Feature Article

The impact of mobility limitations on health outcomes among older adults

Shirley Musich, PhD [a,*], Shaohung S. Wang, PhD [a], Joann Ruiz, MPH [b], Kevin Hawkins, PhD [a], Ellen Wicker, MHA [c]

[a] Advanced Analytics, Optum, 315 E. Eisenhower Parkway, Suite 305, Ann Arbor, MI 48108, USA
[b] Medicare & Retirement, United Healthcare Alliances, PO Box 9472, Minneapolis, MN 55440, USA
[c] AARP Services, Inc., 601 E. Street, N.W., Washington, D.C. 20049, USA

ARTICLE INFO

ABSTRACT

The purpose of this study was to stratify an older adult population for subsequent interventions based on functional ability, and to estimate prevalence, characteristics and impact of mobility limitations on health outcomes. In 2016, surveys were sent to a stratified random sample of AARP® Medicare Supplement insureds; mobility limitations were defined using two screening questions. Responses were stratified to three mobility limitation levels. Multivariate regression models determined characteristics and impact on health outcomes. Among weighted survey respondents (N = 15,989), severe, moderate and no limitation levels were 21.4%, 18.4% and 60.3%, respectively. The strongest predictors of increased limitations included pain and poor health. Individuals with more severe limitations had increased falls, decreased preventive services compliance and increased healthcare utilization and expenditures. Utilizing two screening questions stratified this population to three meaningful mobility limitation levels. Higher levels of mobility limitations were strongly associated with negative health outcomes. Mobility-enhancing interventions could promote successful aging.

Introduction

Mobility, including the ability to walk and/or climb stairs, is an important predictor of quality-of-life (QOL)[1–5] among older adults and a measure of successful aging.[6] Mobility limitations put older adults at risk for falls,[1,7–10] reduced access to medical services,[11–13] poor psychological health,[1–3,14–19] declining functional abilities[18–20] and negative health outcomes.[1,7–10,16,21,22] About 30% of older adults (range of 22.5%–46.7% in various studies) have mobility limitations.[11,13,22–25] The onset of chronic conditions, such as arthritis and chronic lung problems, are the most common causes of mobility-related disabilities in older adults.[13,18,26] Mobility problems, including changes in gait, are early indicators of health decline and subsequent disability.[3,4,11] Consequently, early interventions to prevent further limitations could benefit older adults in maintaining or regaining their daily activity levels, promoting healthy aging and QOL over time.

Mobility limitations are frequently associated with localized pain, often in the knee or back.[5,8,27,28] Low-level to debilitating pain or delayed recovery from mobility limitations can result in curtailed activities, which in turn can lead to deconditioning putting the person at increased risk for falls and subsequent disability.[5,8,9] Positive psychosocial attitudes, such as pain acceptance, when the individual is willing to engage in activities despite the pain, have been associated with less pain intensity, reduced pain interference and improved physical functioning.[27,28] For those suffering, pain management techniques including both pharmaceutical and non-pharmaceutical solutions could be integrated into mobility-enhancing interventions.

Mobility limitations, along with accompanying pain, increase the risk for recurrent falls.[5,7,8,10] Severe mobility limitations were shown to increase falls rates by almost 5-fold; with an associated falls history, by 15-fold.[7] Lack of balance, muscle weakness, unsteady gait, pain and certain medications are known falls risk factors.[9] About 30% of older adults fall each year, with 10% incurring injurious falls requiring medical attention.[10] Leading causes for falls include: accidents (31%), gait/weakness (17%) and dizziness/balance (13%),[9] further documenting the importance of problems with balance and walking to falls rates. As harmful as falls can be to the health of older adults, fear of falling, even without a documented fall, can set up

* Corresponding author.
E-mail addresses: shirley.musich@optum.com (S. Musich), sara.wang@optum.com (S.S. Wang), joann_ruiz@uhc.com (J. Ruiz), kevin.hawkins@optum.com (K. Hawkins), ewicker@aarp.org (E. Wicker).

a cycle leading to decreased activities, withdrawal from social engagements and reduced mobility, leading to further weakness, balance and gait issues and eventual disability.[2,9,10]

Psychosocial variables, such as social support, resilience and purpose in life, have been shown to mitigate the damaging effects of chronic disease and the perception of pain.[14,15,18–20,28–30] High resilience (i.e., recovery from adversity and coping skills) or high purpose in life (i.e., finding value and purpose in one's life) are protective against increases in mobility limitations and decreases in activities of daily living (ADLs) or instrumental activities of daily living (IADLs) that compromise the independence of older adults.[15,18–20,28] Purpose and/or resilience are associated with the motivation to engage in health-promoting activities including more physical activity, better nutrition and compliance with recommended preventive services.[20,31] Purpose and resilience are associated with both physical and mental health benefits.[19,20,32] Social support from family and friends can also be beneficial in recovery from mobility limitations and is protective from mental health issues, such as depression and anxiety.[14,29]

Mobility limitations, often associated with multiple chronic conditions, can compromise quality of care delivery by limiting access to specialists, follow-up care and preventive services.[11–13] In addition to transportation issues, access to physician's office space and examination rooms and inability to negotiate safe transfer to examination tables reduces access for those with mobility limitations, especially for those in wheelchairs.[11–13]

While mobility limitations have been identified as detrimental to older adult health, identifying those at risk has proven difficult. Early signs of limitations do not require medical services and, thus, are not well documented in medical diagnoses codes. Risk factors for mobility limitations including being older, female, less educated, having lower socioeconomic status, more chronic conditions and poorer health are not sufficiently distinct to operationalize in effective risk stratification.[4,13,17,19] Targeting individuals for interventions has primarily relied on self-report survey questions regarding functional abilities (e.g., difficulty walking or climbing stairs)[7,10,11,14,16,20,23,24,29,30] or measured functional testing (e.g., timed get up and go (TUG); timed 400 m walk).[1–3,5,13,22,33] To date, while self-reported measures have been validated,[34,35] survey distributions have limited exposure and questions on mobility issues have not been widely considered in clinical appointments.[10] Measured functional testing is even less scalable.[22,33] For population management approaches that could potentially engage large segments of older adults with targeted interventions, identification methodologies would need to be simple, effective, inexpensive and scalable.[7,21]

Stratification methodologies to target interventions have been tested in research settings including use of ADL or IADL disability levels[21] or stratification based on self-reported survey questions or measured functional abilities, usually including walking distances or climbing stairs criteria, from mild to severe mobility limitation or disability levels.[7,10,11,13,22,33] Validation of the utility of the levels for targeting has been documented using future falls[7] and mortality rates.[16,21,22] While these various stratification methodologies are effective, obtaining the information for implementation has proven to be problematic.

Effective interventions to improve mobility and prevent falls are well documented.[36–41] Mobility interventions including falls prevention approaches generally focus on balance and muscle strengthening exercises as most effective in addressing the primary cause of falls and mobility issues.[36,38,39,41] Falls assessments including safety and hazard identification treat a symptom of mobility limitations but have proven effective.[36] Yoga and tai chi have demonstrated improvements in balance and strength[37,40]; mindfulness meditation has been effective in managing pain associated with mo-

bility limitations and chronic conditions.[42] While effective interventions for mobility limitations and falls are available, effective targeting to appropriate subgroups within broader populations of older adults and documented motivation methodologies to engage these older populations have yet to be developed.

While some studies have included Medicare populations,[10,11,21] we found no published research studies to date investigating mobility limitations among older adults with Medicare Supplement plans (i.e., Medigap).[43] While most (about 90%) of those with original fee-for-service Medicare coverage have some type of supplemental insurance coverage, between 27% and 30% (currently about 11.2 million adults) have also purchased Medigap coverage.[43] Since this population may differ from general older adult and/or specifically Medicare populations, it was of interest to determine the prevalence of mobility limitations in this subpopulation of older adults for the purpose of developing population health management strategies and associated interventions.

This study adds to the mobility limitation literature in utilizing two simple screening questions (i.e., trouble with walking or balance and trouble climbing status) to define three levels of increasing mobility limitation levels (none, moderate and severe) that could potentially be used to target individuals for subsequent interventions in a designated population. The utility of the three levels is documented in considering the prevalence and characteristics associated with increasing limitations and then validating the impact on selected health outcomes associated with these designated mobility limitation levels in a nationally representative Medigap population. Health outcomes were focused on objective measures of health from administrative databases.

Thus, our primary objective was to test the utility of utilizing two simple screening questions to stratify a population to severe, moderate and no mobility limitations by estimating the prevalence and associated characteristics among insureds in AARP Medicare Supplement plans. The secondary objective was to validate the impact of these mobility limitation levels on selected health outcomes: falls rates, preventive services compliance, healthcare utilization and expenditures. This research was covered under New England IRB (NEIRB) number 120160532.

Methods

Sample selection

In 2015, approximately 4.0 million Medicare insureds were covered by an AARP Medicare Supplement plan insured by UnitedHealthcare Insurance Company. These plans are offered in all 50 states, Washington DC and various US territories. From August through September 2016, AARP Medicare Supplement insureds were mailed surveys using a nationally randomized stratified methodology. To be eligible for this study, insureds must have been in a plan for a minimum of 12 months and to have been at least 65 years of age. The sample included 16,000 insureds where sicker members were oversampled as they often have lower response rates. Of survey respondents (N = 4664), those who did not match with eligibility files (N = 3) were excluded. Thus, the final study population included 4661 survey respondents. Their responses were then weighted to adjust for non-response bias and to be nationally representative. This weighted study sample will be the focus of the following analyses.

Survey

The mailed survey (49 questions) was developed by UnitedHealthcare and AARP Services, Inc. (ASI) to assess psychosocial aspects of health, including purpose in life, resilience, social

support, health literacy, problems with balance and walking and pain interference with activities. Other questions included financial stress (i.e., worried about paying bills) and living alone. The survey was mailed in August 2016 with a repeat mailing in September 2016 to those who had not yet responded.

Mobility limitation levels

Mobility limitations were measured using two screening questions focused on difficulties with walking or climbing stairs: "In the past 12 months, have you had a problem with balance or walking?" and "Does your health limit you in climbing several flights of stairs?". Mobility limitations were then categorized based on responses to three levels: severe (*Yes for difficulty walking and Yes, limited a lot on climbing stairs*); moderate (*Yes on difficulty walking and No, not limited at all or Yes, limited a little on climbing stairs*) and none (*No on difficulty walking and No, not limited at all on climbing stairs*).

Covariates

Covariates were included to characterize individuals with low, moderate and severe mobility limitations. These covariates included measures of psychosocial variables, demographics, socioeconomic factors, health status and other characteristics taken from health plan eligibility and administrative medical claims.

Psychosocial variables: purpose in life, resilience, social support, health literacy, pain interference and depression

Six psychosocial variables were included to test their potential associations with mobility limitations. Purpose in life was measured using seven items adapted from the National Institutes of Health (NIH) Tuberculosis (TB) Meaning and Purpose Scale Age 18+.[44] Responses, ranging 1–5, were scored if at least four of the seven questions were completed and were averaged across the questions answered to give a range of scores from 1 to 5. Purpose in life was dichotomized as follows: low (scores of 1 to <4.0) and high (score ≥4; corresponding to responses of *agree and strongly agree*).

Resilience was measured using the six-item Brief Resilience Scale.[45] Responses, ranging 1–5, were scored if at least three of the six questions were completed and were averaged across the questions answered to give a range of scores from 1–5. Resilience was then dichotomized as follows: no (scores 1 to <4); and high (scores ≥4; corresponding to responses of *agree and strongly agree*).

Social support was measured using the 12-item Interpersonal Support Evaluation List (ISEL-12).[46] Responses, ranging 1–4, were scored if at least six of the 12 questions were completed and were averaged across the questions answered to give a range of scores from 1 – 4. Social support was dichotomized at the median[46] as: low (scores of 1 to <3.5) and high (scores ≥3.5).

Health literacy, pain interference and depression were included to measure if these variables had influential impacts on mobility limitation levels. Health literacy was measured with the single validated question asking for confidence level in filling out medical forms.[47] Responses of *extremely and quite a bit* were utilized to define high health literacy. Pain interference was measured using the question "During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?". Responses of *extremely and quite a bit* were utilized to define the presence of pain interference. Depression was measured using two questions: " Have you felt calm and peaceful?" and "Have you felt downhearted and blue?" Responses of *none of the time* for the question on feeling calm and peaceful, and *all of the time/most of the time* for the question on feeling downhearted and blue were considered as evidence of depression.

Demographics and health status

Demographic questions included age and gender. Age groups were defined as: 64–69; 70–79; ≥80 years. Geographic regions (Northeast, South, Midwest and West), urban location (urban and other) and low, medium and high minority areas were geocoded from zip codes. AARP Medicare Supplement plan types were grouped by cost-sharing levels, including high-level coverage plans with minimal copayments or deductibles (plans C, F and J), medium-level coverage (plans B, D, E, G, H, I and N) and all other plans (plans A, K, L and non-standardized plans). Four categories of health status were defined based on Hierarchical Condition Category (HCC) scores.[48] This score is used by Centers for Medicare & Medicaid Services (CMS) to risk adjust medical payments across various medical plans according to the health status of the different insured populations and can be used as a surrogate measure of the health status of selected subgroups in Medicare populations. HCC subgroups were defined as follows and utilized to control for health status: HCC scores <0.5; HCC scores 0.5 to <1.2; HCC scores 1.2 to <2.8; and HCC scores ≥2.8. Living alone was assessed from the question "*How many people live with you?*" utilizing a response of *0* to define living alone.

Health outcomes

Four objective health outcomes from administrative databases were utilized to assess the impact of mobility limitations on different aspects of health among older adults: injurious falls, preventive services compliance, healthcare utilization and healthcare expenditures.

Injurious falls

Injurious falls requiring medical services or hip fractures, as a combined measure, were defined from suggested Healthcare Effectiveness Data and Information Set (HEDIS) diagnosis codes.[49] Falls were documented from these selected diagnoses codes at any time during the 12-month pre-period prior to survey completion.

Preventive services: care pattern and medication compliance

Individual-level care pattern and medication compliance were used as quality of care measures determined from evidence-based recommendations of care for chronic conditions. Care patterns included annual physician visits for those with chronic conditions, along with recommendations for preventive care (e.g., regular monitoring of biometric values with lab tests, diabetic vision and foot examinations, etc.). Survey respondents were linked to Evidence-Based Medicine (EBM; Symmetry EBM Connect® Version 8.3) software. This software program was developed to calculate compliance with care patterns from healthcare claims and medications from pharmaceutical claims using a defined set of rules for evidence-based care associated with various chronic conditions. Ten common primary chronic conditions (asthma, coronary artery disease, chronic obstructive pulmonary disease, congestive heart disease, depression, diabetes, hypertension, hyperlipidemia, osteoporosis and rheumatoid arthritis) were included in this analysis. To be considered "compliant," individuals must have been compliant with care patterns (yes/no among those with Medicare Supplement plans) by chronic condition category or with recommended medications (at least 80% compliant) assessed for one year prior to survey completion. We counted the number of care patterns or medications for which each individual was noncompliant across all categories of his or her chronic conditions (e.g., heart disease, diabetes, depression, etc.).

Healthcare utilization and expenditures

Healthcare utilization was defined from administrative medical claims as an inpatient (IP) admission or emergency room (ER) visit within the one year pre-survey. Healthcare expenditures were defined as paid claims (per member per month; pmpm) from the same time period aggregated from Medicare, Medicare Supplement and patient out-of-pocket paid amounts. Prescription drug expenditures included AARP® MedicareRx paid claims and patient copayments (pmpm) for those also enrolled in an AARP MedicareRx plan insured through UnitedHealthcare (about 55% of the overall sample).

Statistical models

Weighting to adjust for survey non-response bias and stratified sampling

Propensity weighting was used to adjust for potential selection bias often associated with survey response to enhance the generalizability of these findings. The propensity weighting utilized available information about the demographic, socioeconomic and health status variables described above that could potentially influence survey response. This information was used to estimate the underlying probability of survey response for each individual. We then used that estimated probability to create and apply a weighting variable to the data, to make those who did respond better resemble all eligible insureds who received the survey. The utility of such propensity weighting models to adjust for external validity threats is described elsewhere.[50,51] In addition, survey responses were weighted to adjust for oversampling to achieve national representation of the entire AARP Medicare Supplement population with one year of plan eligibility.

Characteristics associated with mobility limitation levels were determined using multivariate logistic regression models for moderate and severe limitations versus no limitations weighted to adjust for survey non-response and stratified sampling. Covariates included all of those variables listed in Table 1.

Falls rates, preventive services compliance (care patterns and medication adherence), healthcare utilization (IP admissions and ER visits) and healthcare expenditures (medical and prescription drugs) for no, moderate and severe mobility limitations levels were determined, weighted and regression adjusted for demographic, socioeconomic and survey response variables listed in Table 1.

Results

Overall, 4664 AARP Medicare Supplement insureds responded to the survey (29.2% response rate). Of these, 4661 (99.9%) met the eligibility criteria and were included in the study. Responses were weighted to a nationally representative population of 15,989. Weighted survey respondents were mostly female (58.9%), 70–79 years of age (45.5%) and white (52.3%; low minority). The prevalence of the HCC health status groups (HCC scores <0.5; HCC scores 0.5 to <1.2; HCC scores 1.2 to <2.8; and HCC scores ≥2.8) were as follows: 25.4%, 42.3%, 25.1% and 7.1%, respectively. Among survey respondents, the prevalence of severe, moderate and no mobility limitation levels were 21.4%, 18.4% and 60.3%, respectively (Table 1).

Characteristics associated with mobility limitation levels: severe and moderate versus no limitations

The results of the multivariate logistic models predicting mobility limitations levels are shown in Tables 2a and 2b. The strongest characteristics of moderate and severe mobility limitations from the

regression models were pain interference and poor health. Among the other significant covariates, age ≥80 years, depression, financial stress and being female were also characteristics of moderate and severe limitations. Mobility limitations were associated with reduced likelihoods for high psychosocial variables, including purpose in life, resilience and social support. Resilience, social support and purpose in life were 20%, 20% and 50% reduced, respectively, for those with severe limitations; and 20% reduced for all three measures for those with moderate limitations.

Association of mobility limitation levels with falls rates

Adjusted falls rates were significantly increased for those with moderate and severe mobility limitations. Falls rates for severe and moderate limitations were almost 3-times and 2.5-times higher, respectively, as the rate of those with no limitations (Table 3).

Association of mobility limitation levels with preventive services compliance

Adjusted preventive service care pattern compliance for those with severe limitations was significantly lower compared to those with no limitations: –3.7% points (pp). There were no significant differences in care pattern compliance associated with moderate limitations. Additionally, compliance with medication protocols was also significantly lower for those with severe and moderate limitations (–11.1 pp and –6.9 pp, respectively).

Association of mobility limitation levels with healthcare utilization and expenditures

There was a dose-response relationship for adjusted healthcare utilization for IP admissions and ER visits (all moderate and severe versus no limitations level comparisons significant) across severe, moderate and no limitations levels (Table 3). A similar dose-response relationship was evident for adjusted paid medical and drug expenditures (all moderate and severe versus no limitations level comparisons significant with the exception of moderate drug expenditures compared to no limitations). As mobility limitations levels increased, medical and drug expenditures significantly increased (Table 3). Severe limitations demonstrated the largest association with utilization and expenditures compared to no limitations levels (IP +11.5 pp; ER +6.9 pp; medical expenditures +$728 per member per month (pmpm); prescription drug expenditures +$134 pmpm). Moderate limitations were associated with significantly higher utilization and expenditures compared to no limitations but were not as impactful as severe limitations (IP +9.1 pp; ER +5.9 pp; medical expenditures +$398 pmpm; drug expenditures not significant).

Discussion

In this population of AARP Medicare Supplement insureds, 21.4%, 18.4% and 60.3% were assessed as having severe, moderate and no mobility limitations, respectively. Our overall mobility limitation prevalence of 39.8% was within range of mobility limitations rates (22.5%–46.7%) among older adults commonly reported by the US government and a number of individual research studies.[11,13,22–25] Estimates are remarkably consistent, despite use of different mobility limitation criteria (e.g., self-reported, measured, multiple different survey question combinations, multiple objective measurements). Overall, those with moderate and severe mobility limitations, as expected, were older, more female, reported higher financial stress and more depression.[4,13,17,19] The categories of moderate and severe mobility limitations split the mobility limited

Table 1
Unadjusted demographics for weighted study population by mobility limitation levels.

	All mean or %	Mobility limitation levels			p-value
		Severe mean or %	Moderate mean or %	None mean or %	
Number	15,989	2937	3414	9638	
Demographic variables					
Gender					
Male	41.1	32.6	40.7	43.8	<0.0001
Female	58.9	67.4	59.3	56.2	
Age	76.7	80.6	77.5	75.2	<0.0001
65–69	21.3	10.3	19.3	25.4	<0.0001
70–79	45.5	35.0	42.2	49.8	
≥80	33.2	54.8	38.5	24.8	
Minority (from zipcode)					
Low	52.3	52.7	50.1	53.0	0.04
Median	44.5	44.5	46.6	43.8	
High	3.2	2.9	3.4	3.2	
Median income (from zipcode)					
Low	15.6	19.3	17.1	13.9	<0.0001
Median	36.9	41.8	37.0	35.4	
High	47.5	38.9	45.8	50.6	
Location					
Urban	82.1	76.5	82.5	83.7	<0.0001
Other	17.9	23.6	17.6	16.3	
Region					
Midwest	16.7	17.5	15.7	16.9	<0.0001
Northeast	23.5	22.0	23.6	24.0	
South	39.5	41.7	37.0	39.6	
West	20.3	18.7	23.7	19.5	
Plan type					
High coverage	72.1	73.0	73.2	71.5	0.11
Medium coverage	3.6	3.5	3.0	3.8	
Other	24.3	23.5	23.8	24.7	
Live alone					
Live alone	29.2	37.7	28.2	27.0	<0.0001
Live with others	70.8	62.3	71.8	73.0	
Claims-based variables					
Fall/hip fracture in pre-period	5.3	10.7	8.2	2.7	<0.0001
Health status					
HCC <0.50	25.4	7.1	19.5	33.2	<0.0001
HCC 0.50 to <1.20	42.3	32.2	43.9	44.8	
HCC 1.20 to <2.80	25.1	43.2	28.3	18.5	
HCC ≥2.8	7.1	17.5	8.2	3.5	
Inpatient admissions (annual)	13.6	25.3	18.1	8.4	<0.0001
Emergency room visits (annual)	29.6	39.6	33.3	25.2	<0.0001
Medical expenditures – pmpm	$998	$1665	$1182	$730	<0.0001
Number with drug coverage	8747	1691	1977	5079	
Drug expenditures – pmpm	$220	$331	$214	$185	0.01
Survey variables					
Purpose in life score	3.9	3.5	3.9	4.1	<0.0001
High (score ≥ 4)	53.7	29.1	49.4	62.7	<0.0001
Low (score < 4.0)	46.3	70.9	50.6	37.3	<0.0001
Resilience score	3.8	3.4	3.7	3.9	<0.0001
High (score ≥4)	48.3	27.1	42.8	56.7	<0.0001
Low (score < 4)	51.7	72.9	57.2	43.3	
Social support score	3.4	3.1	3.3	3.5	<0.0001
High (score ≥3.5)	49.8	32.3	44.7	56.9	<0.0001
Low (score < 3.5)	50.2%	67.7%	55.3%	43.1%	
Pain interference					
High	13.3%	46.6%	11.7%	3.7%	<0.0001
Low	86.7%	53.4%	88.3%	96.3%	
Depression					
Yes	8.6%	23.5%	8.6%	4.0%	<0.0001
No	91.4%	76.5%	91.4%	96.0%	
Financial stress					
High	13.5%	22.8%	14.3%	10.4%	<0.0001
Low	86.5%	77.2%	85.7%	89.6%	
Health literacy					
High	74.3%	57.5%	72.8%	80.0%	<0.0001
Low	25.7%	42.5%	27.2%	20.0%	

HCC=Hierarchical Condition Category; pmpm = per member per month.

population roughly in half (46% severe; 54% moderate) to more manageable subgroups for potential interventions.

The strongest characteristics associated with moderate and severe mobility limitations were self-reported pain interference and poor health documented from administrative data. Thus, the integration of pain management strategies, such as pain acceptance, would be essential to any intervention approaches for these individuals.[27,28] Of note, mobility limited individuals had poorer psychological health

Table 2a
Characteristics associated with severe mobility limitations compared to no limitations.

Variables	Odds ratio	p-value
Pain interference	13.2	<0.0001
HCC Score ≥2.8	10.0	<0.0001
HCC Score 1.20 to <2.80	4.8	<0.0001
Age ≥80	2.6	<0.0001
Depression	2.1	<0.0001
HCC Score 0.50 to <1.20	2.0	<0.0001
Female	1.9	<0.0001
Financial stress-high	1.4	<0.0001
Age 70–79	1.3	0.0008
Social support-high	0.8	0.001
Health literacy-high	0.8	0.0003
Resilience-high	0.8	0.0002
Minority-high	0.7	0.02
Urban	0.7	<0.0001
Purpose in life-high	0.5	<0.0001

Note: Only significant variables are shown. HCC=Hierarchical Condition Category.

Table 3
Regression adjusted health outcomes associated with mobility limitation levels.

Regression adjusted estimates	Mobility limitation levels			p-value	
	Severe	Moderate	None	Severe vs. none	Moderate vs. none
Falls					
Fall/hip fracture in pre-period (annual)	8.5%	8.0%	3.1%	<0.0001	<0.0001
Healthcare utilization					
Inpatient admissions (annual)	21.0%	18.6%	9.5%	<0.0001	<0.0001
Emergency room visits (annual)	34.3%	33.3%	27.4%	<0.0001	<0.0001
Healthcare expenditures					
Medical expenditures (pmpm)	$1515	$1185	$786	<0.0001	<0.0001
Drug expenditures (pmpm)	$327	$215	$193	<0.0001	0.08
Preventive services					
Care pattern (% compliance)	18.7%	22.8%	22.4%	0.001	0.64
Medication adherence (% compliance)	62.5%	66.7%	73.6%	<0.0001	<0.0001

pmpm = per member per month.

markers: more likely to report depression (negative marker) and less likely to have high purpose in life, resilience or social support (positive markers). Thus encouraging positive psychological resources may be an effective starting point to enhance motivation for change.[14,15,18–20,28] Improvements in resilience have been associated with improvements in physical function[32]; social support with decreases in depression.[14] Social and neighborhood participation, particularly activities outside of the house, have been shown to increase odds of recovery from mobility limitations, improve self-efficacy, reduce stress and increase physical activity levels.[29,30]

Falls rates among those with moderate and severe mobility limitation were increased by almost 3-fold compared to those with no limitations. This rate is consistent with another study indicating a 4.6-fold increase in individuals with "manifest mobility" requiring difficulty in a 2-km walk (a higher criterion than our question enquiring about "problems with balance or walking").[7] That our mobility limitation subgroups were characterized by high levels of pain interference would also be consistent with an increased risk of falls.[5,8] Pain management may be a prerequisite to engagement in recommended falls assessments and prevention programs.

A dose-response relationship of increasing IP admissions, ER visits and healthcare expenditures was evident across mobility limitation levels. Moderate and severe mobility limitations were associated with more IP admissions and ER visits; higher medical expenditures; and higher drug expenditures. On an annual basis, IP admissions and ER visits increased by 96% and 121% for those mod-

Table 2b
Characteristics associated with moderate mobility limitations compared to no limitations

Variable	Odds ratio	p-value
HCC Score ≥2.8	3.0	<0.0001
Pain interference	2.7	<0.0001
HCC Score 1.20 to <2.80	2.0	<0.0001
Age ≥80	1.4	<0.0001
HCC Score 0.50 to <1.20	1.4	<0.0001
West	1.4	<0.0001
Depression	1.4	0.0005
Female	1.2	<0.0001
Financial stress-high	1.2	0.02
Minority-medium	1.1	0.006
Live alone	0.8	0.0003
Social support-high	0.8	<0.0001
Resilience-high	0.8	<0.0001
Purpose in life-high	0.8	<0.0001
Plan type medium coverage	0.7	0.01

Note: Only significant variables are shown. HCC=Hierarchical Condition Category.

erately and severely limited, resulting in increased additional medical expenditures of $4781 and $8,739, respectively. The healthcare utilization and expenditures in these analyses documented the poor health status of those in the mobility limitation subgroups. The added healthcare expenditures associated with moderate limitations (i.e., difficulty with walking and minimal limitations in climbing stairs) compared with a reported $3050 to $4010 additional healthcare expenditures associated with increasing difficulty walking one-quarter mile.[52] Mortality rates by mobility limitation levels have also been utilized to document and validate subgroup criteria for disability levels: those with more extensive disabilities had the highest mortality rates.[16,21,22,52]

Since multiple chronic conditions are a primary cause for mobility limitations,[13,18,26] access to quality care and condition management programs will be essential in managing the health of these individuals. Preventive services, follow-up care and access to specialists must be readily available. Unfortunately, physical access to physicians, especially specialists, is reported to be compromised, not only in transportation to physician's offices but also in limitations in office space, difficulties in transferring and lack of equipment to accommodate those with disabilities.[11–13] The preventive services compliance results are consistent with these issues. Those with severe limitations were 17% less likely to be compliant with chronic condition care patterns and 15% less likely to be compliant with medication protocols.

Targeting mobility limited individuals for subsequent interventions requires a simple, scalable strategy to effectively stratify the older adult population. The two screening questions formatted to yes/no responses focused on difficulty walking or climbing stairs and could be delivered inexpensively via interactive voice response technology (IVR) to broad populations of older adults. The responses could then be utilized to stratify those populations to three meaningful subgroups based on functional abilities. This would then enable varying intervention strategies to be directed to the three mobility limitation levels. Those with no limitations could be targeted with prevention strategies encouraging ongoing physical and social activities; those with moderate limitations may require coping strategies and positive reinforcement along with balance and strengthening exercises; and those more severely limited may require case management to address their unique circumstances. While other

researchers have recommended and validated stratification methodologies, to date, none have been widely utilized.[7,10,11,13,21,22,33]

Interventions to improve mobility and prevent falls have a long history of research identifying the most effective approaches.[36] Mobility and falls prevention programs recommend balance and muscle strengthening exercises as a first priority.[4,8,9,25,36–41] These programs have proven highly effective for those who engage. Falls assessments are recommended to be part of annual clinical visits with subsequent referrals to physical therapists for evaluation and treatment recommendations.[4] Unfortunately, patients do not always acknowledge having fallen and physicians do not always have time, especially since those with mobility limitations often have multiple chronic conditions requiring medical attention.[10] Poor vision and hearing loss are also important risk factors for falls and should be taken into consideration in falls prevention programs.[7,9,13,53] Pain may not be generally recognized as a falls risk factor or as a contributing factor to mobility limitations; however, pain management strategies may be required for effective mobility interventions.[5,8,27,28] These strategies could include mindfulness meditation approaches,[42] coaching of pain acceptance[27,28] and judicious use of pain pharmaceuticals,[54] each with varying degrees of effectiveness in managing aging pain. Motivation to engage in programs at any level continues to be problematic for mobility intervention programs. Exploration of positive psychological approaches including resilience and purpose may prove useful as initial engagement strategies prior to balance and exercise programs.[15,18–20,28,32]

This study has some limitations. This population of AARP Medicare Supplement insureds may not generalize to all older adults or other Medicare Supplement beneficiaries. While we did adjust for survey non-response and the random stratified sampling methodology, the response rate of 29% was relatively low. We utilized a yes/no response for problems with balance and walking which did not allow discrimination of the extent of mobility problems. However, by combining those responses with difficulty climbing stairs, we were able to distinguish two meaningful limitation subgroups. In addition, self-reported responses may have led to misclassification of some individuals; however, these types of questions have been well-validated as reflective of the individual's actual functional abilities.[34,35] Injurious falls rates were determined from medical diagnosis codes and thus underestimate the overall magnitude of falls experiences in this population. Injurious falls represent only about one-third of actual self-reported falls including falls with no injuries requiring medical attention.[10] Strengths of this study include the examination of objective measures of health outcomes with the consistency of the results adding credibility to our conclusions.

Conclusions

Overall, 21.4%, 18.4%, and 60.3% of AARP Medicare Supplement insureds reported severe, moderate and no mobility limitations, respectively. Moderate and severe limitations demonstrated significantly increased falls, decreased preventive service compliance and increased healthcare utilization and expenditures as mobility limitation severity increased. Thus two simple screening questions were utilizable in stratifying this population of older adults to three levels of increasing mobility limitation levels. Subsequently, mobility-enhancing interventions could be targeted by limitation levels to improve mobility and QOL and promote successful aging.

Conflict of interest statement

References

1. Davis JC, Best JR, Bryan S, et al. Mobility is a key predictor of change in well-being among older adults who experience falls: evidence from the Vancouver Falls Prevention Clinic Cohort. *Arch Phys Med Rehabil*. 2015;96:1634–1640.
2. Trombetti A, Reid KF, Hars M, et al. Age-associated declines in muscle mass, strength, power, and physical performance: impact of fear of falling and quality of life. *Osteoporos Int*. 2016;27:463–471.
3. Groessl EJ, Kaplan RM, Rejeski WJ, et al. Health-related quality of life in older adults at risk for disability. *Am J Prev Med*. 2007;33:214–218.
4. Brown CJ, Flood KL. Mobility limitation in the older patient: a clinical review. *JAMA*. 2013;310:1168–1177.
5. Stubbs B, Schofield P, Patchay S. Mobility limitations and fall-related factors contribute to the reduced health-related quality of life in older adults with chronic musculoskeletal pain. *Pain Pract*. 2016;1:80–89.
6. Montross LP, Depp C, Daly J, et al. Correlates of self-rated successful aging among community-dwelling older adults. *Am J Geriatr Psychiatr*. 2006;14:43–51.
7. Mänty M, Heinonen A, Viljanen A, et al. Self-reported preclinical mobility limitation and fall history as predictors of future falls in older women: prospective cohort study. *Osteoporos Int*. 2010;21:689–693.
8. Stubbs B, Schofield P, Binnekade T, Patchay S, Sepehry A, Eggermont L. Pain is associated with recurrent falls in community-dwelling older adults: evidence from a systematic review and meta-analysis. *Pain Med*. 2014;15:1115–1128.
9. Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. *Age Ageing*. 2006;35(suppl 2):ii37–ii41.
10. Shumway-Cook A, Ciol MA, Hoffman J, Dudgeon BJ, Yorkston K, Chan L. Falls in the Medicare population: incidence, associated factors, and impact on health care. *Phys Ther*. 2009;89:324–332.
11. Hoffman JM, Shumway-Cook A, Yorkston KM, Ciol MA, Dudgeon BJ, Chan L. Association of mobility limitations with health care satisfaction and use of preventive care: a survey of Medicare beneficiaries. *Arch Phys Med Rehabil*. 2007;88:583–588.
12. Lagu T, Hannon NS, Rothberg MB, et al. Access to subspecialty care for patients with mobility impairment: a survey. *Ann Intern Med*. 2013;158:441–446.
13. Iezzoni LI, McCarthy EP, Davis RB, Siebens H. Mobility impairments and use of screening and preventive services. *Am J Public Health*. 2000;90:955–961.
14. Lee CT, Yeh CJ, Lee MC, et al. Social support and mobility limitation as modifiable predictors of improvement in depressive symptoms in the elderly: results of a national longitudinal study. *Arch Gerontol Geriatr*. 2012;55:530–538.
15. Terrill AL, Molton IR, Ehde DM, et al. Resilience, age, and perceived symptoms in persons with long-term physical disabilities. *J Health Psychol*. 2016;21:640–649.
16. Perissinotto CM, Stijacic Cenzer I, Covinsky KE. Loneliness in older persons: a predictor of functional decline and death. *Arch Intern Med*. 2012;172:1078–1083.
17. Rosso AL, Taylor JA, Tabb LP, Michael YL. Mobility, disability, and social engagement in older adults. *J Aging Health*. 2013;25:617–637.
18. Manning LK, Carr DC, Kail BL. Do higher levels of resilience buffer the deleterious impact of chronic illness on disability in later life? *Gerontologist*. 2016;56:514–524.
19. Yang Y, Wen M. Psychological resilience and the onset of activity of daily living disability among older adults in China: a nationwide longitudinal analysis. *J Gerontol B Psychol Sci Soc Sci*. 2015;70:470–480.
20. Boyle PA, Buchman AS, Bennett DA. Purpose in life is associated with a reduced risk of incident disability among community-dwelling older persons. *Am J Geriatr Psychiatr*. 2010;18:1093–1102.
21. Hennessy S, Kurichi JE, Pan Q, et al. Disability stage is an independent risk factor for mortality in Medicare beneficiaries aged 65 years and older. *PM R*. 2015;7:1215–1225.
22. Melzer D, Lan TY, Guralnik JM. The predictive validity for mortality of the index of mobility-related limitation–results from the EPESE study. *Age Ageing*. 2003;32:619–625.
23. Courtney-Long EA, Carroll DD, Zhang QC, et al. Prevalence of disability and disability type among adults–United States. *MMWR Morb Mortal Wkly Rep*. 2013;2015(64):777–783.
24. He W, Larsen LJ. U.S. Census Bureau, American Community Survey Reports, ACS-29, Older Americans with a Disability: 2008–2012. Washington, DC: U.S. Government Printing Office; 2014.
25. Jefferis BJ, Merom D, Sartini C, et al. Physical activity and falls in older men: the critical role of mobility limitations. *Med Sci Sports Exerc*. 2015;47:2119–2128.
26. Zhao G, Ford ES, Li C, Crews JE, Mokdad AH. Disability and its correlates with chronic morbidities among U.S. adults aged 50-<65 years. *Prev Med*. 2009;48:117–121.
27. Jensen MP, Smith AE, Alschuler KN, Gillanders DT, Amtmann D, Molton IR. The role of pain acceptance on function in individuals with disabilities: a longitudinal study. *Pain*. 2016;157:247–254.

28. Alschuler KN, Kratz AL, Ehde DM. Resilience and vulnerability in individuals with chronic pain and physical disability. *Rehabil Psychol*. 2016;61:7–18.
29. Latham K, Clarke PJ, Pavela G. Social relationships, gender, and recovery from mobility limitation among older Americans. *J Gerontol B Psychol Sci Soc Sci*. 2015;70:769–781.
30. Sundar V, Brucker DL, Pollack MA, Chang H. Community and social participation among adults with mobility impairments: a mixed methods study. *Disabil Health J*. 2016;9:682–691.
31. Perna L, Mielck A, Lacruz ME, et al. Socioeconomic position, resilience, and health behaviour among elderly people. *Int J Public Health*. 2012;57:341–349.
32. Edwards KA, Alschuler KA, Ehde DM, Battalio SL, Jensen MP. Changes in resilience predict function in adults with physical disabilities: a longitudinal study. *Arch Phys Med Rehabil*. 2017;98:329–336.
33. Shimada H, Sawyer P, Harada K, et al. Predictive validity of the classification schema for functional mobility tests in instrumental activities of daily living decline among older adults. *Arch Phys Med Rehabil*. 2010;91:241–246.
34. Sayers SP, Brach JS, Newman AB, Heeren TC, Guralnik JM, Fielding RA. Use of self-report to predict ability to walk 400 meters in mobility-limited older adults. *J Am Geriatr Soc*. 2004;52:2099–2103.
35. Gill TM, Robison JT, Tinetti ME. Difficulty and dependence: two components of the disability continuum among community-living older persons. *Ann Intern Med*. 1998;128:96–101.
36. Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev*. 2012 Sep 12;9, CD007146.
37. Youkhana S, Dean CM, Wolff M, Sherrington C, Tiedemann A. Yoga-based exercise improves balance and mobility in people aged 60 and over: a systematic review and meta-analysis. *Age Ageing*. 2016;45:21–29.
38. Sherrington C, Whitney JC, Lord SR, Herbert RD, Cumming RG, Close JC. Effective exercise for the prevention of falls: a systematic review and meta-analysis. *J Am Geriatr Soc*. 2008;56:2234–2243.
39. Sherrington C, Tiedemann A, Fairhall N, Close JC, Lord SR. Exercise to prevent falls in older adults: an updated meta-analysis and best practice recommendations. *N S W Public Health Bull*. 2011;22:78–83.
40. Hackney ME, Wolf SL. Impact of Tai Chi Chu'an practice on balance and mobility in older adults: an integrative review of 20 years of research. *J Geriatr Phys Ther*. 2014;37:127–135.

41. Ghimire E, Colligan EM, Howell B, et al. Effects of a community-based fall management program on Medicare cost savings. *Am J Prev Med*. 2015;49:e109–e116.
42. la Cour P, Petersen M. Effects of mindfulness meditation on chronic pain: a randomized controlled trial. *Pain Med*. 2015;16:641–652.
43. AHIP Center for Policy and Research. Trends in Medigap Enrollment and Coverage Options. Retrieved May 1, 2017 from, https://www.ahip.org/wp-content/uploads/2016/04/MedigapEnrollmentReport_Linked.pdf; 2014.
44. Salsman JM, Lai JS, Hendrie HC, et al. Assessing psychological well-being: self-report instruments for the NIH Toolbox. *Qual Life Res*. 2014;23:205–215.
45. Smith BW, Dalen J, Wiggins K, Tooley E, Christopher P, Bernard J. The brief resilience scale: assessing the ability to bounce back. *Int J Behav Med*. 2008;15:194–200.
46. Cohen S, Hoberman HM. Positive events and social support as buffers of life change stress. *J Appl Soc Psychol*. 1983;13:99–125.
47. Wallace LS, Rogers ES, Roskos SE, Holiday DB, Weiss BD. Screening items to identify patients with limited health literacy skills. *J Gen Intern Med*. 2006;21:874–877.
48. Pope GC, Kautter J, Ingber MJ, Freeman S, Sekar R, Newhart C. *Evaluation of the CMS-HCC Risk Adjustment Model*. Retrieved March 3, 2017 from, https://www.cms.gov/Medicare/Health-Plans/MedicareAdvtgSpecRateStats/downloads/evaluation_risk_adj_model_2011.pdf; 2011.
49. National Committee for Quality Assurance. HEDIS® Measures Included in the 2016 Quality Rating System (QRS). Retrieved April 13, 2017 from http://www.ncqa.org/hedis-quality-measurement/hedis-measures/hedis-2016.
50. DEL FairiesJM HaroRL ObenchainAC Leon eds. *Analysis of Observational Healthcare Data Using SAS*. Cary, NC, USA: SAS Institute, Inc; 2010.
51. Seeger JD, Williams PL, Walker AM. An application of propensity score matching using claims data. *Pharmacoepidemiol Drug Saf*. 2005;14:465–476.
52. Hardy SE, Kang Y, Studenski SA, Degenholtz HB. Ability to walk 1/4 mile predicts subsequent disability, mortality, and health care costs. *J Gen Intern Med*. 2011;26:130–135.
53. Jiam NT, Li C, Agrawal Y. Hearing loss and falls: a systematic review and meta-analysis. *Laryngoscope*. 2016;126:2587–2596.
54. Brooks AK, Udoji MA. Interventional techniques for management of pain in older adults. *Clin Geriatr Med*. 2016;32:773–785.