Online Engagement and Cognitive Function among Senior Adults

Brief Running Heading: Online Engagement and Cognition

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

Kyong Hee Chee, PhD

Department of Sociology, College of Liberal Arts, Texas State University

Email: kc26@txstate.edu

Maximiliano Mendieta, PhD

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

Email: maxmend@umflint.edu

Shan Parker, PhD

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

Email: shanpark@umflint.edu

Word Count: 2,938

Online Engagement and Cognitive Function among Senior Adults

Abstract

Aim: Social engagement is known to serve an important role for cognitive health, but there has been limited information on the role of online engagement. This study aims to identify benefits of different online activities for the cognitive function of senior adults.

Methods: Data come from the National Health and Aging Trend Study, Round I – V (2011 – 2015) with more than 8,000 respondents from Medicare beneficiaries. Cognitive function was measured by Clock Drawing Test and immediate 10-word recall. The respondents were also asked if they performed any of the online activities listed.

Results: Some online activities, such as email and texting and seeking medical information, can reduce the risk of cognitive decline. While contacting medical provider using online can increase risk of cognitive decline.

Conclusions: Given the findings, the development of new technologies for online social engagement needs to be one of the priorities for researchers and policymakers in the field of aging and dementia.

Keywords: cognitive function, dependency, loneliness, social engagement, social network,

Online Engagement and Cognitive Function among Senior Adults

Introduction

From the sociological standpoint, aging represents changing social roles expected in later stages of the life course. When older adults are assumed unable to perform their social roles due to disabilities and diseases, they will be marginalized and gradually disengaged from social roles. After a while, the social engagement domain for seniors may be limited to family support, friends, significant others, mealtime enjoyment, and the perceived friendliness of the formal and informal caregivers (1), all of which will typically be weakened in advanced, later life stages.

The power of spirituality, which helps seniors adapt with limitations and challenges, requires connections with family, representing important cultural and social bonds (2). Moreover, social interactions and engagement in various activities have a significant impact on the physiological functioning of the brain, and ultimately the level of cognitive function (3). The level of cognition is significantly related to social connections and interactions, particularly social activities (3).

Cognitive function can be defined based on the activities of thinking, understanding, attention and learning, memory, judgment, and executive function (4). Normal aging can cause slower physical performance due to neuromuscular changes (5). Hence, people in advanced age generally need more time to prepare themselves for talking as longer pauses may help them process the conversation and execute their response throughout a conversation. This slow pace of talking may cause some problems in communication with members of younger age groups who can usually speak at a faster pace.

Physical distance would be one of the barriers for maintaining meaningful social connections (6). Non-visual contact via telephone with adult children can preserve cognitive function among elderly (7). Using telecommunication technologies such as telephone and social media has, therefore, become one of the prominent factors in social interaction among older adults, in particular (8). Hence, certain online activities may facilitate social interaction and reduce the risk of cognitive decline. This process has not yet been examined using longitudinal data with a large sample of senior adults.

There exists some empirical evidence that suggests benefits of using the Internet for older adults' cognition. When compared to their non-user counterparts (9), Internet users among older adults tend to exhibit better performance in delayed recall. Online literacy intervention can not only improve cognitive performance (10) but also lower the risk of dementia in middle-aged adults (11). Although some studies showed the potential cognitive benefits of learning and using Facebook, an online social networking site, for healthy older adults (12), reliance on small sample size, cross-sectional data significantly limits the discussion of a causal relationship between online social engagement and cognitive function.

Considering the high cost of cognitive impairment for the public (13) and need for more affordable, non-medical interventions, this paper aims to assess potential benefits of online activities for cognitive function among older adults, with the hypothesis that the level of cognitive impairment is significantly associated with the extent of online activities.

Method

The data

We used data collected in the National Health and Aging Trend Study (2011-2015), with over 8,000 respondents from Medicare beneficiaries, age 65 and over. Three stage stratified sampling was used in order to select the respondents from the Medicare beneficiaries ages 65 and older as of September 30, 2011. The primary sample units were composed of 95 counties or group of counties across the United States. The secondary sample units were selected based on the ZIP codes and respondents in each ZIP code were selected upon considering the proportion of the race/ethnicity (non-Hispanic Black, Hispanic, White, and other) and age in the population of the same ZIP code (14).

Measurement

The dependent variable was *cognitive function*, which was measured by self-rated memory, orientation and executive function (Clock Drawing Test), and retrieval information (delayed word recall test) (14). The latter was tested by using 3 lists of 10 words, and respondents were randomly assigned to 1 of the 3 lists, which was read to the respondents. After a delay, the respondents were asked to name the words.

The interviewers, as part of a cognitive function test, instructed the respondents to perform Clock Drawing Test (CDT) on the provided piece of paper. The results of CDT were categorized into 6 levels from 0 to 5 when 5 was the most accurate performance and 0 the least, which is highly correlated with Mini Mental State Examination (MMSE) (15). An immediate 10-word recall test was performed to evaluate memory (14). The cut-off for the 10-word list was 6 or above being

considered as normal (16) and less than 3 as impaired (14). Using the combination of the immediate 10-word recall test and the CDT, cognitive function was categorized into 5 levels: normal, mild, mild to moderate, moderate, and severe cognitive function (17).

If the respondent had a severe illness, a hearing loss, or diagnosed dementia at the time of study, a proxy respondent, who was involved in daily activities of the respondent, answered the questions other than CDT and word-recall test (14). The proportion of the self-respondents who had severe cognitive impairment is tabulated in Table 1.

[Table 1 about here]

Independent variables

Online activities considered as the independent variables are using email/texting for communication, seeking medical information online, surfing the Internet for medical information, contact medical provider (online), online banking, online refill prescriptions, and online grocery shopping, which are dichotomous (Yes=1; No=0). After creating global observed variables including all waves, we also created a latent variable called *online engagement* by adding the scores of the aforementioned (observed) variables. The results of Structural Equation Modeling show that all of the observed variables significantly explained the variation of latent variable, online activities (p<.001) (Table 2). Although the likelihood ratio Chi-squared test was statistically significant and the large sample size can be the reason, both Root Mean Square Error of Approximation and Comparative Fit Index indicate that it was a fit model (Table 2).

[Table 2 about here]

Control variables

The control variables in this study were self-reported health status (excellent, good, and fair), falling down, functional limitations in the Activity of Daily Living (ADL): laundry, shopping, meal preparation, money management, walking 6 blocks, climbing 20 stairs, going out, moving inside the house/apartment/unit, getting out of bed, taking shower, dressing, eating, and bathing were considered as functional limitations. Age and living status (alone vs. partner/spouse) were reported by the respondents. Education was asked in the first and fifth waves and categorized into nine levels: no school, 1-8th grade, 9-12th grade/high school diploma, vocational/some college degree, Associate degree, Bachelor's degree, and Master's/Doctoral degree.

Data analysis

The dependent variable (cognitive function) is an ordinal variable with 5 levels ranging from normal to severe and very severe impairment. The independent variables are self-reported activities: using email or online texting, collecting medical information on the websites, searching the Internet for health insurance, communicating with medical provider via online platforms, refilling prescription online, shopping groceries online, online banking, working for payment, participating in religious activities, membership in clubs, walking, going out for enjoyment, caring another person, vigorous physical activities, visiting family members regularly, and volunteer activities.

Longitudinal ordinal logistic regression was used in STATA 15 since the dependent variable was an ordinal variable. Appending all the 5 waves of NHATS in 1 file, global dependent, independent, and control variables were created considering the year. In order to test the proportional odds assumption, Brant's test of ordered logistic regression was used. The results

suggested that the assumptions were met (Chi^2 for all the independent variables=29.44 $p>Chi^2=0.104$).

The possibilities of selective and random attrition over the five waves, which is beyond the scope of the current study, has been examined and reported elsewhere (18). The weighting method used for all waves significantly reduced the impact of both the intermittent and terminal nonresponse bias in the data analyses (18). We excluded those cases with missing values from our statistical analysis to reduce the potential impact of nonresponse bias.

Results

Cognitive impairment

The proportion of participants with mild to severe cognitive impairment declined unlike the proportion of those with normal cognitive function, which showed an increasing trajectory from 19.94% in 2011 to 35.79% in 2015 (Table 1). One of the possible reasons can be attributed to mortality as a significant correlation between cognitive function in the previous term and mortality was found in cross-tabulation in all 4 waves (Chi^2= 72.71 p<0.0001, 62.21 p<0.0001, 38.99 p<0.0001, 46.67 p<0.0001 for 2012 to 2015 respectively).

[Table 3 about here]

Online activities

The proportion of participants who reported at least 1 online activity continuously increased from 42.12% (2011) to 50.74% (2015). Among all of the activities, visiting family members had the highest rate in 5 waves; more than 85% of the participants visited their family members regularly. Going out for enjoyment was in the second rank of activities followed by religious activities, and

walking. Among online activities, online banking (42.86% - 50.79%) was on the top and showed an increasing trend throughout the 5 waves. Email and texting was the second followed by seeking medical information online, online grocery shopping, online refill of prescriptions, communicating with medical provider online, and surfing the Internet for insurance (Table 3).

Control variables

The most frequent functional limitation across 5 waves was walking 6 blocks (41.73% in 2011- 45.07% in 2014) followed by climbing 20 stairs, moving out of bed, going out, moving inside home, and so forth (please see Table 1). In fact, functional limitations were more likely to restrict their physical movements and potentials for social interactions. Hence, online activities could be a partial substitute for face-to-face interactions.

More than half (61.5%) of the respondents had high school or some college degrees, 12.09% and 10.17% had Bachelor degree and Master or Doctoral degree respectively. The proportion of respondents with no school and 1-8 grade education was 1.04% and 11.68% respectively.

Regression model

Two different models were created using longitudinal ordinal regression in order to examine the impact of online engagement and online activities on cognitive function, controlling for function and other control variables (Table 4). The first model considered the latent variable, online activities, whereas the second model included the observed online activities. Based on Model 1, online engagement can significantly reduce the odds of cognitive impairment by 54% ($p<0.001$). Meeting people in clubs (19%, $p=0.016$), going out (39%, $p<0.001$), visit family members (37%, $p=0.001$), volunteer activities (25%, $p=0.002$), and education (26% for each level increase in

education, p<0.001) are other significant factors with similar effects as online engagement. Meanwhile, living alone (11%, p<0.001), limitations in bank/money management (74%, p=0.002), and self-reported health status ("fair" twice as "excellent"; "good" 37% more than "excellent," p<0.001) are the predictors for cognitive deficit over time. In addition to other predictors, people in age categories 75-79 (25%, p=0.073), 80-84 (94%, p<0.001), and 85-89 (220%, p<0.001) are more likely to have more severe cognitive impairment compared with the 65-74 category. In the second model, among online activities, email and online texting (51%, p<0.001) and seeking medical information online (29%, p=0.013), and contact medical provider (150%, p=0.020) significantly predicted the cognitive impairment. The significance level of club meeting disappeared in the second model, while the odds of going out (56%, p<0.001) and limitation in bank/money management (308%, p<0.001) significantly changed. Participants in 75-79 (145%, p=0.042), 80-84 (271%, p<0.001), and 85-89 (413%, p<0.001) age groups were more likely to have more severe cognitive impairment compared with the 65-74 age group. Those who rated their health status as good and fair were 88% (p<0.001) and 275% (p<0.001) more likely to experience more severe cognitive impairment, respectively, compared with those reporting an excellent health status.

Discussion

The results of this study showed that cognitive function declined over the course of 5 years although the number of cases with moderate to severe and severe impairment decreased significantly (see "year" in Table 4). Participant mortality and attrition can be the main reasons for this trend. The relationship between age and cognitive decline that we found is consistent with other reports (19). The new approach to brain and cognitive function is tending toward functional

reorganization and compensation with new situations in old age (20), which can open new doors to maintaining cognitive function through non-pharmacological interventions.

Although Backman and associates reported about the correlation between social network and cognitive decline (19), we found from our study that online activities can reduce the risk of cognitive decline. Our findings are consistent with a longitudinal study of social network and cognition (21) in that engaging in online activities can significantly prevent cognitive impairment over time. Some of the activities are more effective than others, including using email and texting and seeking medical information on websites. Carlson (22) reported that those social contacts stimulating prefrontal cortex are necessary for brain health in general, and cognitive function in particular. Nonetheless, we do not know yet what type of activities and contacts can preserve brain function and the mechanism of online social contacts preventing cognitive decline. Thus, some neurobiological and neuroimaging research in this regard can be promising.

Social interactions can increase a sense of coherence, consequently influencing physical and mental health, and particularly cognitive function among older adults (23). The higher the level of social activity, the better the cognitive function reported in cross-sectional (3) and longitudinal studies (24). In addition to physical disability which is one of the barriers to social interaction, fear of rejection, exploitation, and losing social identity can be other significant barriers against social interaction, leading to isolation and loneliness (25). The feeling of being connected to the outside world can motivate senior adults to learn how to use devices (e.g., computers and tablets) despite some barriers such as sensory and motor limitations (26). In fact, Chan and associates reported that using iPad can enhance episodic memory in older adults (27). Online social activities may lower barriers to social interaction and help reduce the risk of loneliness among older adults and,

ultimately, the risk of cognitive decline. Although there has been limited information about the role of online activities, our results show that email and texting and seeking medical information can reduce the risk of cognitive decline.

It is not clear if cognitive function decline can cause such deficits, or contrarily reduced social connections can increase the risk of cognitive decline. In either way, a longer reaction and process time in conversations and difficulties in finding familiar words that may cause language barriers are less likely to be problematic in asynchronous online social interactions. Importantly, online engagement does not require social motivation nor some of the social skills necessary for face-to-face engagement because it is asynchronous.

Although we did not have access to some determinants of health such as blood pressure and sugar level, self-rated health status can be considered as the outcome measure of health (28). Our study shows that self-rated health status is a significant predictor for cognitive function. We controlled for the role of function, which was missing in previous studies.

~~(29) (30)~~ Although health service seeking behaviors can affect health outcomes, the utilization process and illness response are also important (29). Our findings unexpectedly show that there is a significant positive correlation between online contact with medical providers and cognitive decline. To the best of our knowledge, there is no report about the frequency of online contact with providers and cognitive impairment. It is indeed puzzling why people who engage in contacting medical provider using online are more likely to experience cognitive decline. It is difficult for us to explain this inconsistent finding. Future research needs to examine this unexpected relationship more closely and in greater depth, maybe employing a qualitative approach. Some factors that can affect the outcomes, such as delay in services and quality of care, would be

another aspect to consider. considering some factors that can affect the outcomes, such as delay in services.

In conclusion, healthy aging is one of the most important objectives of Healthy People 2020. Research findings that show significant factors related to cognitive function can lead public health policymakers to develop research-based interventions in order to maintain or even enhance the health status of senior citizens. We believe that social engagement as one of the preventive factors for cognitive decline needs to be more actively explored. Online social activities capitalizing on emerging technology should be regarded in social, psychological, behavioral, and neurobiological research in order to enrich impactful research findings and inform policymakers.

How can we then implement the results of this study in policy and practice? Our policy recommendations include a three-prong approach where DHHS policy, Group Medical Insurance providers, and Center for Medicare & Medicaid Services establish funds dedicated to preventing abnormal cognitive decline, funds for maintaining cognitive health, and funds to cover treatment and care for irreversible cognitive decline. The three-prong approach can support a national, state, and local integrated policy (macro policy) according to which all government services can be offered fully online, with citizen care (i.e. client, customer, citizen service) driven by social-media style technology.

The lowering of red-tape barriers through increased citizen access to government and health-related services based on technology will require that older adults maintain online skills and social group networking skills well into their old-old years. Ideally, different local-level organizations such as cities, counties, and community partners would implement programs that

connect all older adults with access to computer technology in their homes, churches, libraries, community centers, senior centers, universities, etc.

We did not have access to the frequency of online social activities. Hence, we recommend collecting data about the number of activities in the next wave of NHATS. Moreover, variations in the older population make it difficult to generalize the results.

Disclosure statement

The authors disclose no conflicts of interest.

References

1. Park NS. The relationship of social engagement to psychological well-being of older adults in assisted living facilities. J Appl Gerontol. 2009;28(4):461-81.

2. Sorrell JM. Successful aging, choosing wisdom over despair. Journal of Psychosocial Nursing. 2011;49(3):23-7.

3. Krueger KR, Wilson RS, Kamenetsky JM, Barnes LL, Bienias JL, Bennett DA. Social Engagement and Cognitive Function in Old Age. Exp Aging Res. 2009;35(1):45-60.

4. Carlsson CM, Gleason CE, Puglielli L, Asthana S. Dementia including Alzeheimer's disease. In: Halter JB, Ouslander JG, Tinetti ME, Asthana S, High KP, Studenski SA, et al., editors. Hazzard's geriatric medicine and gerontology. Chicago, IL: McGraw-Hill; 2009.

5. Galvin JE. Mental status and neurological examination in older adults. In: Halter JB, Ouslander JG, Tinetti ME, Asthana S, High KP, Studenski SA, et al., editors. Hazzard's geriatric medicine and gerontology. Chicago, IL: McGraw-Hill; 2009. p. 153-69.

6. Anderson R. Disabled and Out? Social Interaction Barriers and Mental Health among Older Adults with Physical Disabilities: the University of Nebraska; 2018.

7. Kim J-H, Chon D. Association of solidarity between adult children and older parents with cognitive decline. Geriatr Gerontol Int. 2018;18(10):1501-6.

8. Cotten SR, Anderson WA, McCullough BM. Impact of internet use on loneliness and contact with others among older adults: cross-sectional analysis. J Med Internet Res. 2013;15(2):e39-e.

9. Xavier AJ, d'Orsi E, de Oliveira CM, Orrell M, Demakakos P, Biddulph JP, et al. English Longitudinal Study of Aging: Can Internet/E-mail Use Reduce Cognitive Decline? The Journals of Gerontology: Series A. 2014;69(9):1117-21.

10. Morton TA, Wilson N, Haslam C, Birney M, Kingston R, McCloskey L-G. Activating and Guiding the Engagement of Seniors With Online Social Networking: Experimental Findings From the AGES 2.0 Project. J Aging Health. 2018;30(1):27-51.

11. Anstey KJ, Bahar-Fuchs A, Herath P, Kim S, Burns R, Rebok GW, et al. Body brain life: A randomized controlled trial of an online dementia risk reduction intervention in middle-aged adults at risk of Alzheimer's disease. Alzheimer's & Dementia: Translational Research & Clinical Interventions. 2015;1(1):72-80.

12. Myhre JW, Mehl MR, Glisky EL. Cognitive Benefits of Online Social Networking for Healthy Older Adults. J Gerontol B Psychol Sci Soc Sci. 2017;72(5):752-60.

13. Lin P-J, Zhong Y, Fillit HM, Chen E, Neumann PJ. Medicare Expenditures of Individuals with Alzheimer's Disease and Related Dementias or Mild Cognitive Impairment Before and After Diagnosis. J Am Geriatr Soc. 2016;64(8):1549-57.

14. 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.

15. Agrell B, Dehlin O. The clock-drawing test. Age Ageing. 1998;27:399-403.

16. 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.

17. Amini R, Chee KH, Swan J, Mendieta M, Williams T. The Level of Cognitive Impairment and Likelihood of Frequent Hospital Admissions. J Aging Health. 2017:898264317747078.

18. DeMatteis J, Freedman VA, Kasper JD. National Health and Aging Trends Study Development of Round 5 Survey Weights. NHATS Technical Paper #14. Baltimore, MD: Johns Hopkins University School of Public Health; 2016.

19. Bäckman L, Jones S, Small BJ, Agüero-Torres H, Fratiglioni L. Rate of Cognitive Decline in Preclinical Alzheimer's Disease: The Role of Comorbidity. The Journals of Gerontology: Series B. 2003;58(4):P228-P36.

20. Reuter-Lorenz PA, Lustig C. Brain aging: reorganizing discoveries about the aging mind. Curr Opin Neurobiol. 2005;15(2):245-51.

21. Holtzman RE, Rebok GW, Saczynski JS, Kouzis AC, Wilcox Doyle K, Eaton WW. Social network characteristics and cognition in middle-aged and older adults. J Gerontol B Psychol Sci Soc Sci. 2004;59(6):P278-84.

22. Carlson MC. Promoting Healthy, Meaningful Aging Through Social Involvement. Cerebrum. 2011.

23. Eriksson BG, Mellström D, Svanborg A. Medical-social intervention in a 70-year-old Swedish population. A general presentation of methodological experience. Compr Gerontol C. 1987;1:49-56.

24. Zhou Z, Wang P, Fang Y. Social Engagement and Its Change are Associated with Dementia Risk among Chinese Older Adults: A Longitudinal Study. Sci Rep. 2018;8(1):1551.

25. Goll JC, Charlesworth G, Scior K, Stott J. Barriers to Social Participation among Lonely Older Adults: The Influence of Social Fears and Identity. PLoS One. 2015;10(2):e0116664.

26. Chaffin AJ, Harlow SD. Cognitive Learning Applied to Older Adult Learners and Technology. Educational Gerontology. 2005;31(4):301-29.

27. Chan MY, Haber S, Drew LM, Park DC. Training Older Adults to Use Tablet Computers: Does It Enhance Cognitive Function? Gerontologist. 2016;56(3):475-84.

28. Cesari M, Onder G, Zamboni V, Manini T, Shorr RI, Russo A, et al. Physical function and self-rated health status as predictors of mortality: results from longitudinal analysis in the ilSIRENTE study. BMC Geriatr. 2008;8(34).

29. MacKian S. A review of health seeking behaviour: problems and prospects. 2003.

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

Conflict of Interest Checklist:

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

Max Mendieta: Literature review, develop the Introduction and contribute to the discussion;

K.H. Chee: Literature review, develop the introduction and method, contribute to the discussion, and edit the manuscript;

Shan Parker: Develop the introduction and contribute to the discussion;

Sponsor's Role: "none".

Table 1. Characteristics of the participants

		Year N (%)				
		2011	2012	2013	2014	2015
Age	65 – 69	1,325 (17.94)	923 (14.04)	473 (8.97)	198 (4.57)	1,063 (13.23)
	70 – 74	1,481 (20.05)	1.280 (19.49)	1,129 (21.40)	988 (22.80)	1,784 (22.19)
	75 – 79	1,447 (19.59)	1,293 (19.67)	1040 (19.71)	861 (19.87)	1,623 (20.19)
	80 – 84	1,399 (18.94)	1,308 (19.90)	1080 (20.46)	918 (21.19)	1,501 (18.67)
	85 – 89	961 (13.01)	989 (15.05)	855 (16.21)	756 (17.45)	1,145 (14.25)
	90+	773 (10.47)	779 (11.85)	699 (13.25)	612 (14.12)	922 (11.47)
	Male	2,966 (40.16)	-	2300 (39.66)	1,857 (39.58)	3,407 (40.88)
Ethnicity	White, non-hispanic	5,212 (71.32)	-	4,085 (70.96)	3,369 (71.64)	5,703 (70.13)
	Black, nonhispanic	1,495 (20.46)	-	1,231 (21.38)	982 (20.88)	1,710 (21.03)
	Other‡	208 (2.84)	-	141 (2.45)	113 (2.40)	244 (3.00)
	Hispanic	387 (5.30)	-	296 (5.14)	235 (4.99)	467 (5.74)
	More than one	6 (0.08)	-	4 (0.07)	4 (0.09)	8 (0.10)
Levels of cognition	Normal	934 (19.94)	932 (25.77)	814 (25.96)	1,086 (40.21)	1,769 (35.79)
	Mild	1,583 (33.80)	1,264 (34.96)	1,061(33.84)	680 (25.18)	1,475 (29.84)
	Mild to moderate	1,269 (27.10)	809 (22.37)	679 (21.66)	548 (20.29)	1,035 (20.94)
	Moderate	558 (11.92)	473 (13.08)	322 (10.27)	242 (8.96)	490 (9.91)
	Severe	339 (7.24)	138 (3.82)	259 (8.26)	145 (5.37)	174 (3.52)
Function	Walking 6 blocks	41.73 (3,148)	43.18 (2,586)	44.49 (2,133)	45.07 (1,781)	41.63 (3,102)
	Climb 20 stairs	35.02 (2,633)	36.16 (2,154)	35.86 (1,714)	37.01 (1,459)	34.25 (2,555)
	Moving out of bed	21.88 (1,665)	20.72 (1,254)	20.82 (1,017)	22.44 (906)	22.49 (1,704)
	Going out	20.69 (1,547)	21.04 (1,247)	21.19 (1,013)	22.51 (889)	20.76 (1,545)
	Moving inside home	20.26 (1,538)	19.43 (1,175)	18.62 (906)	20.17 (811)	19.77 (1,493)
	Bathing	18.12 (1,379)	17.68 (1,071)	18.49 (903)	20.11 (812)	17.91 (1,357)
	Meal preparation	13.28 (653)	12.74 (494)	12.74 (408)	15.00 (397)	14.63 (737)
	Dressing	12.39 (936)	17.23 (1,109)	19.87 (1,056)	21.13 (925)	16.15 (1,259)
	Shopping	12.16 (496)	11.68 (383)	10.76 (288)	12.43 (279)	13.20 (575)
	Shower	10.71 (914)	17.40 (1,132)	19.23 (1,028)	19.67 (868)	13.93 (1,093)
	Laundry	9.68 (438)	8.63 (310)	8.73 (255)	8.87 (212)	9.68 (450)
	Bank/money management	8.45 (400)	7.54 (284)	7.37 (222)	8.95 (226)	8.91 (439)
	Eating	6.64 (505)	6.22 (376)	6.87 (335)	7.12 (387)	6.38 (483)
	Toilet	4.36 (331)	8.90 (579)	10.31 (552)	10.62 (469)	6.56 (515)
	Use telephone	3.72 (282)	3.27 (197)	3.58 (174)	3.71 (149)	3.31 (250)

Note. ‡ American Indian, Asian, Native Hawaiian, Pacific Islander, other non-hispanic

Table 2. Structural Equation Model - online engagement

Online activities	Coefficient (*SE*)	95% CI
Email/texting	1^{***} (Constrained)	0.82 – 0.83
Medical info. online	1.76^{***} (0.06)	1.63 – 1.88
Internet for insurance	1.35^{***} (0.05)	1.25 – 1.45
Contact medical provider online	1.79^{***} (0.06)	1.67 – 1.92
Online banking	1.92^{***} (0.07)	1.79 – 2.06
Online refill prescription	1.56^{***} (0.06)	1.45 – 1.68
Online grocery shopping	1.48^{***} (0.06)	1.37 – 1.60

Note. N=11,352 Log Likelihood=-40064.25
LR baseline vs. saturated: Chi^2 (14)= 743.21^{***} Comparative Fit Index (CFI)=0.923
Root Mean Square Error Approximation (RMSEA)=0.068^{***} (95% CI: 0.064 – 0.072)
$^{*}p<0.05$ $^{**}p<0.01$ $^{***}p<0.001$

Table 3. Proportions of activities 2011-2015

	Year % (*N*)				
Activities	2011	2012	2013	2014	2015
Online engagement	42.12 (2,536)	44.45 (2,163)	46.07 (1,813)	47.41 (1,564)	50.74 (3,299)
Visit family regularly	85.29 (6,482)	87.29 (5,281)	86.60 (4,221)	85.00 (3,428)	84.93 (6,427)
Out for enjoyment	73.60 (5,594)	75.28 (4,557)	74.72 (3,641)	74.75 (3,014)	74.81 (5,662)
Religious	57.98 (4,408)	58.21 (3,520)	58.10 (2,830)	57.99 (2,338)	57.89 (4,382)
Walking	57.79 (4,395)	57.60 (3,485)	57.71 (2,814)	56.08 (2,261)	57.97 (4,390)
Online banking	42.86 (1,086)	44.54 (963)	45.17 (819)	46.71 (730)	50.79 (1,675)
Email/texting	39.82 (2,397)	41.20 (2,005)	43.40 (1,709)	45.94 (1,515)	50.61 (3,291)
Medical info. online	35.28 (894)	36.11 (781)	36.96 (670)	38.49 (602)	39.25 (1,295)
Club meetings	34.37 (2,613)	36.86 (2,229)	36.62 (1,784)	38.08 (1,535)	35.84 (2,714)
Vigorous activities	33.83 (2,572)	34.53 (2,090)	34.76 (1,693)	34.12 (1,375)	35.69 (2,702)
Online grocery shopping	29.98 (760)	30.19 (653)	33.09 (600)	32.44 (507)	36.78 (1,213)
Volunteer activities	22.54 (1,714)	23.07 (1,396)	23.12 (1,127)	24.13 (973)	24.14 (1,828)
Online refill prescription	17.55 (445)	19.02 (411)	21.46 (389)	22.31 (349)	22.04 (727)
Care another person	16.44 (1,250)	16.44 (995)	16.52 (805)	16.50 (665)	17.41 (1,318)
Contact medical provider online	15.58 (395)	16.98 (367)	19.96 (357)	24.82 (388)	27.86 (918)
Work for payment	11.61 (826)	11.25 (633)	11.41 (505)	10.44 (374)	12.42 (853)
Internet for insurance	11.44 (290)	12.49 (270)	12.47 (226)	13.64 (213)	16.72 (551)

Table 4. Online engagement/online activities and cognitive impairment 2011-2015

Predictors		Model 1 OR	Model 1 95% CI	Model 2 OR	Model 2 95% CI
Online engagement		0.46***	0.38 – 0.55	-	-
Online activities	Email/texting	-	-	0.49***	0.35 – 0.69
	Medical info. online	-	-	0.71*	0.55 – 0.93
	Internet for insurance	-	-	1.23	0.84 – 1.80
	Contact medical provider online	-	-	1.50*	1.07 – 2.10
	Online refill prescription	-	-	0.97	0.76 – 1.32
	Online grocery shopping	-	-	0.85	0.65 – 1.11
	Online banking	-	-	1.00	0.76 – 1.32
Living alone		1.11***	1.05 – 1.17	1.13**	1.05 – 1.22
Falling Injury		0.80*	0.67 – 0.96	0.82	0.62 – 1.08
Work for payment		0.94	0.75 – 1.18	0.86	0.62 – 1.18
Religious		1.13	0.95 – 1.34	1.04	0.79 – 1.36
Club meetings		0.81*	0.68 – 0.96	0.84	0.65 – 1.10
Walking		1.13	0.95 – 1.35	0.99	0.74 – 1.34
Out for enjoy		0.61***	0.50 – 0.76	0.44***	0.30 – 0.65
Care another person		0.86	0.72 – 1.03	0.88	0.67 – 1.16
Vigorous activities		1.09	0.92 – 1.28	1.18	0.91 – 1.51
Visit family regularly		0.63***	0.48 – 0.82	0.69*	0.43 – 1.12
Volunteer activities		0.75**	0.63 – 0.91	0.74*	0.57 – 0.97
Use telephone		1.48	0.80 – 2.73	1.81	0.65 – 5.03
Laundry		0.90	0.61 – 1.32	1.07	0.55 – 2.07
Shopping		0.82	0.62 – 1.10	0.65	0.39 – 1.07
Meal preparation		0.74	0.53 – 1.02	0.81	0.46 – 1.42
Bank/money management		1.74**	1.22 – 2.49	3.08***	1.71 – 5.55
Shower		0.38	0.09 – 1.55	0.13	0.01 – 4.14
Toilet		1.82	0.18 – 18.77	-	-
Dressing		1.11	0.57 – 2.15	0.98	0.34 – 2.86
Walking 6 blocks		1.06	0.85 – 1.34	0.84	0.56– 1.26
Climb 20 stairs		1.03	0.81 – 1.30	1.07	0.70 – 1.65
Going out		0.75	0.54 – 1.04	0.63	0.35 – 1.12
Moving inside home		1.31	0.97 – 1.79	1.11	0.65 – 1.88
Moving out of bed		1.07	0.82 – 1.39	1.08	0.69 – 1.72
Eating		0.63	0.30 – 1.35	0.72	0.21 – 2.41
Bathing		1.05	0.72 – 1.53	0.72	0.36 – 1.45
Age groups†	75-79	1.25	0.98 – 1.59	1.45*	1.01 – 2.13
	80-84	1.94***	1.50 – 2.51	2.71***	1.80 – 4.09
	85-89	2.20***	1.61 – 3.01	4.13***	2.38 – 7.17
	90=<	0.89	0.71 – 1.10	1.04	0.76 – 1.44
Health status	Fair	2.00***	1.57 – 2.55	2.75***	1.75 – 4.33
	Good	1.37***	1.15 – 1.63	1.88***	1.42 – 2.47
Education		0.74***	0.69 – 0.80	0.77***	0.70 – 0.84
Year		0.78***	0.74 – 0.82	0.75***	0.70 – 0.82
σ_u^2		2.73	2.25 – 3.33	3.60	2.69 – 4.81
		N=4,860		N=2,492	
		Wald $Chi^2(35)=592.14^{***}$		Wald $Chi^2(41)=236.85^{***}$	
		Log Likelihood=-5848.31		Log Likelihood=-2624.96	
		LR vs. ologit $Chibar^2(01)=325.62^{***}$		LR vs. ologit $Chi^2(2)=166.82^{***}$	

Note. OR: Odds Ratio CI: Confidence Interval

† 65 - 74 is the reference group

The reported likelihood-ratio test shows that there is enough variability between *individuals (respondents)* to favor a random-effects ordered logistic regression over a standard ordered logistic regression.

*$p<0.05$ **$p<0.01$ ***$p<0.001$