines in the ability to perform ADLs and IADLs appear to be precipitating variables in transitions to living environments that offer greater levels and availability of assistance.

Given these findings, it would be informative to know more about the pattern and order of these declines. In a longitudinal study conducted by Jagger, Arthur, Spiers, and Clarke (2001), 47.6% of individuals 75 years of age and older (N=1,344) who reported no difficulty with ADLs at an initial assessment reported some loss in ability to perform ADLs independently at a later assessment (approx. every 20 months). This pattern reflects the nature of ADLs to decline with age. The order of decline in activities, across gender and age groups, was bathing, mobility, toileting, dressing, transfers from bed and chair, and feeding. The authors concluded that losses in lower-extremity strength (bathing, mobility, toileting) precede losses in upper-extremity strength (dressing, feeding). These findings provide additional information about when older adults may need different types of support.

Discussion

The growing aging population has diverse needs, including requirements of assistance with chronic disease management, ADLs, and IADLs. In some cases these needs necessitate a transition to a living environment that offers greater levels of assistance. However, most older adults prefer to age in place and there may be significant benefits from delaying or avoiding moving to skilled nursing residences. Research suggests that transitions to skilled nursing residences may be anxiety-provoking (e.g., Biedenharn & Normoyle, 1991), and a threat to quality of life and loss of independence (Starck, 1992). Quality of life has been shown to decrease with growing level of dependence and institutionalization (Kostka & Jachimowicz, 2010).

An additional practical consideration is that as the level of care increases, so do the costs. For example, assisted living is less costly than nursing home care. The average cost of a private room in an assisted living residence 35% to 43% less than a private bed in a nursing facility (GAO, 1999). Given these benefits, there is a need to understand how to support older adults in making choice-driven decisions about where they live. By supporting their current needs, unwanted transitions to higher levels of care may be reduced. Much more research is needed, particularly converging evidence given the complex nature of ADL and IADL functioning and the wide variation in support services available and required across different living contexts.

Critical Opportunities for Assistive Technologies

Findings such as these are essential for pinpointing the progression of decline in independent functioning. Jaggar and colleagues' (2001) findings are consistent with the data we presented regarding the provision and requirement of ADL and IADL assistance in different living environments. Bathing, dressing, toileting, and transfer (often a component of toileting) appear to be the ADLs that are in most need of assistance, particularly when greater levels of care are necessitated. Assistance appears to be needed with most of the IADLs, particularly for those who reside at home with informal caregivers and in skilled nursing. Although assistive devices exist for these activities, they may not be used universally, the reason for which is an area in need of exploration.

Mobile manipulator robots designed to assist with ADLs could support older adults' preferences for aging in place. Mobile manipulator robots may also be able to alleviate some of the caregiver burden. Over seven million Americans provide 120 million hours of informal care to approximately 4.2 million functionally disabled older adults every week (DHHS, 1998). If the work of these caregivers were to be replaced by formal caregivers, the cost has been estimated to

range from \$45 billion to \$94 billion dollars a year (DHHS, 1998). Not only does informal care substitute for formal care, it also facilitates professional care when both informal and formal caregivers are involved (Geerlings, Pot, Twisk, & Deeg, 2005). There is a substantial amount of data on the emotional and physical toll of informal caregiving (DHHS, 1998). Moreover, caregiver-related needs, such as depressive symptoms and activity restriction, are a significant predictor of long-term care utilization (Bookwala et al., 2004). Assistive mobile manipulator robots have the potential to reduce this caregiver burden.

Our needs assessment integrated data from various literatures and studies to the degree that has not been done previously. Our review provides insight into where older adults' needs for assistance are the greatest and what the nature of their need is. A comprehensive needs assessment, such as this, is an essential first step in understanding where robot assistance is necessary in difference contexts. Moreover, this needs assessment can directly inform a requirements analysis from which to guide the design of future mobile manipulator robots (Beith, 2001).

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