Amini Reza (Orcid ID: 0000-0002-0634-1469)

The impact of the interaction between mild and mild-to-moderate cognitive impairment with chronic health problems on hospital admission among community-dwelling older adults

Brief Running Heading: Cognitive Impairment and Hospital Admission

Reza Amini*, PhD, MD, MPH

*Corresponding Author

Department of Public Health and Health Sciences, University of Michigan-Flint

ORCID ID: 0000-0002-0634-1469

Email: dramini@umich.edu   Phone: +1(810) 762-3172

Address: 303 Kearsley St., Flint, MI 48502, USA

Bushra Kawser, BS

Department of Public Health and Health Sciences, University of Michigan-Flint

Email: bkawser@umich.edu

Word Count: 3,148

Manuscript: 2,999   Abstract: 150

Tables: 4

Figures: 1

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/ggi.14070

The impact of the interaction between mild and mild-to-moderate cognitive impairment with chronic health problems on hospital admission among community-dwelling older adults

Abstract

Aim: This study aims to examine the effect of concurrent mild and mild-to-moderate Cognitive Impairment (CI) with chronic diseases on Hospital Admission (HA) among community-dwelling older adults.

Method: The National Health and Aging Trends Study (2011-2018), with 1,225 respondents (each wave), were used. The number of HA within one year was the outcome. Clock Drawing Test, Delayed Word Recall Test, self-reported chronic diseases, and their interactions were the independent variables.

Results: The effect of CI on the frequency of HA varies for EF and memory impairment. EF impairment concurrent with the history of heart attack or Diabetes Mellitus (DM) can increase the risk of HA. Memory impairment concurrent with hypertension, DM, or stroke can increase the chance of HA.

Conclusion: Screening to identify mild and mild-to-moderate CI at the time of admission can help to reduce the risk of rehospitalization, especially for patients with DM, hypertension, stroke, and heart attack.

Keywords: dementia; health problems; hospital admission; mild cognitive impairment

Introduction

Any defect in one or more of the main components of Cognitive Function (CF) (i.e., memory, visuospatial function, language, attention, and executive function) may develop some signs and symptoms of Cognitive Impairment (CI), which is also known as Mild Cognitive Impairment (MCI) and associated with aging (1). Approximately 10 to 15% of cases with MCI transit to Alzheimer's Disease (AD) or other types of neurocognitive disorders (dementia) (2, 3). Considering that the population of people diagnosed with AD is projected to surpass 10 million in 2050, the number of MCI cases is projected to surpass 70 million in 2050 in the US (4, 5). Besides, MCI cases are more susceptible to repeated Hospital Admission (HA) (6) when, conversely, HA can trigger CI among older adults living in the community (7). Consequently, HA is expected to rise in the next decades as chronic health problems, in particular neurocognitive disorders, are prevalent among older adults (8). Hence, policymakers and clinical professionals need to understand the trajectory of HA among people with mild and mild-to-moderate CI and the interactions between CI and chronic health problems.

The more severe the CI, the more frequent HA will be (9). Also, their survival time after discharge from hospital is approximately half of people without neurocognitive disorders (10). People with neurocognitive disorders are more susceptible to be hospitalized due to trauma, infections, neurologic, psychiatric, orthopedic, and respiratory health problems (11).

Many chronic health problems are correlated with CI. Diabetes Mellitus (DM) can increase the cytokines that increase inflammation in the central nervous system. Furthermore, dysregulation of glucose homeostasis, changes in the hypothalamic-pituitary-adrenal axis, and obesity can synergize the adverse effect of high blood sugar on both Executive Function (EF) and memory (12). It is also evident that cardiovascular and cerebrovascular disorders can increase the risk of CI through different pathophysiologic pathways, including damage to the white matter due to high blood pressure and stroke (13, 14). Chronic lung diseases are associated with CI (15). The correlation between CI and chronic health problems, DM, cardiovascular disorders, and stroke, can increase the risk of frequent HA (16-18). Hence, we hypothesize that the effect of concurrent such health problems and mild and mild-to-moderate CI can increase the risk of frequent HA compared to those older adults with normal CF without these health problems when previous studies did not control for the interactions between levels of CI and chronic health problems.

Methods

This study used the National Health and Aging Trends Study (NHATS), which surveys age-eligible (i.e., 65 and over) Medicare beneficiaries using stratified sampling in three stages to develop a nationally representative sample. In the first stage, the primary sample units were formed by selecting a group of counties in each state. In the second phase, the ZIP codes within each selected county/group of counties were selected; then, in the third stage, based on the proportion of race and ethnicity and age groups in each ZIP code, the participants were selected (19). In 2011, the weighted response rate was more than 71%, with 8,245 complete surveys (20). Following 2011, the same group of participants was invited to the annual survey. This study used eight waves of NHATS (2011 – 2018), which were appended then balanced by excluding those participants who had not participated in all eight waves. Participants with moderate, moderate to severe, and severe Clock Drawing Test (CDT) were excluded from the dataset. Also, participants diagnosed with dementia were excluded from the regression models. Considering that rehospitalization is more common among older adults with CI who live in the community (9), this study included only community-dwelling older adults in all eight waves (n=9,800, 1,225 per wave).

Measurement

The dependent variable of this study was the number of HA within 12 months prior to the time of surveys. All the participants were asked if they had any overnight hospital stays within the last 12 months (>93% agreement with claim data (21)). If they responded yes, they were asked how many times they had stayed in a hospital for at least one night. If the respondents answered no to the previous question, the number of HA was considered zero. The response to the latter question was considered as the number of HA. These two variables were combined to form one variable as the number of HA.

The Executive Function (EF) and memory were the dependent variables for the first set of regression analyses (chronic health issues predicting CF). EF and memory were independent variables for the second set of regression analyses predicting the frequency of HA. The CDT was used to measure the EF (22) and the Delayed Word Recall Test (DWRT) for memory function (19).

The score of CDT was categorized from 0 to 5, the least to the most accurate; then, it was reverse coded as 0 indicated no EF impairment (normal CDT) to 5 indicated very severe EF impairment. Those participants with normal, mild, and mild-to-moderate (0, 1, and 2 respectively) remained in the dataset.

DWRT with three 10-word lists were used to measure memory; before performing the CDT, participants listened to the randomly assigned word list. After the CDT, they were asked to repeat the words. The number of correct words was counted, and the results were categorized into three levels: <5 as severe memory impairment (100% sensitivity and specificity), 5-6 mild memory impairment (93.0 and 90.3 sensitivity and specificity, respectively), and >=7 as normal memory (23). Then these categories were reversed coded when 0 indicated no memory impairment, 1 mild memory and 2 severe memory impairment.

All of the respondents (self-response, no proxy) were asked if they had been diagnosed with DM, hypertension, heart diseases, lung diseases, dementia, and cancer. Individuals having a heart attack, stroke, fall events during the past 12 months were asked to identify the incidence of health issues between waves. The ability to walk six blocks every day was considered as the level of activity and function since it was significantly correlated with HA (IRR[1]=0.608, p<0.001).

Ethnicity was categorized into four groups: Non-Hispanic Whites, Hispanics, African Americans, and others. For each category, a dummy variable was created, and Non-Hispanic Whites were the reference group in all analyses. Living status was a binary variable as those respondents living with their spouse, a partner, or someone other than a partner, compared with those living alone.

Statistical Analysis

The longitudinal ordered logistic regression was used to examine the correlation between chronic health problems and CF. Since the number of HA was a count variable and 82.70% of the participants had zero HA within the last 12 months at the time of interview, the effects of overdispersion (i.e., response variance greater than the mean) could cause the underestimation of the errors. Therefore, longitudinal Zero-Inflated models were more appropriate than other count models. The

[1] Incidence Rate Ratio (IRR)

Vuong test and coefficient of alpha were used to choose between longitudinal zero-inflated negative binomial (xtzinb) and longitudinal zero-inflated Poisson (xtzip). Since the Vuong test of none of the models was statistically significant, xtzip was employed for all the regression models (CF predicting HA) (24).

[Insert Table 1 about here]

Results

Across all waves, more than 80% of the participants had no HA within 12 months before the survey, followed by one admission per year (12.49%). The results of the CDT showed that 20.24% of the participants had mild-to-moderate EF impairment in 2011. This rate dropped to 11.27% in 2016 then increased to 14.20% in 2018. The rate of participants with mild EF impairment decreased from 51.27% in 2011 to 39.18% in 2018, with some fluctuations in between. Normal EF was a little different as it had a somewhat upward trend starting with 28.49% in 2011, rising to 46.61% in 2018 (Figure 1.A). Contrarily, normal memory showed a downward trend throughout the eight waves. As the participants grew older, the rate of heart disease, hypertension, DM, and lung disease increased (Figure 1.B, Table 1).

[Insert Figure 1 about here]

Concerning the correlation between chronic health problems and CF, those participants who had a history of heart attack and DM were approximately 50% (OR=1.50, p=0.008) and 30% (OR=1.30, p=0.007) more likely to have mild or mild-to-moderate EF impairment, respectively. Those participants with a history of hypertension, DM, and/or stroke were 46% (OR=1.46, p=0.001), 33% (OR=1.33, p=0.028), and 65% (OR=1.65, p=0.015) more likely to have mild and severe memory impairment, respectively.

HA and EF

Participants with mild and mild-to-moderate EF impairment were approximately 9% more likely to have more frequent HA. All of the chronic health problems increased the risk of frequent HA, all of which were statistically significant (i.e., heart attack 46%, heart disease 62%, hypertension 26%, DM 22%, lung diseases 20%, stroke 53%, cancer 44%). Falling within the last 12 months increased the possibility of repeated HA by 33%. In contrast, the ability to walk six blocks could reduce the risk of frequent HA by 34% (Table 3, Model 1)

[Insert Table 2 about here]

Concerning demographics, one year increase in age could increase the risk of repeated HA by 2%. Hispanics and African Americans were more likely to have repeated HA compared to Non-Hispanic Whites. In the inflated section of the model, walking six blocks could increase the chance of zero HA significantly (Table 3, Model 1).

Considering Model 1 in Table 2, the interactions between EF and heart attack and EF and DM were examined in two different models.

Heart attack alone can be a significant predictor of HA. Among participants with normal EF, those who had a heart attack were approximately 71% more likely to have frequent HA compared with normal EF without heart attack. Concurrent mild EF impairment and heart attack can increase the risk of frequent HA by 44% compared to those with normal EF without a history of heart attack. Among participants with mild-to-moderate EF impairment, those with no history of heart attack were approximately 20% more likely to have frequent HA compared to normal EF and no heart attack. The risk difference with a history of heart attack can increase to 85% (Table 3, Model 2).

Mild EF impairment and DM can increase the risk of frequent HA by 29% compared with those with normal EF without DM. This risk among participants with DM and mild-to-moderate impairment can increase to 62% compared to those who had normal EF without DM (Table 3, Model 3).

HA and Memory

Participants with mild and severe memory impairment were approximately 11% more likely to have more frequent HA compared to normal memory function. A history of heart attack, heart disease, hypertension, DM, lung diseases, stroke, and cancer could increase the risk of repeated HA by 68%, 65%, 18%, 21%, 25%, 39%, and 42%, respectively. (Table 4, Model 1).

[Insert Table 3 about here]

Considering the regression model in Table 2, Model 2, the interactions between memory and hypertension, memory and DM, and Memory and stroke were examined in three different models.

Among participants with normal memory, those who had hypertension were 86% more likely to have frequent HA. Participants with mild memory impairment without hypertension were 96% more likely to have repeated HA compared with those with normal memory and no hypertension. Mild memory impairment and hypertension could have similar results to mild impairment without hypertension (IRR=1.92 and 1.96, respectively). Regarding severe memory impairment with and without hypertension, they were more likely to have repeated HA by 74% and 119%, respectively, compared with normal memory without hypertension (Table 4, Model 2).

[Insert Table 4 about here]

Concerning the interactions between DM and memory impairment, those with normal memory and DM were 55% more likely to have frequent HA compared with normal memory without DM. Mild memory with DM or without DM could increase the risk of frequent HA by 40% and 55%, respectively. Among older people with severe memory impairment, having DM could increase the risk of frequent HA by 64% compared to normal memory without DM. Severe memory impairment without DM could increase the risk of HA by 40% (Table 4, Model 3).

Those participants with mild memory impairment and stroke were 66% more likely to have frequent HA compared with normal memory and no stroke. Severe memory impairment without stroke could increase the risk of frequent HA by 29% when severe impairment and stroke together could increase this risk to 83% compared with normal memory with no stroke (Table 4, Model 4).

Discussion

The results of this study showed that EF and memory impairment could increase the risk of frequent HA by 9% and 11%, respectively. This risk is higher than the approximately 6% HA rate for AD and similar to 10.6% for Vascular Dementia (25). Consistent with Natalwala et al. report, this study found that the effect of CI on HA depends on certain comorbidities (25). Certain health problems and mild and mild-to-moderate CI can synergize each other’s effect on the frequency of HA. This finding is similar to what Tuppin et al. reported that patients diagnosed with neurocognitive disorders admitted to hospital due to neurological, psychiatric, respiratory, and urology problems (26). Nevertheless, the finding is slightly different from our previous cross-sectional study, which indicated that CI could independently increase the risk of HA among older adults (9). One of the differences between the previous report and the current study, besides using the longitudinal data, is that the current study focused on people living in the community. Nevertheless, the interactions between CI and health problems vary in EF and memory. Both heart attack and heart diseases can increase the risk of repeated HA. However, concerning the interactions between EF and these two predictors, there was no significant relationship between heart disease and CDT score, which is consistent with other reports (25, 26). On the other hand, a heart attack was significantly correlated with CDT score when cases with a history of a heart attack were approximately 50% more likely to have mild or mild-to-moderate EF impairment. Controlling for these interactions revealed that the effect of a heart attack on HA varies across the levels of EF. Among normal EF, those with a history of a heart attack were more likely to being hospitalized. This rate dropped for cases with mild EF impairment then increased for mild-to-moderate and a positive history of a heart attack. To the best of our knowledge, this is a new finding as there are reports about heart failure and CF (16), but not heart attack.

Our findings at the population level support the biological findings of the causal relationship between DM and CI reported by Gaspar et al. (12). DM could increase the risk of mild and mild-to-moderate EF impairment by 30% when DM could increase the risk of frequent HA among normal EF group. This rate could increase for mild and mild-to-moderate EF impairment. Feil et al. reported that older adults with CI are more susceptible to poor diet and low physical activities, which can worsen DM side-effects (27). Hence, DM and EF impairment can synergize their impacts on HA. This is also a new finding that can shed light on some reasons for repeated HA among older adults with DM. Considering that EF and memory can decline after HA, especially among old-old and oldest populations (7), also, MCI cases remain undiagnosed for a long time, it would be helpful if the case with DM screened for CI at the time of admission and discharge. According to the Alzheimer's Disease Association, early diagnosis of alive cases with AD in 2018 could save the health care cost by $7 trillion (28).

Regarding memory and chronic health problems, only hypertension, stroke, and DM significantly predicted the variations of memory function. Hypertension can significantly increase the risk of HA among older adults with normal memory. Besides, concurrent hypertension and mild and severe memory impairment can increase this risk compared to those with normal memory without hypertension. According to Cho et al., known cases of hypertension and CI experience side effects of hypertension due to the lack of medication adherence (29), which can be a mediating factor between CI and uncontrolled hypertension, rendering more HA. DM itself can increase the risk of frequent HA. However, the combination of memory impairment and DM increases this risk significantly. People with DM and mild memory impairment are more susceptible to frequent HA compared with normal memory without DM. This risk slightly increases among people with severe memory impairment and DM. Mild memory impairment and stroke can significantly increase this risk, and the occurrence of stroke in people with severe memory impairment can raise this risk.

The ability to walk six blocks can predict the frequency of HA as those who were able to walk this distance were less likely to have frequent HA by 34% and more likely to have no HA.

Since hospital admissions are significant events, older adults are more likely to remember them accurately (21). Nonetheless, the recall bias of the respondents could confound the reliability of self-reported HA, chronic health problems, and the ability to walk. The questionnaire asked "hospital stays" within the last year. However, there is the possibility that the respondents considered admission to other care units, such as rehabilitation centers, as a hospital stay. Considering the type of admission, we suggest controlling for this variable in future studies.

Social support and engagement to care providers is a significant factor in preserving the physical and mental health of community-dwelling older adults (30). Thus, more research about CI, social support, and outcome of chronic health issues can help understand the social determinants of HA among community-dwelling older adults.

The results of this study suggest that concurrent physical health problems (i.e., heart attack and DM) with EF impairment can increase this risk tremendously. This pattern is different for memory as people concurrently suffering from memory impairment and hypertension, stroke, and DM are at higher risk of frequent HA, which can conversely increase the risk of memory and EF impairment and create a vicious cycle. Screening for memory impairment among older patients with hypertension, DM, and stroke can be recommended at the time of admission and discharge. The same suggestion can be made for EF screening among older patients with a heart attack and DM.

Disclosure statement

The authors disclose no conflicts of interest.

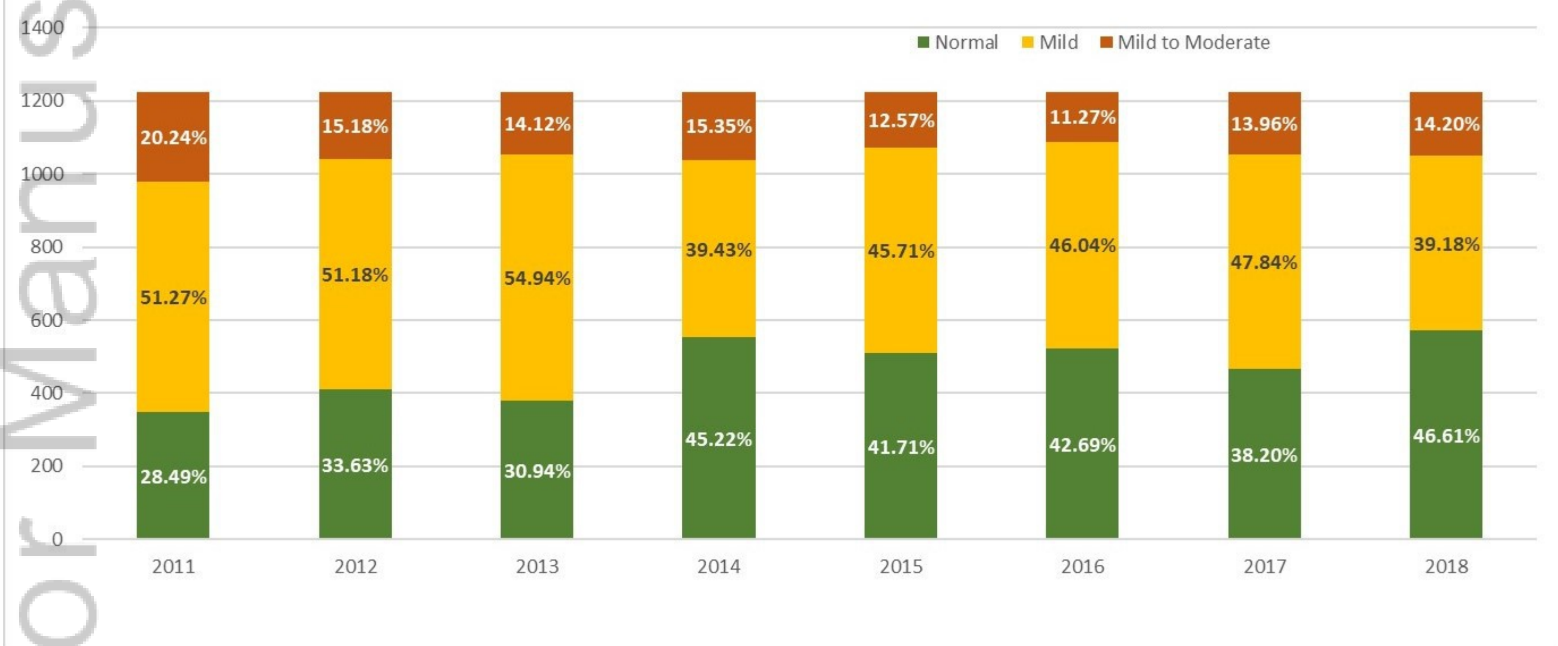
References

1. Strauss SE, Tinetti ME. Evaluation, management, and decision making with the older patients. In: Halter JB, Ouslander JG, Tinetti ME, Studenski S, High KP, Asthana S, editors. Hazzard's geriatric medicine and gerontology. 1. Chicago, IL: Mc Graw Hill; 2009. p. 133-40.
2. Petersen RC, Doody R, Kurz A, Mohs RC, Morris JC, Rabins PV, et al. Current concepts in mild cognitive impairment. Arch Neurol. 2001;58(12):1985-92.
3. Burns A, Iliffe S. Alzheimer's disease. Br Med J. 2009;338(7692):467-71.
4. Manly JJ, Tang M-X, Schupf N, Stern Y, Vonsattel J-PG, Mayeux R. Frequency and Course of Mild Cognitive Impairment in a Multiethnic Community. Ann Neurol. 2008;63(4):494-506.
5. Brookmeyer R, Evans DA, Hebert L, Langa KM, Heeringa SG, Plassman BL, et al. National estimates of the prevalence of Alzheimer's disease in the United States. Alzheimer's & dementia : the journal of the Alzheimer's Association. 2011;7(1):61-73.
6. Callahan KE, Lovato JF, Miller ME, Easterling D, Snitz B, Williamson JD. Associations of Mild Cognitive Impairment with Hospitalization and Readmission. J Am Geriatr Soc. 2015;63(9):1880-5.
7. Wilson RS, Hebert LE, Scherr PA, Dong X, Leurgens SE, Evans DA. Cognitive decline after hospitalization in a community population of older persons. Neurology. 2012;78(13):950-6.
8. Strunk BC, Ginsburg PB, Banker MI. The Effect Of Population Aging On Future Hospital Demand. Health Aff (Millwood). 2006;25(3):w141-w9.
9. Amini R, Chee KH, Swan J, Mendieta M, Williams T. The Level of Cognitive Impairment and Likelihood of Frequent Hospital Admissions. J Aging Health. 2019;31:967-88.
10. Sampson EL, Leurent B, Blanchard MR, Jones L, King M. Survival of people with dementia after unplanned acute hospital admission: a prospective cohort study. Int J Geriatr Psychiatry. 2013;28(10):1015-22.
11. Toot S, Devine M, Akporobaro A, Orrell M. Causes of hospital admission for people with dementia: a systematic review and meta-analysis. J Am Med Dir Assoc. 2013;14(7):463-70.
12. Gaspar JM, Baptista FI, Macedo MP, Ambrósio AF. Inside the Diabetic Brain: Role of Different Players Involved in Cognitive Decline. ACS Chem Neurosci. 2016;7(2):131-42.
13. Kim J, Park E, An M. The Cognitive Impact of Chronic Diseases on Functional Capacity in Community-Dwelling Adults. The journal of nursing research : JNR. 2019;27(1):1-8.
14. Manolio TA, Olson J, Longstreth WT. Hypertension and cognitive function: pathophysiologic effects of hypertension on the brain. Curr Hypertens Rep. 2003;5(3):255-61.
15. Morley JE. Cognition and Chronic Disease. J Am Med Dir Assoc. 2017;18(5):369-71.
16. Agarwal KS, Kazim R, Xu J, Borson S, Taffet GE. Unrecognized Cognitive Impairment and Its Effect on Heart Failure Readmissions of Elderly Adults. J Am Geriatr Soc. 2016;64(11):2296-301.
17. Greysen S, Stijacic Cenzer I, Auerbach AD, Covinsky KE. Functional impairment and hospital readmission in medicare seniors. JAMA Internal Medicine. 2015;175(4):559-65.
18. Gure TR, Langa KM, Fisher GG, Piette JD, Plassman BL. Functional Limitations in Older Adults Who Have Cognitive Impairment Without Dementia. J Geriatr Psychiatry Neurol. 2013;26(2):78-85.
19. Kasper JD, Freedman VA. National Health and Aging Trends Study User Guide: Rounds 1, 2 & 3 Final Release. Baltimore: Johns Hopkins University School of Public Health2015.

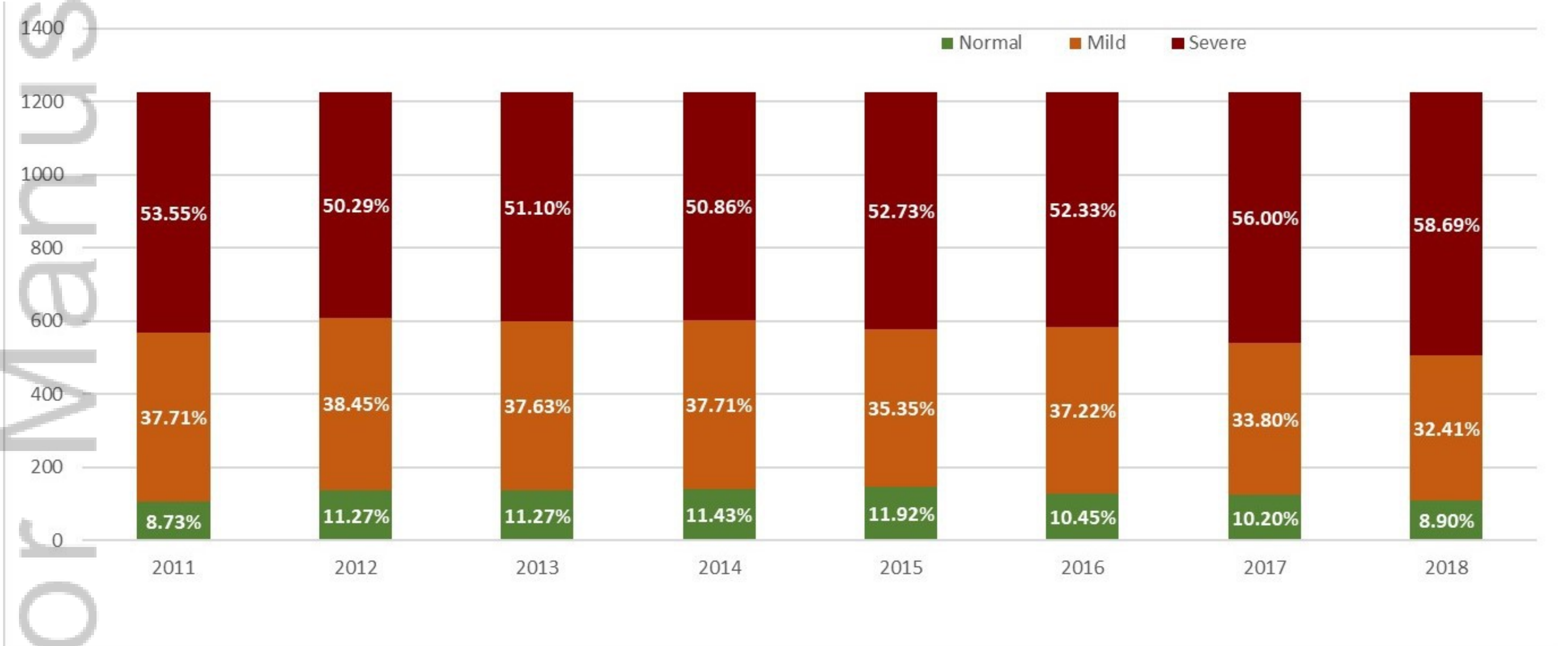
20. Montaquila J, Freedman VA, Spillman B, Kasper JD. National Health and Aging Trends Study Development of Round 1 Survey Weights, NHATS Technical Paper #2. NHATS Technical Paper #2 [Internet]. 2012. Available from: www.NHATS.org.
21. Short ME, Goetzel RZ, Pei X, Tabrizi MJ, Ozminkowski RJ, Gibson TB, et al. How accurate are self-reports? Analysis of self-reported health care utilization and absence when compared with administrative data. J Occup Environ Med. 2009;51(7):786-96.
22. Samton JB, Ferrando SJ, Sanelli P, Karimi S, Raiteri V, Barnhill JW. The Clock Drawing Test: Diagnostic, Functional, and Neuroimaging Correlates in Older Medically Ill Adults. J Neuropsychiatry Clin Neurosci. 2005;17(4):533-40.
23. Takayama Y. A Delayed Recall Battery as a Sensitive Screening for Mild Cognitive Impairment: Follow-up Study of Memory Clinic Patients after 10 years. J Med Dent Sci. 2010;57:177-84.
24. Institute for Digital Research and Education (IDRE). Stata Data Analysis Examples: Zero-inflated Negative Binomial Regression Los Angeles: UCLA; 2011 [Available from: http://www.ats.ucla.edu/stat/stata/dae/zinb.htm.
25. Natalwala A, Potluri R, Uppal H, Heun R. Reasons for hospital admissions in dementia patients in Birmingham, UK, during 2002-2007. Dement Geriatr Cogn Disord. 2008;26(6):499-505.
26. Tuppin P, Kusnik-Joinville O, Weill A, Ricordeau P, Allemand H. Primary health care use and reasons for hospital admissions in dementia patients in france: database study for 2007. Dement Geriatr Cogn Disord. 2009;28(3):225-32.
27. Feil DG, Zhu CW, Sultzer DL. The relationship between cognitive impairment and diabetes self-management in a population-based community sample of older adults with Type 2 diabetes. J Behav Med. 2012;35(2):190-9.
28. Alzheimer's Association. 2019 Alzheimer's disease facts and figures. 2019.
29. Cho MH, Shin DW, Chang SA, Lee JE, Jeong SM, Kim SH, et al. Association between cognitive impairment and poor antihypertensive medication adherence in elderly hypertensive patients without dementia. Sci Rep. 2018;8(1):11688.
30. Golden J, Conroy RM, Lawlor BA. Social support network structure in older people: underlying dimensions and association with psychological and physical health. Psychol Health Med. 2009;14(3):280-90.

Figure 1.A The proportion of normal to mild-to-moderate executive function impairment across all waves among community-dwelling older adults

Figure 1.B The proportion of normal to severe memory impairment across all waves among community-dwelling older adults



GGI_14070_Figure1-A.jpg



GGI_14070_Figure1-B.jpg

Geriatrics & Gerontology International Self-reported Potential Conflict of Interest Disclosure Statement

Conflict of Interest Checklist:

Elements of Financial/Personal Conflicts	Reza Amini		Bushra Kawser	
	Yes	No	Yes	No
Employment/Leadership position/Advisory role:		X		X
Stock ownership or options:		X		X
Patent royalties/licensing fees:		X		X
Honoraria (e.g. lecture fees):		X		X
Manuscript fees:		X		X
Research funding:		X		X
Subsidies or Donations:		X		X
Endowed departments by commercial entities:		X		X
Travel fees, gifts, and others:		X		X

If there are more than 5 authors, please copy this form.

***Authors can be listed by abbreviations of their names**

For "yes", provide a brief explanation: ______________________________

Author Contributions:

Reza Amini: Lead the project, developing the idea, literature review, data analysis, writing the manuscript, edit and submit to the GGI; Corresponding author;

Bushra Kawser: Literature review, develop the Introduction and contribute to the discussion;

Sponsor's Role: "none".

Table 1. Frequency of Hospital Admission, CDT score, word recall, and control variables among community-dwelling older adults (2011-2018)

	2011	2012	2013	2014	2015	2016	2017	2018	Global
	Mean(SD) Range	Mean(SD) Range	Mean(SD) Range	Mean(SD) Range	Mean(SD) Range	Mean(SD) Range	Mean(SD) Range	Mean(SD) Range	Mean(SD) Range
Hospital Admission	0.21(0.77) 0 – 17	0.27(1.15) 0 – 30	0.27(0.89) 0 – 15	0.27(0.75) 0 – 11	0.22(0.59) 0 – 7	0.26(0.67) 0 – 7	0.30(0.84) 0 – 11	0.30(0.73) 0 – 8	0.26(0.81) 0 – 30
	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)
Executive Function†									
Normal	349(28.49)	412(33.63)	379(30.94)	554(45.22)	511(41.71)	523(42.69)	468(38.20)	571(46.61)	3,213(37.47)
Mild	628(51.27)	627(51.18)	673(54.94)	483(39.43)	560(45.71)	564(46.04)	586(47.84)	480(39.18)	4,118(48.02)
Mild to Moderate	248(20.24)	186(15.18)	173(14.12)	188(15.35)	154(12.57)	138(11.27)	171(13.96)	174(14.20)	1,244(14.51)
Memory‡									
Normal	107(8.73)	138(11.27)	138(11.27)	140(11.43)	146(11.92)	128(10.45)	125(10.20)	109(8.90)	1,031(10.52)
Mild	462(37.71)	471(38.45)	461(37.63)	462(37.71)	433(35.35)	456(37.22)	414(33.80)	397(32.41)	3,556(36.29)
Severe	656(53.55)	616(50.29)	626(51.10)	623(50.86)	646(52.73)	641(52.33)	686(56.00)	719(58.69)	5,213(53.19)
Health Problems									
Heart Attack	124(10.13)	23(1.88)	20(1.63)	20(1.63)	10(0.82)	21(1.72)	20(1.64)	26(2.12)	264(2.70)
Heart Dis.	173(14.13)	196(16.00)	220(17.97)	247(20.18)	267(21.80)	277(22.61)	300(24.49)	330(26.94)	2,010(20.52)
HTN	773(63.21)	801(65.39)	825(67.40)	854(69.71)	867(70.78)	878(71.73)	900(73.47)	925(75.51)	6,823(69.65)
DM	242(19.76)	262(21.39)	279(22.76)	292(23.84)	299(24.41)	312(25.47)	322(26.29)	329(26.88)	2,337(23.85)
Lung Disease	154(12.57)	173(14.12)	192(15.67)	206(16.82)	227(18.53)	246(20.10)	267(21.81)	283(23.14)	1,748(17.84)
Stroke	75(6.13)	13(1.066)	15(1.22)	18(1.47)	12(0.98)	23(1.88)	18(1.47)	18(1.48)	192(1.96)
Cancer	312(25.47)	65(5.31)	65(5.31)	74(6.05)	76(6.20)	74(6.04)	83(6.78)	81(6.62)	830(8.48)
Dementia	5(0.41)	8(0.65)	13(1.06)	18(1.47)	25(2.04)	29(2.37)	34(2.78	50(4.08)	182(1.86)
History of Fall	87(7.10)	105(8.57)	104(8.50)	119(9.71)	133(10.86)	111(9.06)	132(10.78)	135(11.02)	926(9.45)
Walks 6 Blocks	962(79.05)	945(77.84)	915(75.31)	893(73.86)	881(73.23)	845(69.89)	798(66.50)	734(61.58)	6,973(72.19)
Live Not Alone	866(70.87)	869(70.94)	834(68.08)	833(68.00)	823(67.18)	819(66.86)	813(66.37)	792(64.65)	6,649(67.87)
Community-Dwelling	1,200(97.96)	1,197(97.71)	1,194(97.47)	1,186(96.82)	1,184(96.65)	1,178(96.16)	1,169(95.43)	1,151(93.96)	9,459(96.52)

Notes. † CDT: Clock Drawing Test; ‡ Delayed Word Recall Test; HTN: Hypertension; DM: Diabetes Mellitus.

Table 2. Regression Models: Health problems predict the level of EF and memory impairment among older adults (2011-2018).

Predictors	Model 1: EF(CDT)		Model 2: Memory(DWRT)	
	OR (SE)	95% CI	OR (SE)	95% CI
Heart Attack	1.50 (0.23) **	1.11 – 2.03	1.01 (0.17)	0.73 – 1.41
Heart Disease	0.94 (0.09)	0.78 – 1.13	1.10 (0.13)	0.87 – 1.40
Hypertension	1.16 (0.10)	0.98 – 1.38	1.46 (0.16) **	1.18 – 1.81
DM	1.30 (0.13) *	1.07 – 1.58	1.33 (0.17) *	1.03 – 1.71
Lung Disease	0.92 (0.09)	0.75 – 1.12	0.84 (0.11)	0.66 – 1.07
Stroke	1.34 (0.24)	0.94 – 1.91	1.65 (0.34) *	1.10 – 2.46
Cancer	1.04 (0.10)	0.86 – 1.24	0.97 (0.09)	0.80 – 1.17
Year	0.90 (0.01) ***	0.88 – 0.91	1.03 (0.01) **	1.01 – 1.05
Sigma2_u	1.73 (0.12)		3.85 (0.24)	3.41 – 4.34
	Log Likelihood=-7404.29 Wald Chi2(8)=158.54*** N=8,089		Log Likelihood=-7321.80 Wald Chi2(8)=41.22*** N=9,254	

Notes. Longitudinal Random-effects ordered logistic regression
EF: Executive Function; CDT: Clock Drawing Test; DWRT: Delayed Word Recall Test; DM: Diabetes Mellitus; OR: Odds Ratio.
$^{*}p<0.05$ $^{**}p<0.01$ $^{***}p<0.001$

Table 3. Longitudinal zero-inflated Poisson regression model: the level of EF predicting hospital admission among older adults (2011-2018)

Predictors		Model 1		Model 2		Model 3	
		IRR (SE)	95% CI	IRR (SE)	95% CI	IRR (SE)	95% CI
EF (CDT)		1.09 (0.04) *	1.02 – 1.18	-	-	-	-
Heart Attack		1.46 (0.14) ***	1.22 – 1.76	-	-	1.46 (0.14) ***	1.22 – 1.75
Normal EF & HA		-	-	1.71 (0.32) **	1.18 – 2.28	-	-
Mild EF		-	-	1.09 (0.07)	0.96 – 1.22	-	-
Mild EF & HA		-	-	1.44 (0.19) *	1.11 – 1.88	-	-
MM EF		-	-	1.20 (0.10) *	1.03 – 1.41	-	-
MM EF & HA		-	-	1.85 (0.30) ***	1.35 – 2.55	-	-
Heart Disease		1.62 (0.09) ***	1.44 – 1.82	1.62 (0.1) ***	1.44 – 1.81	1.62 (0.10) ***	1.44 – 1.81
Hypertension		1.26 (0.08) **	1.09 – 1.42	1.24 (0.09) **	1.09 – 1.41	1.25 (0.08) **	1.10 – 1.42
DM		1.22 (0.07) ***	1.11 – 1.40	1.25 (0.07) **	1.11 – 1.40	-	-
Normal EF & DM		-	-	-	-	1.14 (0.12)	0.93 – 1.40
Mild EF		-	-	-	-	1.05 (0.07)	0.91 – 1.20
Mild EF & DM		-	-	-	-	1.29 (0.12) **	1.08 – 1.53
MM EF		-	-	-	-	1.10 (0.10)	0.92 – 1.32
MM EF & DM		-	-	-	-	1.62 (0.18) ***	1.30 – 2.02
Lung Disease		1.20 (0.07) ***	1.11 – 1.41	1.25 (0.08) ***	1.11 – 1.41	1.25 (0.08) ***	1.11 – 1.41
Stroke		1.53 (0.16) **	1.16 – 1.78	1.44 (0.16) **	1.16 – 1.78	1.44 (0.16) **	1.16 – 1.78
Cancer		1.44 (0.11) ***	1.26 – 1.70	1.48 (0.12) ***	1.27 – 1.72	1.46 (0.11) ***	1.26 – 1.70
Falling		1.33 (0.10) ***	1.15 – 1.54	1.32 (0.10) ***	1.15 – 1.53	1.33 (0.10) ***	1.15 – 1.54
Walks 6 Blocks		0.66 (0.05) ***	0.57 – 0.78	0.66 (0.05) ***	0.57 – 0.77	0.67 (0.05) ***	0.57 – 0.78
Age		1.02 (0.01) ***	1.01 – 1.03	1.02 (0.01) ***	1.01 – 1.03	1.02 (0.01) ***	1.01 – 1.03
Hispanic		1.30 (0.18) *	1.01 – 1.76	1.34 (0.19) *	1.01 – 1.77	1.31 (0.19)	0.99 – 1.73
African American		1.15 (0.11)	0.92 – 1.35	1.11 (0.11)	0.92 – 1.35	1.09 (0.11)	0.90 – 1.32
Other Ethnicities		0.43 (0.16) *	0.17 – 0.82	0.37 (0.15) *	0.17 – 0.81	0.37 (0.15) *	0.17 – 0.81
Women		0.90 (0.05)	0.81 – 1.01	0.90 (0.05) *	0.81 – 1.01	0.90 (0.05)	0.81 – 1.00
Lives with Partner		1.02 (0.06)	0.90 – 1.13	1.01 (0.06)	0.90 – 1.13	1.01 (0.06)	0.90 – 1.12
Year		0.98 (0.01) *	0.95 – 0.99	0.97 (0.01) *	0.95 – 0.99	0.97 (0.01) *	0.95 – 0.99
Inflated	Walks 6 Blocks	0.60 (0.12) ***	0.38 – 0.84	0.60 (0.12) ***	0.37 – 0.83	0.61 (0.12) ***	0.38 – 0.85
	Hispanic	-0.10 (0.24)	-0.54 – 0.41	-0.06 (0.24)	-0.53 – 0.41	-0.09 (0.24)	-0.56 – 0.39
	African American	0.18 (0.15)	-0.16 – 0.42	0.13 (0.15)	-0.16 – 0.42	0.11 (0.15)	-0.19 – 0.40
	Other Ethnicities	-2.36 (2.61)	-17.29 – 10.50	-3.63 (8.89)	-21.05 – 13.79	-3.67 (9.33)	-21.98 – 14.63
		Log Likelihood=-4931.039 LR Chi2(18)=335.00*** N=8,117		Log Likelihood=-4803.79 LR Chi2(20)=329.41*** N=7,963		Log Likelihood=-4803.08 LR Chi2(20)=330.82*** N=7,963	

Notes. IRR: Incidence Rate Ratio; EF: Executive Function; HA: Heart Attack; MM: Mild-to-Moderate * p<0.05 ** p<0.01 *** p<0.001

Table 4. Longitudinal zero-inflated Poisson regression model: Memory predicting hospital admission among older adults (2011-2018)

Predictors	Model 1		Model 2		Model 3		Model 4	
	IRR (SE)	95% CI	IRR (SE)	95% CI	IRR (SE)	95% CI	IRR (SE)	95% CI
Memory (DWRT)	1.11 (0.04) **	1.03 – 1.20	-	-	-	-	-	-
Heart Attack	1.68 (0.14) ***	1.42 – 1.98	1.69 (0.14) ***	1.43 – 1.99	1.67 (0.14) ***	1.41 – 1.97	1.67 (0.14) ***	1.42 – 1.98
Heart Disease	1.65 (0.09) ***	1.48 – 1.83	1.64 (0.09) ***	1.45 – 1.83	1.65 (0.09) ***	1.48 – 1.83	1.65 (0.09) ***	1.48 – 1.83
Hypertension	1.18 (0.07) **	1.05 – 1.33	-	-	1.18 (0.07) **	1.05 – 1.33	1.18 (0.07) **	1.05 – 1.33
Normal DWRT & HTN	-	-	1.86 (0.39) **	1.23 – 2.81	-	-	-	-
Mild DWRT	-	-	1.96 (0.40) **	1.32 – 2.93	-	-	-	-
Mild DWRT & HTN	-	-	1.92 (0.38) **	1.31 – 2.82	-	-	-	-
Severe DWRT	-	-	1.74 (0.35) *	1.17 – 2.59	-	-	-	-
Severe DWRT & HTN	-	-	2.19 (0.42) ***	1.50 – 3.20	-	-	-	-
DM	1.21(0.07) **	1.08 – 1.34	1.21 (0.07) **	1.08 – 1.34	-	-	1.21 (0.07) **	1.08 – 1.35
Normal DWRT & DM	-	-	-	-	1.55 (0.30) *	1.06 – 2.27	-	-
Mild DWRT	-	-	-	-	1.29 (0.15) *	1.04 – 1.61	-	-
Mild DWRT & DM	-	-	-	-	1.55 (0.20) **	1.20 – 1.99	-	
Severe DWRT	-	-	-	-	1.40 (0.15) **	1.13 – 1.73	-	-
Severe DWRT & DM	-	-	-	-	1.64 (0.20) ***	1.30 – 2.08	-	-
Lung Disease	1.25 (0.07) ***	1.12 – 1.40	1.25(0.07) ***	1.12 – 1.40	1.25 (0.07) ***	1.12 – 1.40	1.25 (0.07) ***	1.12 – 1.40
Stroke	1.39 (0.14) **	1.14 – 1.71	1.40 (0.14) **	1.14 – 1.71	1.39 (0.14) **	1.14 – 1.71	-	-
Normal DWRT & Stroke	-	-	-	-	-	-	1.31 (0.58)	0.55 – 3.10
Mild DWRT	-	-	-	-	-	-	1.21 (0.12)	0.99 – 1.461
Mild DWRT & Stroke	-	-	-	-	-	-	1.66 (0.40) *	1.04 – 2.68
Severe DWRT	-	-	-	-	-	-	1.29 (0.13) **	1.07 – 1.56
Severe DWRT & Stroke	-	-	-	-	-	-	1.83 (0.27) ***	1.37 – 2.44
Cancer	1.42 (0.11) ***	1.22 – 1.64	1.41 (0.11) ***	1.22 – 1.63	1.42 (0.11) ***	1.23 – 1.64	1.42 (0.11) ***	1.22 – 1.64
Falling	1.23 (0.09) **	1.08 – 1.41	1.23 (0.09) **	1.07 – 1.41	1.23 (0.09) **	1.07 – 1.41	1.23 (0.09) **	1.07 – 1.41
Walks 6 Blocks	0.71 (0.05) ***	0.61 – 0.82	0.71 (0.05) ***	0.62 – 0.82	0.71 (0.05) ***	0.61 – 0.81	0.71 (0.05) ***	0.61 – 0.82
Age	1.02 (0.01) ***	1.01 – 1.03	1.02 (0.01) ***	1.01 – 1.03	1.02 (0.01) ***	1.01 – 1.03	1.02 (0.01) ***	1.01 – 1.03
Hispanic	1.21 (0.17)	0.93 – 1.59	1.22 (0.17)	0.93 – 1.60	1.23 (0.17)	0.94 – 1.62	1.22 (0.17)	0.93 – 1.60
African American	1.06 (0.10)	0.89 – 1.28	1.07 (0.01)	0.89 – 1.28	1.07 (0.10)	0.90 – 1.29	1.07 (0.10)	0.89 – 1.28
Other Ethnicities	0.42 (0.14) *	0.21 – 0.81	0.42 (0.14) *	0.21 – 0.82	0.42 (0.14) *	0.21 – 0.82	0.42 (0.14) *	0.21 – 0.82
Women	0.91 (0.05)	0.82 – 1.01	0.91 (0.05)	0.82 – 1.01	0.91 (0.05)	0.82 – 1.01	0.91 (0.05)	0.82 – 1.01
Lives with Partner	0.97 (0.05)	- 0.87 – 1.08	0.97 (0.05)	0.87 – 1.07	0.97 (0.05)	0.87 – 1.08	0.97 (0.05)	0.87 – 1.07
Year	0.97 (0.01) **	0.95 – 0.99	0.97 (0.01) **	0.95 – 0.99	0.97 (0.01) **	0.95 – 0.99	0.97 (0.01) **	0.95 – 0.99
Inflated								
Walks 6 Blocks	0.67 (0.11) ***	0.45 – 0.90	0.68 (0.11) ***	0.45 – 0.90	0.66 (0.11) ***	0.44 – 0.89	0.67 (0.11) ***	0.45 – 0.90
Hispanic	-0.17 (0.24)	-0.63 – 3.00	-0.17 (0.24)	-0.63 – 0.30	-0.16 (0.24)	-0.62 – 0.33	-0.17 (0.24)	-0.63 – 0.30
African American	0.06 (0.15)	-0.23 – 0.35	0.06 (0.15)	-0.23 – 0.35	0.07 (0.15)	-0.22 – 0.35	0.06 (0.15)	-0.23 – 0.35
Other Ethnicities	-1.97 (1.74)	-5.37 – 1.44	-1.96 (1.74)	-5.38 – 1.42	-1.97 (1.76)	-5.42 – 1.47	-1.95 (1.723)	-5.33 – 1.42
	Log Likelihood=-5531.26		Log Likelihood=-5526.08		Log Likelihood=-5529.89		Log Likelihood=-5530.78	
	LR Chi2(17)=347.85***		LR Chi2(20)=358.22***		LR Chi2(20)=350.60***		LR Chi2(20)=348.81***	
	N=9,113		N=9,113		N=9,113		N=9,113	

Notes. IRR: Incidence Rate Ratios; EF: Executive Function; HTN: Hypertension; DM: Diabetes Mellitus; DWRT: Delayed Word Recall Test *p<0.05**p<0.01***p<0.001