Published in final edited form as:
Osteoporos Int. 2016 March ; 27(3): 943–951. doi:10.1007/s00198-015-3350-4.

Cognitive status is a determinant of health resource utilization among individuals with a history of falls: a 12-month prospective cohort study

Jennifer C. Davis[a,b], **Larry Dian**[c], **Karim M. Khan**[a], **Stirling Bryan**[d], **Carlo A. Marra**[e], **Chun Liang Hsu**[a,b], **Patrizio Jacova**[a,b], **Bryan K Chiu**[a,b], and **Teresa Liu-Ambrose**[a,b,g]

[a]Center for Hip Health and Mobility, Robert HN Ho Building 2635 Laurel St, Vancouver, BC V5Z 1M9, Canada [b]Aging, Mobility, and Cognitive Neuroscience Lab, Department of Physical Therapy, 2211 Wesbrook Mall, University of British Columbia, Vancouver, British Columbia, V6T 2B5, Canada [c]Department of Medicine, University of British Columbia, Vancouver, British Columbia, Canada [d]Centre for Clinical Epidemiology and Evaluation, 828 West 10th Avenue, University of British Columbia & VCHRI, Vancouver, British Columbia, V6T 2B5, Canada [e]School of Pharmacy, Memorial University, Newfoundland [g]Djavad Mowafaghian Centre for Brain Health, 2211 Wesbrook Mall, University of British Columbia, Vancouver, British Columbia, V6T 2B5, Canada

Abstract

Introduction—Although falls are costly there are no prospective data examining factors among fallers that drive health care resource utilization. We identified key determinants of health resource utilization (HRU) at 6 and 12 months among older adults with a history of falls. Specifically, with the increasing recognition that cognitive impairment is associated with increased falls risk, we investigated cognition as a potential driver of health resource utilisation.

Methods—This 12-month prospective cohort study at the Vancouver Falls Prevention Clinic (n=319) included participants with a history of at least one fall in the previous 12 months. Based on their cognitive status, participants were divided into two groups: 1) No Mild Cognitive Impairment (MCI) and 2) MCI. We constructed two linear regression models with HRU at 6 and 12 months as the dependent variables for each model, respectively. Predictors relating to mobility, global cognition, executive functions and cognitive status (MCI versus no MCI) were examined. Age, sex, comorbidities, depression status and activities of daily living were included regardless of statistical significance.

*Corresponding Author: Teresa Liu-Ambrose, PhD, PT, Tel: 1-604-875-4111 ext. 69059, Fax: 1-604-875-4762, lambrose@exchange.ubc.ca.

Conflict of Interest

Jennifer C Davis, Larry Dian, Karim Miran-Khan, Stirling Bryan, Carlo A Marra, Chung Liang Hsu, Patrizio Jacova, Bryan Chiu, and Teresa Liu-Ambrose declare that they have no conflict of interest.

Author's Contributions

TLA was principal investigator for the Vancouver Falls Prevention Clinic Cohort study. TLA, LD, CAM, KMK, SB and JCD were responsible for study concept and design, acquisition of data, data analysis and interpretation, writing and reviewing of the manuscript. JCD was responsible for data analysis. JCD, SB, LD, CAM, CLH, BC, KMK and LA drafted and critically reviewed the manuscript. JCD, TLA and SB acquired and interpreted the data.

CIHR Author Manuscript
CIHR Author Manuscript

Results—Global cognition, comorbidities, working memory and cognitive status (MCI versus no MCI ascertained using the MoCA) were significant determinants of total HRU at 6 months. The number of medical comorbidities and global cognition were significant determinants of total HRU at 12 months.

Conclusion—MCI status was a determinant of HRU at 6 months among older adults with a history of falls. As such, efforts to minimize health care resource use related to falls, it is important to tailor future interventions to be effective for people with MCI who fall.

Trial Registration—ClinicalTrials.gov Identifier: NCT01022866

Keywords

falls; cost; health resource utilization; older adults

Introduction

Falls and injuries resulting from falls in older adults are a costly public health problem [1–4] but national burden of disease data come with a wide range of estimates. At the low end, falls were estimate to cost > 9 billion dollars in the US (2008 prices) [5]. However, other evaluations of US $75 to US $100 billion put falls as the most costly injury among older people. This phenomenon, that fall related costs are great but that estimates vary, is seen in other countries where data exist.

For individual fallers, estimates of health care utilization costs also vary widely. This is not surprising as the clinical scenario around a fall can vary from a mild loss of confidence to significant trauma without long-term disability, and not uncommonly to serious hip fracture and death. In keeping with these varied outcomes, the cost of falls per person ranges from $2000 USD to $43000 UDS depending on fall severity and whether hospitalization was required [5,6].

We previously reported some specific health care utilization costs of falls in Canada [7]. Falls and fall related injuries account for 10–15% of emergency department presentations and 6% of hospital admissions of those aged 65 years and older [8,9]. Common diagnoses for fall related injuries are fractures and lacerations [7]. Canadian emergency department fall-related presentation had a mean cost of CAD$11,408 (SD: $19,655) [7]. Hospital admission for fall-related injuries cost CAD$29,363 (SD: $22,661); hip fractures cost $39,507 (SD: $17,932) [7]. One way of capturing the major categories of costs in this setting is do divide costs into those associated with (i) health care professional services, (ii) hospital visits, and (iii) laboratory investigations/imaging).

For researchers, hospital administrators and government policy makers to better understand ways to mitigate the cost of falls, there is a need to connect demographic and clinical/ laboratory data (inputs) with falls costs (outcomes). Few studies have reported detailed clinical characterization of fallers with their fall-related health resource utilisation accurately, prospectively and for a clinically relevant period (e.g., 12 months). Ideally, such as study would measure key risk factors for falls include impaired physiological function [10,11]. With the increasing recognition that even mild declines in cognitive abilities among older adults without a diagnosis of dementia (i.e., mild cognitive impairment) is associated with increased falls risk [12,13], cognitive status (i.e., MCI or non-MCI) may be a significant driver of health resource utilization.

To address the fairly limited knowledge base around the determinants of costs of falls in older people who have already fallen and are increased risk of further injury including fracture, we designed a study to carefully characterise a cohort of older people who had a fall (inception cohort) and to accurately characterise their health care utilisation over two time points in a one year followup period. Our specific objectives were to: 1) detail the 6-month and 12-month prospective costs incurred by older fallers based on three specific categories of health care resource utilization (health care professional, hospital admission and laboratory tests/investigations). 2) Examine the trajectory of health care utilization across the period – do patients deteriorate (become more costly, require transfer?) or do they 'recover' (i.e. appear to reduce their costs in the 2^{nd} half-year). 3). Identify the key determinants of health resource utilization, with a specific focus on MCI status. We anticipated that these novel data would contribute to identifying the cluster of clinical features that might identify the 'expensive faller'. Such a scenario might contribute to allowing hospitals to plan (cost allocation, case mix), clinicians to consider targets for intervention (if amenable), and researchers to focus on preventing falls among high-cost older fallers.

METHODS

Study design—We conducted a longitudinal analysis of a 12-month prospective cohort study at the Vancouver Falls Prevention Clinic (www.fallclinic.com) from June 7, 2010 through October 24, 2013. Participants received a comprehensive assessment at the Vancouver Falls Prevention Clinic at baseline and 12-months.

Participants—All participants in this study had experienced a minimum of one minimal displacement non-syncopal fall in the past 12 months.[14] Fall history was determined from two sources: 1) participant recall; and 2) participant's immediate family member or friend recall.

The sample consisted of 319 (available case analysis, note the sample varies based on analysis) women and men referred by their general practitioner or emergency department physician to the Vancouver Falls Prevention Clinic. From June 2010 through October 2013, all patients presenting to the Vancouver Falls Prevention Clinic were invited to participate in a cohort study. Community dwelling women and men who lived in the lower mainland region of British Columbia were eligible to be seen at the Vancouver Falls Prevention Clinic and thus eligible for study entry if they:

1. were adults ≥ 70 years of age referred by a medical professional to the Falls Prevention Clinic as a result of seeking medical attention for a non-syncopal fall in the previous 12 months;
2. understood, spoke, and read English proficiently;

3. had a Physiological Profile Assessment (PPA) [15] fall risk score of at least 1.0 SD above age-normative value (i.e. impaired) or Timed Up and Go Test (TUG) [16] performance slower than 15 seconds or one additional non-syncopal fall in the previous 12 months;
4. were expected to live for at least another 12 months (based on the geriatricians' expert opinion);
5. were able to walk 3 metres with or without an assistive device; and
6. were able to provide written informed consent.

We excluded those with a formal diagnosis confirmed by a physician of neurodegenerative disease (e.g., Parkinson's disease) or dementia, patients who recently had a stroke, those with clinically significant peripheral neuropathy or severe musculoskeletal or joint disease, and anyone with a history indicative of carotid sinus sensitivity (i.e., syncopal falls). We highlight that exclusions for this study were based on clinical grounds. The Falls Prevention Clinic serves to treat older adults at risk of impaired mobility and functional decline.

Ethical approval was obtained from the Vancouver Coastal Health Research Institute and the University of British Columbia's Clinical Research Ethics Board (H09-02370). All participants provided written informed consent.

Measures

For participants in this cohort, we report the following measurements relating to mobility and cognitive function. These measurement were collected at baseline in conjunction with the patient's index visit at the Vancouver Falls Prevention Clinic.

Comorbidity, activities of daily living and depression—Functional comorbidity index (FCI) was calculated to estimate the number of comorbidities associated with physical functioning [17]. We used the Lawton and Brody [18] Instrumental Activities of Daily Living Scale (IADL) to screen for impaired IADLs. This scale subjectively assesses ability to telephone, shop, prepare food, housekeep, do laundry, handle finances, be responsible for taking medication and determining mode of transportation. We used the 15-item Geriatric Depression Scale (GDS) [19,20] to indicate the presence of depression; a score of ≥ 5 indicates depression [21].

Balance and mobility—Mobility and balance were assessed using the Short Physical Performance Battery (SPPB) [22] and the Timed-Up-and-Go Test (TUG) [23]. For the SPPB, participants were assessed on performances of standing balance, walking, and sit-to-stand. Each component is rated out of four points, for a maximum of 12 points; a score $<$ 9/12 predicts subsequent disability [24]. For the TUG, participants rose from a standard chair, walked a distance of three meters, turned, walked back to the chair and sat down [23]. We recorded the time (s) to complete the TUG, based on the average of two separate trials. A TUG performance time of $>$ 13.5 seconds correctly classified persons as fallers in 90% of cases [23].

Physiological Falls Risk—Physiological falls risk was assessed using the short form of the Physiological Profile Assessment (PPA). The PPA is a valid [58, 59] and reliable [60] measure of falls risk. Based on a participant's performance in five physiological domains – postural sway, reaction time, strength, proprioception, and vision – the PPA computes a falls risk score (standardized score) that has a 75% predictive accuracy for falls in older people [10,11]. A PPA Z-score of ≥ 0.60 indicates high physiological falls risk [25].

Global Cognitive function and MCI Status—We assessed global cognition using the Mini Mental State Examination (MMSE) and the Montreal Cognitive Assessment (MoCA). The MMSE is scored on a 30-point scale with a median score of 28 for healthy community dwelling octogenarians with more than 12 years of education [26]. The MMSE can be used to screen for cognitive impairment (i.e., MMSE <24) [26]. The MMSE may underestimate cognitive impairment for frontal system disorders because it has no items specifically addressing executive function [26].

The MoCA, a brief screening tool for MCI [27]. Using a cut-off of 26, the MoCA had a sensitivity of 90% to detect MCI and a specificitify of 87%. It is more sensitive than the MMSE in detecting mild cognitive impairment [27]. It is a 30-point test covering eight cognitive domains: 1) attention and concentration; 2) executive functions; 3) memory; 4) language; 5) visuo-constructional skills; 6) conceptual thinking; 7) calculations; and 8) orientation. Scores below 26 indicate possible MCI. A bonus point is given to individuals with less than 12 years of education.

Executive function—To capture the 3 key distinct executive function processes we measured: 1) selective attention and conflict resolution (or response inhibition) [28]; 2) set shifting; and 3) updating (or working memory). We used: 1) the Stroop Test [29] to assess selective attention and conflict resolution; 2) the Trail Making Tests (Part A & B) to assess set shifting [30]; and 3) the verbal digits forward and backward tests to index working memory [31].

For the Stroop Test [29], participants first read out words printed in black ink (e.g., BLUE). Second, they named the display colour of coloured-X's. Finally, they were shown a page with colour-words printed in incongruent coloured inks (e.g., the word "BLUE" printed in red ink). Participants were asked to name the ink colour in which the words were printed (while ignoring the word itself). We recorded the time participants took to read the items in each condition and calculated the time difference between the third condition (Stroop 3) and the second condition (Stroop 2). Smaller time differences indicate better selective attention and conflict resolution performance.

For the Trail Making Tests (Part A & B) [32], participants were required to draw lines connecting encircled numbers sequentially (Part A) or alternating between numbers and letters (Part B). The difference in time to complete Part B and Part A was calculated, with smaller difference scores indicating better set shifting performance.

For the Verbal Digits Forward and Backward Tests [33], participants repeated progressively longer random number sequences in the same order as presented (forward) and the reversed order (backward). Successful performance on the verbal digits span backward test represents a measure of central executive function due to the additional requirement of manipulation of information within temporary storage [34]. Thus, we subtracted the verbal digits backward test score from the verbal digits forward test score to provide an index of working memory with smaller difference scores indicating better working memory.

Primary Outcome Measure – Costs

The primary outcome variable of interest was healthcare resource utilization (HRU). We used a questionnaire to track total healthcare resource utilization prospectively for each participant over the 12-month study period [35] where entry into the study followed (within the past 12 months) a fall that led to Falls Clinic referral. Using a 6-month recall period, we collected these questionnaires at six and 12 months. The major resource categories were: 1) any visits to healthcare professionals (including general practitioners, specialists, physiotherapists etc); 2) all visits, admissions or procedures carried out in a hospital; and 3) laboratory and diagnostic tests. Our base case analysis considered the costs of delivering the program and all HRU.

For each component HRU, we assigned a unit cost. All costs for admission to hospital were based on the fully allocated cost model of a tertiary care hospital, Vancouver General Hospital. For unit costs of healthcare professionals, we based costs on fee for service rates from the British Columbia Medical Services Plan 2009 price list. Unit costs for specialized services such as physiotherapy, chiropractic or naturopathic medicine were taken from the BC Association website for each specialty. We did not have access to the actual cost of each item of HRU and therefore assigned a unit cost specific to the health professional seen, procedure or laboratory test performed. We inflated or deflated (where appropriate) costs to 2013 Canadian dollars using the consumer price index reported by Statistics Canada. Discounting was not relevant given our analytic time horizon was less than 12 months.

Grouping

We used the MoCA score (scoring range 0–30) to divide participants into two groups: 1) No MCI (i.e., MoCA score ≥ 26; reference group) and 2) MCI (i.e., MoCA score < 26).

Statistical Analyses

Data distributions were initially examined using visual inspection of histograms and computation of skew and kurtosis values. Bivariate correlations of baseline variables collected at the Falls Prevention Clinic were computed to determine the strength of association with the key predictors (i.e., total health resource utilization at 6 months and 12 months). In all instances, health resource utilization variables were the dependent variables. The sub categories of health resource utilization included resource utilization related to: 1) Health care professional visits, 2) Admissions to hospital and 3) Laboratory tests/ investigations.

For the main analyses, multiple linear regression models were constructed using the STATA 13.0 regress procedure. All of the HRU data were significantly skewed and thus, all health resource utilization variables were log transformed. Because completion rates for the dependent and independent variables varied slightly, the number of individuals included in each linear model differed slightly (as noted in the tables). Visual inspection of histograms of the model residual values demonstrated that the residuals were normally distributed and that there were no outlier cases that would unduly influence the model parameters. A separate linear regression model was constructed for each predictor variable. In all models, age, sex, comorbidities, depression status and activities of daily living were forced into the model regardless of statistical significance based on evidence based biological relevance. Due to significant positive skew (skew and kurtosis > |1|) of the all HRU variables, all HRU scores were $\log_{10}$ transformed.

Results

Participants

Of the 319 participants who were included in this cohort study, 64 had no MCI and 255 had MCI. Table 1 reports descriptive statistics of all available cases at baseline for our variables of interest for this cohort. At baseline, the two groups (i.e., no MCI versus MCI) demonstrated statistically significant differences on the following variables: age, sex, MMSE, MoCA and DSST.

Table 2 reports the mean HRU per participant at 6 and 12 months. Overall, the mean costs incurred at 6 and 12 months were not significantly different (i.e., comparable costs were incurred during the first six months compared with the latter six months). Admissions to hospital accounted for the largest proportion of total mean costs. Laboratory test/ investigations accounted for the smallest proportion of total mean costs. This trend was consistent regardless of cognitive status. Between those with MCI and without MCI, there were no statistically significant differences on any of the HRU variables collected. The HRU variables presented in Table 2 are the non-transformed values. The median (IQR) HRU at 6 months was CAD $960 (1456) and at 12 months was CAD $930 (1422) per participant. The median (IQR) HRU for the three subcategories (1) Health care professionals, 2) Admissions to hospital and 3) Laboratory tests/investigations) respectively, at 6 months was: 641 (714), 96 (449) and 71 (132) and at 12 months was 644 (764), 97 (494) and 41 (109) per participant.

Table 3 reports the prospective falls including frequency of falls over 12 months, indoor/ outdoor falls and injurious falls classification. Participants demonstrated a trend to experiencing more indoor falls than outdoor falls. Participants who incurred a fall were more likely to have a non-injurious or mild injurious fall.

Table 4 reports the linear regression models highlighting key drivers of HRU at 6 months (n=188). Global cognition, comorbidities, working memory and cognitive status (MCI versus no MCI ascertained using the MoCA) were significant determinants of total HRU at 6 months. Group status (MCI versus no MCI) was a significant predictor of HRU at 6 months but not at 12 months. The number of medical comorbidities and global cognition were significant determinants of total HRU at 12 months after adjusting for known covariates.

Discussion

In our 12-month prospective study among older adults with a previous history of falls, we study provide novel evidence that cognitive status (i.e., the presence of MCI) significantly predicted increased health resource utilization at 6 months after adjusting for known covariates. The presence of MCI and working memory at baseline did not predict health resource utilization at 12 month after adjusting for known covariates. However, global cognition (ascertained using the MMSE) and comorbidities remained significant determinants of health resource utilization at 12 months. Our findings indicate that the first six months period after the geriatrician's clinical assessment may be an important window to intervene for these patients to attempt to reduce costs. In practical clinical terms, the geriatrician usually assessed the patient within 2 months of the index fall, so our study suggests that prompt clinical assessment and then intervention may be warranted.

Although not significant, there were substantial differences between groups (i.e., no MCI versus MCI) based on admissions to hospital in the first 6 months post baseline assessment at the Vancouver Falls Prevention Clinic. Specifically, the MCI group incurred approximately double the mean costs compared with the "no MCI" group. At 12 months, a similar trend was observed where the mean costs incurred by the MCI group were approximately 1.5 times greater than the "no MCI" group.

The Central Benefit Model (CBM) conceptual framework proposed by Liu-Ambrose et al. [36] provides a framework to discuss our finding that that MCI predicted increased health resource utilization among fallers. Our data demonstrated that working memory and cognitive status (MCI versus no MCI ascertained using the MoCA) were significant determinants of total HRU at 6 months. Working memory is an executive function and the MoCA includes several executive function components. The Central Benefit Model highlighted that reduced executive functions may increase an individual's likelihood of sustaining future falls through four possible and/or interrelated pathways. These included (i) impaired balance and gait secondary to reduced attentional capacity, (ii) impaired central processing and integration and (iii) impaired execution of postural responses. Further, reduced executive functions may increase falls risk through (iv) deficits in judgment and decreased self-regulation. Falls risk may be increased indirectly via secondary disruptions in executive functions-related behaviour, such as a loss in motivation and initiation. Additionally, impaired balance and gait and loss of motivation and initiation may lead to further reductions in executive functions. In this study, we saw that group allocation (MCI status) and executive functions (i.e., working memory) significantly explained significant variation in total HRU at 6 months. Global cognition remained a significant predictor of HRU at 12 months. Given that we are already dealing with a population of individuals who have experienced a fall in the past 12 months and that the observed falls frequency (i.e., number of falls ascertained prospectively) did not significantly predict health resource utilization at 6 or 12 months, our data indicate that cognitive status trumps fall status in predicting health resource utilization. These data extends the CBM conceptual framework in providing new evidence that cognition plays a key role in predicting HRU among fallers.

In line with this evidence, the incidence of falls among individuals with cognitive impairments is estimated at twice that of cognitively intact older adults [12]. Individuals with MCI have greater falls risk and perform more poorly on measures of executive function [37] compared with individuals who do not have MCI. The underlying basis for why individuals with cognitive impairment experience more falls and whether or not they experience most expensive falls is still not well understood; however, one likely contributor is reduced cognitive resources. We postulate that cognitive resources are required to maintain postural stability while integrating musculoskeletal and sensory systems to plan movements and successfully adapt to changing environmental demands [38]. An inability to cope with such demands may result in instability, poor motor control, and consequently, falls. Falls in turn will leave to further health resource utilization.

Interestingly, we found that falls frequency (i.e., number of falls ascertained prospectively) did not significantly predict health resource utilization at 6 or 12 months. We also did not find a significant different in the frequency or severity of falls between the groups. The falls rates observed in this study were comparable to previously published cohorts [39]. One potential reason for this is that all individuals in this cohort study had sustained at least one fall in the past 12 months at baseline so we were already dealing with a population of "fallers". As such, our data suggest MCI and impaired executive functions drives hospital admission costs which in turn account for the largest proportion of health care resource utilization. Based on our findings, we pose the following question as a future research direction: Given that falls alone did not predict total HRU at 6 and 12 months, is it possible that the greatest gains in terms of costs and health outcomes (i.e., consequences) could be achieved through intervening first on cognitive outcomes as a means to maintain or improve older adults mobility?

We acknowledge the following limitations of our study. First, there were missing data that could influence the interpretation of the results. It is possible that individuals who did not complete the cohort study were different that those who did. Further, future research should explore whether these overall findings are restricted to those with impaired mobility (i.e., moderate to high falls risk) or if these findings can be extended to a general population.

In conclusion, our 12-month prospective study, we found cognitive status – presence of MCI – significantly predicted health resource utilization at 6 months. Future research is needed to further understand the interplay between mobility and cognition. Given that MCI status more strongly predicts HRU at 6 months compared with prospective falls, it may critical to target future inventions aimed at preventing falls also at combatting cognitive decline in order to achieve the most efficient health and economic gains. This hypothesis needs to be explored further in this population so that we are appropriately designing interventions to most effectively maintain and improve mobility among older adults. In summary, this study provides initial direction for future interventions aimed at reducing the costs and consequences of falls to also target specifically those subgroups with impaired cognitive function (i.e., people with MCI who fall).

CIHR Author Manuscript
CIHR Author Manuscript

Acknowledgments

Funding: The Canadian Institute for Health Research Emerging Team Grant (CIHR, MOB-93373 to KMK, TLA, CAM) provided funding for this study.

We thank the Vancouver Falls Prevention Cohort study participants. The Canadian Institute for Health Research Emerging Team Grant (CIHR, MOB-93373 to KMK, TLA, CAM) provided funding for this study. TLA is a Canada Research Chair in Physical Activity, Mobility, and Cognitive Neuroscience, a Michael Smith Foundation for Health Research (MSFHR) Scholar, a Canadian Institutes of Health Research (CIHR) New Investigator, and a Heart and Stroke Foundation of Canada's Henry JM Barnett's Scholarship recipient. JCD was funded by a CIHR and MSFHR Postdoctoral Fellowship. CLS is a Alzheimer's Society Research Program Trainee. These funding agencies did not play a role in study design.

References

1. Burge R, Dawson-Hughes B, Solomon DH, Wong JB, King A, Tosteson A. Incidence and economic burden of osteoporosis-related fractures in the United States, 2005–2025. J Bone Miner Res. 2007; 22(3):465–475. [PubMed: 17144789]
2. Tinetti ME, Williams CS. Falls, injuries due to falls, and the risk of admission to a nursing home. N Engl J Med. 1997; 337(18):1279–1284. [PubMed: 9345078]
3. Wiktorowicz ME, Goeree R, Papaioannou A, Adachi JD, Papadimitropoulos E. Economic implications of hip fracture: health service use, institutional care and cost in Canada. Osteoporos Int. 2001; 12(4):271–278. [PubMed: 11420776]
4. Towne SD Jr, Ory MG, Smith ML. Cost of Fall-Related Hospitalizations among Older Adults: Environmental Comparisons from the 2011 Texas Hospital Inpatient Discharge Data. Popul Health Manag. 2014
5. Davis JC, Robertson MC, Ashe MC, Liu-Ambrose T, Khan KM, Marra CA. International comparison of cost of falls in older adults living in the community: a systematic review. Osteoporos Int. 2010
6. Heinrich S, Rapp K, Rissmann U, Becker C, Konig HH. Cost of falls in old age: a systematic review. Osteoporos Int. 2009 Epub ahead of print.
7. Woolcott JC, Khan KM, Mitrovic S, Anis AH, Marra CA. The cost of fall related presentations to the ED: a prospective, in-person, patient-tracking analysis of health resource utilization. Osteoporos Int. 2012; 23(5):1513–1519. [PubMed: 21892675]
8. National Center for Injury Prevention and Control. statistics and activities. Int J Trauma Nurs. 1998; 4(1):18–22. [PubMed: 9505614]
9. Sattin RW, Lambert Huber DA, DeVito CA, Rodriguez JG, Ros A, Bacchelli S, Stevens JA, Waxweiler RJ. The incidence of fall injury events among the elderly in a defined population. Am J Epidemiol. 1990; 131(6):1028–1037. [PubMed: 2343855]
10. Lord S, Clark R, Webster I. Physiological factors associated with falls in an elderly population. Journal of American Geriatrics Society. 1991; 39:1194–1200.
11. Lord S, Ward J, Williams P, Anstey K. Physiological factors associated with falls in older community-dwelling women. Journal of American Geriatrics Society. 1994; 42:1110–1117.
12. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med. 1988; 319(26):1701–1707. [PubMed: 3205267]
13. van Dijk PT, Meulenberg OG, van de Sande HJ, Habbema JD. Falls in dementia patients. Gerontologist. 1993; 33(2):200–204. [PubMed: 8468012]
14. Delbaere K, Close JC, Heim J, Sachdev PS, Brodaty H, Slavin MJ, Kochan NA, Lord SR. A multifactorial approach to understanding fall risk in older people. J Am Geriatr Soc. 2010; 58(9): 1679–1685. [PubMed: 20863327]
15. Lord, S., Sherrington, C., Menz, H. Falls in older people. Risk factors and strategies for prevention. Cambridge: Cambridge University Press; 2001. A physiological profile approach for falls prevention; p. 221-238.

16. Whitney JC, Lord SR, Close JC. Streamlining assessment and intervention in a falls clinic using the Timed Up and Go Test and Physiological Profile Assessments. Age Ageing. 2005; 34(6):567–571. [PubMed: 16267180]
17. Groll DL, To T, Bombardier C, Wright JG. The development of a comorbidity index with physical function as the outcome. J Clin Epidemiol. 2005; 58(6):595–602. [PubMed: 15878473]
18. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist. 1969; 9(3):179–186. [PubMed: 5349366]
19. Yesavage JA. Geriatric Depression Scale. Psychopharmacol Bull. 1988; 24(4):709–711. [PubMed: 3249773]
20. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, Leirer VO. Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res. 1982; 17(1):37–49. [PubMed: 7183759]
21. van Marwijk HW, Wallace P, de Bock GH, Hermans J, Kaptein AA, Mulder JD. Evaluation of the feasibility, reliability and diagnostic value of shortened versions of the geriatric depression scale. Br J Gen Pract. 1995; 45(393):195–199. [PubMed: 7612321]
22. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. N Engl J Med. 1995; 332(9):556–561. [PubMed: 7838189]
23. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. Phys Ther. 2000; 80(9):896–903. [PubMed: 10960937]
24. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-Extremity Function in Persons over the Age of 70 Years as a Predictor of Subsequent Disability. N Engl J Med. 1995; 332(9):556–562.doi: 10.1056/NEJM199503023320902 [PubMed: 7838189]
25. Delbaere K, Close JCT, Brodaty H, Sachdev P, Lord SR. Determinants of disparities between perceived and physiological risk o falling among elderly people: cohort study. British Medical Journal. 2010
26. Folstein MF, Folstein SE, McHugh PR. “Mini-mental state”. A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975; 12(3):189–198. [PubMed: 1202204]
27. Nasreddine ZS, Phillips NA, Bedirian V, Charbonneau S, Whitehead V, Collin I, Cummings JL, Chertkow H. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc. 2005; 53(4):695–699. [PubMed: 15817019]
28. Miyake A, Emerson MJ, Friedman NP. Assessment of executive functions in clinical settings: problems and recommendations. Semin Speech Lang. 2000; 21(2):169–183. [PubMed: 10879548]
29. Graf P, Uttl B, Tuokko H. Color- and picture-word Stroop tests: performance changes in old age. J Clin Exp Neuropsychol. 1995; 17(3):390–415. [PubMed: 7650102]
30. Spreen, O., Strauss, E. A compendium of neurological tests. 2. New York: Oxford University Press, Inc; 1998.
31. Wechsler, D. Wechsler Adult Intelligence Scale - Revised. The Psychological Corporation, Harcourt Brace Jovanovich; 1981.
32. Spreen, OSE. A Compendium of Neurological Tests. 2. New York: Oxford University Press, Inc; 1998.
33. Wechsler, D. Wechsler Adult Intelligence Scale - Revised. The Psychological Corporation, Harcourt Brace Jovanovich; 1981.
34. Baddeley A. Working memory. Science. 1992; 255(5044):556–559. [PubMed: 1736359]
35. Maetzel A, Li LC, Pencharz J, Tomlinson G, Bombardier C. The economic burden associated with osteoarthritis, rheumatoid arthritis, and hypertension: a comparative study. Ann Rheum Dis. 2004; 63(4):395–401. [PubMed: 15020333]
36. Liu-Ambrose T, Nagamatsu LS, Hsu CL, Bolandzadeh N. Emerging concept: ‘central benefit model’ of exercise in falls prevention. Br J Sports Med. 2013; 47(2):115–117. [PubMed: 22522589]

37. Delbaere K, Kochan NA, Close JC, Menant JC, Sturnieks DL, Brodaty H, Sachdev PS, Lord SR. Mild cognitive impairment as a predictor of falls in community-dwelling older people. Am J Geriatr Psychiatry. 2012; 20(10):845–853. [PubMed: 23011051]
38. Murray, CWS., Lopez, A. Global and regional descriptive epidemiology of disability: Incidence, prevalence, health expectancies, and year lived with disability. Boston: The Havard School of Public Health; 1996.
39. Lo AX, Brown CJ, Sawyer P, Kennedy RE, Allman RM. Life-space mobility declines associated with incident falls and fractures. J Am Geriatr Soc. 2014; 62(5):919–923. [PubMed: 24731095]

Summary

Falls are a costly public health problem worldwide. The literature is devoid of prospective data that identifies factors among fallers that significantly drive health care resource utilization. We found that cognitive function – specifically, executive functions – and cognitive status are significant determinants of health resource utilization among older fallers.

Table 1

Description of Participant Groups at Baseline

Variable	**No MCI (n =64)**	**MCI (n =255)**	**Total (n=319)**	**Group comparison *p* value**[1]
Age (years)	80 (6)	82.3 (6.6)	82 (7)	0.0022 *
Sex (m/f)	2/46	12/46	111/195	0.021 *
Education[2]				0.167
1	4	29	33	
2	8	51	59	
3	9	49	58	
4	2	20	22	
5	8	28	36	
6	24	66	90	
Lives alone[3]				0.328
1	20	80	100	
2	26	95	121	
3	3	28	31	
Weight (kg)	71 (17)	69 (16)	70 (16)	0.613
Height (cm)	161 (12)	161 (10)	161 (10)	0.732
PPA	1.6 (1.1)	1.7 (1.0)	1.7 (1.1)	0.280
GDS	2.9 (2.6)	3.1 (2.5)	3.1 (2.5)	0.605
FCI	2 (2)	3 (2)	3 (2)	0.087
IADLs	7.1 (1.7)	6.7 (1.8)	6.8 (1.8)	0.126
TUG	18.0 (7.9	20.8 (10.5)	20.3 (10.1)	0.062
NIA	7.5 (2.3)	7.2 (2.6)	7.2 (2.6)	0.350
MMSE	27 (4)	26 (3)	26 (3)	0.010 *
MoCA	27.9 (1.1)	20.8 (4.0)	21.9 (4.5)	<0.001 *
Stroop Difference	−17.5 (132.3)	−8.2 (90.4)	−9.9 (99.6)	0.5263
Trail Making Difference	68.9 (55.0)	159.2 (201.0)	142.2 (185.9)	0.0018 *
Digits	3.0 (3.4)	3.6 (2.5)	3.5 (2.7)	0.1067

[1]For all variables except sex, this value represents the *p* value for the one-way ANOVA omnibus *F* statistic. For sex, the value represents the *p* value for the χ^2 test. For variables in which the omnibus test was significant, groups with shared subscripts are not significantly different (*p*>.05).

[2]Education sample size: No MCI (n=55), MCI (n=243), Total (n=298)

[3]Lives alone: No MCI (n=49), MCI (n=203), Total (n=252)

*p < 0.05

CIHR Author Manuscript

CIHR Author Manuscript

Table 2

Description of Participant Health Resource Utilization by Cognitive Status

Cost Variables	**No MCI (n =64)**	**MCI (n =255)**	**Total (n=319)**	**Group comparison *p* value[1]**
Costs reported between baseline and 6 months	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)	
Health care professionals	690 (676) 510 (528)	856 (960) 672 (747)	819 (906) 641 (714)	0.2790
Admissions to hospital	877 (2604) 89 (283)	1932 (6218) 100 (585)	1698 (5632) 96 (449)	0.2687
Laboratory tests/investigations	130 (146) 76 (138)	117 (267) 69 (131)	120 (244) 71 (132)	0.7518
Total health resource utilization	1697 (2833) 881 (1024)	2905 (6322) 965 (1791)	2637 (5750) 960 (1456)	0.2408
Costs reported between 6 and 12 months	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)	Mean (SD) Median (IQR)	
Health care professionals	761 (903) 487 (840)	859 (832) 661 (765)	836 (848) 644 (765)	0.5295
Admissions to hospital	1239 (2704) 96 (425)	1813 (7508) 97 (516)	1677 (6687) 97 (493)	0.6408
Laboratory tests/investigations	93 (108) 51 (158)	72 (96) 40 (98)	77 (99) 41 (109)	0.2481
Total health resource utilization	2093 (2815) 1014 (1491)	2744 (7624) 926 (1437)	2590 (6798) 930 (1422)	0.4078

[1]For all variables except sex, this value represents the p value for the one-way ANOVA omnibus F statistic. For variables in which the omnibus test was significant, groups with shared subscripts are not significantly different (p>.05).

Table 3

Description of Prospective Falls by Cognitive Status (No MCI versus MCI)

	No MCI (n =64)	MCI (n =255)	Total (n=319)	Group comparison *p* value[1]
Fall Variables	Frequency (%)	Frequency (%)	Frequency (%)	
Indoor falls				0.736
0	35 (55)	141 (55)	176 (55)	
1	8 (13)	47 (18)	55 (17)	
2	7 (11)	20 (8)	27 (8)	
3	4 (6)	12 (5)	16 (5)	
≥4	10 (16)	35 (14)	45 (14)	
Outdoor falls				0.308
0	46 (72)	177 (69)	223 (70)	
1	8 (13)	40 (16)	48 (15)	
2	0 (0)	12 (5)	12 (4)	
3	1 (2)	2 (1)	3 (1)	
≥4	9 (14)	24 (9)	33 (10)	
Non-injurious falls				0.994
0	42 (66)	165 (65)	207 (65)	
1	9 (14)	38 (15)	47 (15)	
2	4 (6)	14 (5)	18 (6)	
3	1 (2)	6 (2)	7 (2)	
≥4	8 (13)	32 (13)	40 (13)	
Mild-injurious falls				0.685
0	38 (59)	159 (62)	197 (62)	
1	11 (17)	44 (17)	44 (14)	
2	4 (6)	14 (5)	18 (6)	
3	1 (2)	11 (4)	12 (4)	
≥4	10 (16)	27 (11)	37 (12)	
Severe-injurious falls				0.201
0	53 (83)	221 (87)	274 (86)	
1	2 (3)	11 (4)	13 (4)	
2	2 (3)	1 (0)	3 (1)	
3	0 (0)	0 (0)	0 (0)	
≥4	7 (11)	22 (9)	29 (9)	
First fall-degree of injury				
Non-injurious	12 (44)	52 (47)	64 (46)	
Mild-injurious	13 (54)	54 (49)	67 (49)	
Severe-injurious	2 (7)	5 (45)	7 (5)	
First fall - location				
Indoor	19 (70)	77 (69)	96 (70)	
Outdoor	8 (30)	34 (31)	42 (30)	
Total falls				0.757

	No MCI (n =64)	MCI (n =255)	Total (n=319)	Group comparison *p* value[1]
0	30 (47)	120 (47)	150 (47)	
1	9 (14)	52 (20)	61 (19)	
2	10 (16)	33 (13)	43 (13)	
3	4 (6)	16 (6)	20 (6)	
≥4	11 (17)	34 (13)	45 (14)	

[1]The value represents the *p* value for the χ^2 test.

Table 4

Multiple Linear Regression Summary for predicting key drivers of Health Resource Utilization at 6 Months

Independent Variables	Total HRU at 6 Months	
	Unstandardized β (Standard Error)	**P-value**
Model	R^2 11% N=188	
Age	−0.005 (0.015)	0.770
Sex (Male = reference)	−0.3 (0.2)	0.089
FCI	0.14 (0.05)	0.007 *
GDS	−0.01 (0.04)	0.758
IADL	0.06 (0.07)	0.385
MMSE	0.08 (0.24)	0.035 *
Verbal Span Digits Difference Test	−0.08 (0.04)	0.038 *
Group (1 = reference; no MCI) 2 (MCI)	0.5 (0.2)	0.045 *

* $p < 0.05$

FCI = Functional Comorbidity Index

MMSE = Mini Mental State Examination

GDS = Geriatric Depression Scale

IADL = Instrumental Activities of Daily Living