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## Abstract

*Background:* Research has demonstrated a clear association between cognitive decline and non-cognitive disability; however, all of these studies focus on disability as a correlate or result of some level of cognitive impairment or dysfunction. The relationship between disability and cognition is likely a complex one, that is currently incompletely described in the literature. *Objectives:* Our objective was to estimate the prevalence of long-term, non-cognitive disability using a population-representative sample of adults aged 18 and older, and then estimate the association between long-term, non-cognitive disability and self-reported worsening memory. *Methods:* Using the 2009 Florida Behavioral Risk Factor Surveillance System (BRFSS), we measured the relationship between non-cognitive disability and worsening memory using multivariable logistic regression analysis weighted to account for the complex sampling design of the BRFSS. We also estimated the adjusted odds of worsening memory by disability severity, classified according to the types of assistance needed. *Results:* Approximately 18% (95% confidence interval = (16%, 19%)) of Floridians were living with a long-term, non-cognitive disability in 2009. Among adults with no disability during or prior to the last year, only 5% reported worsening memory. The proportion of Floridians reporting worsening memory increases with increasing severity of disability-related limitations. In a multivariable logistic regression model, odds of worsening memory increased significantly with severity of disability-related limitations. *Conclusions:* These results highlight the association between non-cognitive disability and subsequent increased odds of worsening memory, independent of several other known risk factors, and a dose-response association with disability-related limitations.

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## Abstract

### Background

Research has demonstrated a clear association between cognitive decline and non-cognitive disability; however, all of these studies focus on disability as a correlate or result of some level of cognitive impairment or dysfunction. The relationship between disability and cognition is likely a complex one, that is currently incompletely described in the literature.

### Objectives

Our objective was to estimate the prevalence of long-term, non-cognitive disability using a population-representative sample of adults aged 18 and older, and then estimate the association between long-term, non-cognitive disability and self-reported worsening memory.

### Methods

Using the 2009 Florida Behavioral Risk Factor Surveillance System (BRFSS), we measured the relationship between non-cognitive disability and worsening memory using multivariable logistic regression analysis weighted to account for the complex sampling design of the BRFSS. We also estimated the adjusted odds of worsening memory by disability severity, classified according to the types of assistance needed.

### Results

Approximately 18% (95% confidence interval = (16%, 19%)) of Floridians were living with a long-term, non-cognitive disability in 2009. Among adults with no disability during or prior to the last year, only 5% reported worsening memory. The proportion of Floridians reporting worsening memory increases with increasing severity of disability-related limitations. In a multivariable logistic regression model, odds of worsening memory increased significantly with severity of disability-related limitations.

### Conclusions

These results highlight the association between non-cognitive disability and subsequent increased odds of worsening memory, independent of several other known risk factors, and a dose-response association with disability-related limitations.

### Keywords:

[Disability](#), [Memory impairment](#), [BRFSS](#), [Instrumental Activities of Daily Living](#), [Activities of Daily Living](#)

Disability has been variously defined for the purposes of surveillance, health and social services programs, and research, often with a focus on functional impairment.<sup>1</sup> As a result, disability, defined with a focus on physical impairment, may be perceived as being independent of cognitive impairment affecting the mind. In fact, the two are intimately connected.<sup>2, 3, 4</sup> While there are many different models of disability and the disablement process,<sup>5, 6, 7</sup> our view of disability is aligned with the World Health Organization's (WHO) International classification of Functioning, Disability, and Health (ICF).<sup>7</sup> That is, disability is not simply the consequence of a disease or disease process,<sup>8</sup> rather it is one's life experience as measured by a complex mixture of health, function, participation, and the social and physical environment. Impairments may be intrinsic to the individual, but the notion of disability incorporates the context in which the individual with impairment lives out his or her life. To put it another way, disability is a gap between personal capability and environmental demand.<sup>5</sup>

Previous research demonstrates a clear association between cognitive decline and non-cognitive disability<sup>9, 10, 11, 12</sup>; however, all of these studies focus on disability as a correlate or result of some level of cognitive impairment or dysfunction. For example, worsening memory may lead to limitations in activities of daily living including self-care<sup>13</sup> and may interfere with health maintenance activities like taking medications as prescribed.<sup>14</sup> An important gap in the research literature concerns the effects of non-cognitive disability on subsequent worsening memory and confusion. There is still much to learn about the relationship, including the direction, temporal sequence, and strength of association. Research is needed that can tease out the nuances of this association, and perhaps identify effective interventions to limit the effect of non-cognitive disability on worsening memory.

As a preliminary step toward that goal, we estimated the association between long-term, non-cognitive disability and self-reported worsening memory or confusion during the previous 12 months – both overall and by severity of non-cognitive disability – in a population-representative sample of Floridians, aged 18 and older. We hypothesized that the proportion of people who reported worsening memory or confusion in the previous 12 months would be greater among those with more severe disability-related limitations.

## Methods

### Study population

The current study utilizes data collected from Floridians on the 2009 Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is an ongoing, random digit-dialed telephone survey of non-institutionalized adults age 18 and older in the United States and its territories.<sup>15, 16, 17</sup> The BRFSS is coordinated by the Centers for Disease Prevention and Control (CDC) and administered at the state level. Annually, the BRFSS collects a variety of demographic, health behavior, health outcome, and health care access information designed to represent the age, sex, and racial/ethnic characteristics of all non-institutionalized adults in a state.<sup>18</sup> In 2009, the Florida BRFSS used a disproportionate stratified sampling design that randomly selects telephone numbers from a probability sample of households with telephones.<sup>18</sup> In order to provide relevant state population estimates, individual BRFSS participants are assigned a weight, or a value that accounts for sampling design and survey non-response.<sup>18</sup>

In the current analysis – more fully described below – we combine six separate questions about disability: (1) any activity limitations, (2) use of special equipment, (3) IADL assistance needs (state-added), (4) ADL assistance needs (state-added), (5) main condition or disability limiting activities (state-added), and (6) duration of disability (state-added). Together, these six questions about disability experience form our exposure variable of primary interest. We also use a state-added question about worsening memory or confusion as our outcome variable of primary interest. The only instance of this specific combination of questions appearing simultaneously on the BRFSS occurred in Florida between April 2009 and December 2009.

### Measures of disability

The BRFSS includes two questions to measure prevalence of disability. Participants were considered to have a disability if they answered “yes” to one or both of the following questions: “Are you limited in any way in any activities because of physical, mental, or emotional problems?” and, “Do you now have any health problem that requires you to use special equipment, such as a cane, a wheelchair, a special bed, or a special telephone? [Include occasional use or use in certain circumstances.]” This definition is consistent with CDC’s definition of disability and also consistent with the WHO ICF broad definitions of impairment and function.<sup>7, 19</sup>

Disability is a broad term, and the ways in which individuals experience disability are as diverse as the individuals themselves. During 2009, the Florida Office on Disability and Health<sup>20</sup> partnered with the state BRFSS office to capture a more specific description of this experience by including measures of severity and duration of disability-related limitations (DRL), as well as major type of disability. In addition to the usual disability questions, Participants were asked, “Because of any impairment or health problem, do you need the help of other persons in handling your routine needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes?” and “Because of any impairment or health problem, do you need the help of other persons with your personal care needs, such as eating, bathing, dressing, or getting around the house?” These two questions are closely aligned with the definitions of Instrumental Activities of Daily Living (IADL) and Activities of Daily Living (ADL) respectively and also have been used as part of an optional module on the BRFSS previously (2000 BRFSS optional module questionnaire example at <http://www.cdc.gov/brfss/questionnaires/pdf-ques/2000brfss.pdf>).

To better understand the main type of disability individuals were living with, we asked, “What is your main health condition or disability that limits your activity?” The list of possible answers was as follows: Physical impairment or disability, learning or intellectual disability, memory or cognitive disability, emotional problems, hearing disability, blindness, or speech impairment. We considered participants who answered this question with any valid response other than “memory or cognitive disability” as a person living primarily with a non-cognitive disability. In addition to severity and type of disability, we also asked, “How long have your activities been limited due to this condition or impairment?” Participants responded with the number of years and months as appropriate.

Participants were classified into one of four possible groups. Group 1 is comprised of participants that reported having no disability ( $n = 5101$ ) as measured by any of the disability-related questions above.

Participants in group 2 reported disability without IADL or ADL limitations ( $n = 1041$ ). These participants reported limitations in activities because of physical, mental, or emotional problems; having a health problem that requires the use of special equipment; or both. However, they also answered “no” to the two questions measuring IADL and ADL limitations. Participants in group 3 reported disability with IADL limitations but no ADL limitations ( $n = 420$ ). Participants in group 4 reported disability with any ADL limitations ( $n = 142$ ) – with or without IADL limitations. For ease of reporting and readability we will refer to the groups by number (1, 2, 3, or 4) for the remainder of this article.

### Outcome measure

Our primary outcome of interest was worsening memory in the past 12 months. In 2009, the Florida BRFS included a set of ten state-added questions related to memory loss and confusion. The question used in the current analysis as the main outcome measure was, “During the past 12 months, have you experienced confusion or memory loss that is happening more often or is getting worse?” Possible answer choices were yes, no, don't know/not sure, and refused. We recoded all instances of don't know/not sure and refused to missing. This self-reported measure of worsening memory or confusion is not clinically validated and may not reflect the presence of any specific disease<sup>21</sup>; however, the Alzheimer's Association recently published an endorsement of this question for use at annual wellness visits for older adults.<sup>22</sup>

### Temporal sequence

Although the BRFS is a cross-sectional population survey by design, we were able to study the association between worsening memory or confusion in the previous 12 months and severity of disability among those that have been living with disability for longer than 12 months. We used the duration of disability question to exclude 180 participants who reported living with a disability for 12 months or less (see [Fig. 1](#)).



*Fig. 1*

Temporal sequence between disability status and confusion or memory loss that is happening more often or getting worse, as measured in the 2009 (April–December) Florida Behavioral Risk Factor Surveillance System. Diagram depicts how the questions in the 2009 BRFS were constructed in such a way that worsening or more frequent confusion or memory loss may be reported as subsequent to initially living with a non-cognitive disability. Here, participant  $i$  is interviewed on day 0 and reports a non-cognitive disability which began more than a year ago. Participant  $i$  also experienced confusion or memory loss that was happening more often or was getting worse during the previous year.

## Adjustment variables

Variable selection was carried out using a combination of *a priori* knowledge and the change-in-estimate method.<sup>23, 24, 25, 26, 27</sup> We started with 18 candidate variables selected for their previously published association with disability<sup>1, 28, 29</sup> and cognitive function.<sup>2, 30, 31, 32, 33, 34</sup> These variables included socio-demographic characteristics (age, gender, race/ethnicity, marital status, employment status, annual household income, years of formal education) and physical and mental health functioning (smoking status, BMI, diabetes, coronary heart disease, stroke, hypertension, cholesterol level, heavy drinking behavior, level of physical activity, and poor mental health). The change-in-estimate method retains a candidate variable from the adjusted model if its removal from the model would alter the coefficient for the exposure variable of primary interest, in this case worsening memory, by at least ten percent. This process of removing and adding variables in a step-wise fashion is repeated until continuing to do so no longer produces a meaningful change in effect.<sup>23, 24, 25, 26, 27</sup> This method yielded a statistically sufficiently adjusted model consisting of the following variables: employment status and self-reported poor mental health days in the previous month. However, we additionally retained age, gender, race/ethnicity, education, income, and marital for their importance to the face validity of the adjusted model.

## Statistical analysis

The Florida BRFSS sampled and interviewed 7556 participants between April 2009 and December 2009 – the time period in which the cognitive impairment module was included in the questionnaire. We excluded 140 participants from the analysis who did not answer the question that measured more frequent or worsening confusion or memory in the past year. In order to assess the association between *non-cognitive* disability that began more than one year ago and *subsequent* worsening confusion or memory in the previous year, we excluded all participants who reported that memory or cognitive disability was their main condition or disability that limited their activity ( $n = 26$ ), participants who reported having disability for less than one year ( $n = 180$ ), and participants who did not answer the question measuring disability status ( $n = 233$ ). Participants were dropped because of missing data for covariates of interest using listwise deletion in all models. In the final adjusted model, 273 were dropped because of missing data for covariates. In total, 852 (11%) participants were excluded, resulting in a final analysis sample size of 6704 (Fig. 2). In a sensitivity analysis (data not shown), participants that were excluded were more likely to report more frequent or worsening confusion or memory loss in the previous year. This was expected given that we excluded all participants whose primary disability was related to memory or cognition. Excluded participants were also more likely to report living with a disability, had a lower average income, and were less likely to be married.

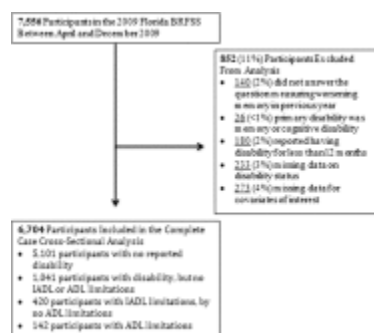


Fig. 2

Flow diagram depicting the inclusion and exclusion of participants in the final analysis.

Univariate analysis was conducted on all variables of interest among categories of severity of DRL to describe differences between groups. Descriptive percentages and 95% confidence intervals (CI) are given in [Table 1](#). We used multivariable logistic regression to measure the association between severity of DRL and incident or worsening cognition adjusted for other risk factors. Crude and adjusted odds ratios and 95% CI are given in [Table 2](#). All analyses were conducted using Stata 13.1 (StataCorp. 2013. *Stata Statistical Software: Release 13*. College Station, TX: StataCorp LP.), using weighting procedures to account for the complex sampling design of the BRFSS. The University of North Texas Health Science Center Institutional Review Board approved this project as exempt.

Table 1 Weighted characteristics of respondents to the 2009 (April–December) Florida Behavioral Risk Factor Surveillance System by disability status and severity of disability-related limitations

Characteristic	Disability ( <i>n</i> = 5101)	Disability, no IADL <sup>a</sup> or ADL <sup>b</sup> limitations ( <i>n</i> = 1041)	Disability, IADL limitations without ADL limitations ( <i>n</i> = 420)	Disability, any ADL limitations ( <i>n</i> = 142)	Overall ( <i>n</i> = 6704)
Worsening memory, % (95% CI)	5 (4, 6)	14 (10, 18)	27 (20, 35)	38 (26, 52)	7 (6, 8)
Age, mean	48 (47, 49)	57 (55, 59)	57 (54, 60)	59 (55, 63)	50 (49, 50)
Gender, % (95% CI)					
Female	51 (49, 54)	46 (41, 52)	60 (50, 68)	49 (36, 62)	51 (49, 54)
Race/ethnicity, % (95% CI)					
White, non- Hispanic	62 (59, 65)	74 (68, 80)	60 (50, 69)	48 (35, 61)	63 (61, 66)
Black, non- Hispanic	13 (11, 15)	10 (7, 14)	15 (10, 22)	21 (12, 35)	13 (11, 15)
Hispanic, any race	20 (18, 23)	9 (5, 14)	16 (8, 27)	23 (13, 37)	19 (17, 21)
Other race, non-Hispanic	5 (4, 6)	7 (3, 12)	9 (5, 17)	8 (3, 20)	5 (4, 7)
Education, % (95% CI)					
Less than high school	7 (6, 8)	11 (8, 14)	17 (11, 27)	19 (11, 30)	8 (7, 9)
High school graduate	27 (25, 30)	27 (23, 32)	29 (22, 36)	32 (21, 45)	27 (25, 29)
Some college	27 (25, 29)	34 (29, 39)	33 (25, 41)	36 (24, 50)	28 (26, 30)



College graduate	39 (37, 42)	29 (24, 34)	21 (14, 31)	14 (06, 27)	37 (35, 39)
Household income, % (95% CI)					
<\$15,000	4 (3, 5)	12 (8, 16)	21 (14, 29)	29 (19, 43)	6 (5, 7)
\$15,000–\$24,999	15 (14, 18)	22 (18, 27)	29 (21, 38)	31 (20, 44)	17 (15, 19)
\$25,000–\$49,999	26 (24, 28)	23 (20, 28)	29 (22, 38)	14 (7, 25)	26 (24, 28)
\$50,000–\$74,999	13 (12, 15)	13 (10, 18)	6 (3, 11)	9 (4, 19)	13 (11, 14)
≥\$75,000	29 (27, 31)	17 (13, 21)	5 (3, 10)	10 (3, 25)	26 (24, 28)
Missing	12 (11, 15)	12 (9, 16)	11 (7, 16)	8 (3, 16)	12 (11, 14)
Employment, % (95% CI)					
Employed	63 (60, 65)	40 (34, 46)	14 (9, 21)	6 (3, 12)	57 (55, 59)
Not employed	19 (17, 21)	17 (13, 21)	17 (10, 26)	20 (10, 35)	19 (17, 21)
Retired	17 (16, 19)	32 (28, 37)	34 (26, 43)	29 (19, 41)	20 (19, 21)
Unable to work	1 (0, 1)	11 (8, 15)	35 (27, 44)	45 (33, 59)	4 (4, 5)
Married, % (95% CI)					
	66 (64, 69)	63 (58, 68)	53 (44, 62)	57 (44, 70)	65 (63, 68)
Poor mental health, % (95% CI)					
At least one day in past thirty days	26 (24, 29)	39 (34, 45)	50 (41, 59)	54 (41, 67)	29 (27, 32)

[a](#)IADL = Instrumental Activities of Daily Living.

[b](#)ADL = Activities of Daily Living.

Table 2 Results of a weighted analysis regressing worsening memory or confusion in previous year (yes/no) on selected participant characteristics, 2009 Florida BRFSS

Characteristic	Unadjusted OR <sup>a</sup> (95% CI <sup>b</sup> )	Adjusted <sup>c</sup> OR (95% CI)
Severity of disability		
No disability	Referent	Referent
Disability, no IADL <sup>d</sup> or ADL <sup>e</sup> limitations	3.19 (2.23, 4.57)**	1.73 (1.12, 2.65)*
Disability, IADL limitations, no ADL limitations	7.32 (4.81, 11.16)**	3.09 (1.94, 4.92)**
Disability, any ADL limitations	12.40 (6.94, 22.14)**	5.28 (2.84, 9.80)**
Age (years)	1.02 (1.01, 1.03)**	1.02 (1.01, 1.03)**
Gender		
Male	Referent	Referent

Female	1.19 (0.89, 1.58)	1.01 (0.75, 1.36)
Race/ethnicity		
White, non-Hispanic	Referent	Referent
Black, non-Hispanic	0.68 (0.42, 1.11)	0.55 (0.031, 0.97)*
Hispanic, any race	0.34 (0.19, 0.60)**	0.31 (0.17, 0.58)**
Other race, non-Hispanic	0.79 (0.38, 1.66)	0.64 (0.30, 1.35)
Education		
College graduate	Referent	Referent
Some college	1.59 (1.11, 2.29)*	0.97 (0.65, 1.45)
High school graduate	2.21 (1.53, 3.20)**	1.46 (0.95, 2.24)
Less than high school	3.50 (2.09, 5.85)**	2.06 (1.08, 3.93)*
Household income		
>\$75,000	Referent	Referent
\$50,000–\$75,000	1.85 (1.11, 3.08)*	1.34 (0.78, 3.30)
\$25,000–\$50,000	2.19 (1.41, 3.40)**	1.55 (0.91, 2.65)
\$15,000–\$25,000	4.23 (2.72, 6.58)**	2.27 (1.29, 3.99)*
<\$15,000	5.08 (2.96, 8.75)**	1.60 (0.77, 3.30)
Missing	1.67 (0.96, 2.92)	0.97 (0.51, 1.84)
Employment		
Employed	Referent	Referent
Not employed	2.57 (1.67, 3.98)**	1.77 (1.10, 2.87)*
Retired	3.08 (2.23, 4.25)**	1.52 (0.95, 2.45)
Unable to work	9.67 (6.12, 15.29)**	2.28 (1.27, 4.11)*
Married		
Yes	Referent	Referent
No	1.07 (0.81, 1.42)	0.66 (0.48, 0.93)*
Poor mental days		
None in past thirty days	Referent	Referent
At least one in past thirty days	4.03 (3.02, 5.37)**	4.15 (3.04, 5.66)**

\* $p < 0.05$ ; \*\* $p < 0.001$ .

aOR = Odds Ratio.

bCI = Confidence Interval.

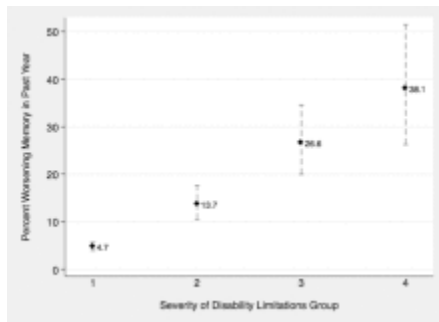
cAdjusted model includes all variables included in the table.

dIADL = Instrumental Activities of Daily Living.

eADL = Activities of Daily Living.

## Results

We estimate that 18% (95% CI = 16%, 19%) of Floridians were living with a long-term, non-cognitive disability in 2009. Of those with no disability during or prior to the last year, only 5% experienced worsening memory in the past year. By contrast 14% of people with a disability, but no IADL or ADL limitation; 27% of people with an IADL, but no ADL limitations; and 38% of people with ADL limitations reported worsening memory in the past year ([Table 1](#) & [Fig. 3](#)).



[Fig. 3](#)

Proportion of Individuals with Non-Cognitive Disability for More than One Year Who Experienced Worsening Memory or Confusion in the past Year, by Severity of Disability, Florida, 2009. *p*-value for trend test <0.0001 Group 1 reported having no disability. Group 2 reported disability without IADL (defined as needing help with handling routine needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes because of impairment or health problem) or ADL (defined as needing help with personal care needs, such as eating, bathing, dressing, or getting around the house because of any impairment or health problem) limitations. Group 3 reported disability with IADL limitations, but no ADL limitations. Group 4 reported disability with any ADL limitations.

On average, people that reported no disability were younger than people in the three DRL groups, they were more often college graduates, more often employed, and had a higher household income. Further, participants with greater levels of DRL more often reported at least one poor mental health day in the previous 30 days ([Table 1](#)).

### Logistic regression analysis

In an unadjusted logistic regression analysis ([Table 2](#)), the odds of worsening memory in the past 12 months significantly increased with severity of DRL. PWD with no IADL or ADL limitations (group 2) had 3.19 (95% CI = 2.23, 4.57) times greater odds of worsening memory compared to people without disability (group 1). PWD and IADL limitations, but no ADL limitations (group 3), had 7.32 (95% CI = 4.81, 11.16) times greater odds of worsening memory compared to people with no disability (group 1). And, PWD, including ADL limitations (group 4), had 12.40 (95% CI = 6.94, 22.14) times greater odds of worsening memory compared to people with no disability (group 1).

We also constructed a multivariable logistic regression model to assess the relationship between disability severity and worsening memory adjusting for age, gender, race/ethnicity, education, income, employment, marital status, and mental health. In the adjusted model the odds of worsening memory were somewhat attenuated, but remained highly significantly greater with greater severity of DRL. Compared to persons with no disability (group 1), PWD with no IADL or ADL limitations (group 2) had 1.73 (95% CI = 1.12, 2.65) times greater odds of worsening memory. Compared to persons with no disability (group 1), PWD with IADL, but no ADL limitations (group 3), had 3.09 (95% CI = 1.94, 4.92) times greater odds of incident or worsening cognition. Finally, compared to persons with no disability (group 1), PWD with ADL limitations (group 4) had 5.28 (95% CI = 2.84, 9.80) times greater odds of incident or worsening cognition ([Table 2](#)).

## Discussion

Results of the present study of a population-representative sample of 6704 adult Floridians reveal that approximately 18% of Floridians are living with a long-term, non-cognitive disability. In 2009, this totaled roughly 2.6 million members of Florida's adult population.<sup>35</sup> Additionally, we observed a statistically significant cross-sectional association between level of DRL and subsequent worsening confusion or memory among adults with long-term, non-cognitive disability. This association remained even after controlling for age, gender, race/ethnicity, education, annual household income, employment, marital status, and recent mental health. Our results suggest that those with the most severe disability limitations are at the greatest risk of worsening memory, independently of other demographic and health factors. Our findings are consistent with others who have found an association between disability and cognition<sup>9, 10, 11, 12</sup>; however, this is the first study, to our knowledge, to investigate changes in confusion and memory that occur subsequent to the onset of non-cognitive disability.

There is some disagreement in the literature about the meaning and/or significance of self-reported perceived memory loss as a proxy measure for actual memory loss. Multiple cross-sectional studies have found little to no association between memory complaints and objective test performance<sup>36, 37, 38</sup>; however, the results of several longitudinal studies suggest that self-reported memory loss may, in fact, be predictive of objective memory performance over time. For example, Jorm and colleagues found that memory complaints among older adults was predictive of past memory performance as well as future memory performance.<sup>39</sup> A community longitudinal study by Schofield and colleagues found that new memory complaints were associated with poorer performance on memory tests at one-year follow up.<sup>40</sup> Finally, in a study by Johansson et al, self-reported decline over a 2-year period was associated with actual decline among older adults.<sup>41</sup> In addition to memory decline, multiple cross-sectional studies associate memory complaints with personality traits, such as depression scores<sup>32, 38, 42</sup> and quality of life.<sup>37</sup> In the current study, we did control for mental health; however it was a self-reported based on the past 30 days and does not take into account the severity of the mental health or any clinically diagnosed mental health condition.

It is unlikely that there is a single mechanism through which more severe non-cognitive disability limitations leads to greater likelihood of worsening memory. There is substantial evidence that physical activity and exercise are protective for many different conditions, including cognitive decline,<sup>33</sup> which is one potential explanation for why those with the most severe functional limitations are more likely to

report worsening memory. We explored controlling for physical activity in our analysis; however, it had little effect on the disability – memory relationship. It should be noted, however, that our measure of physical activity was a self-reported rough measure of *current* physical activity. It is possible that a more precise measure, or a measure of lifelong physical activity, would have explained a larger portion of the observed association.

Another possible pathway between non-cognitive disability and worsening memory is social connectedness. A recent study by Ertel et al reviewed mounting evidence of the role the social environment plays in cognitive decline, and demonstrates a population level association between social integration and cognitive decline<sup>34</sup>; Unfortunately, our data did not include a direct measure of social integration, but we explored adjusting for self-report of receiving emotional support. During the model building process, adding emotional support did not meaningfully change the disability – memory association, and it was decided to remove this variable from the final model in favor of parsimony and increased sample size. Social integration is another example of a difficult to measure characteristic, and again it is entirely possible that a better measure would have been more informative.

This study has some limitations. This analysis of the Florida BRFSS is weighted to be representative of the non-institutionalized adult population of the State of Florida in 2009; however, it is not representative of the entire United States, and therefore, our findings may not generalize to other areas of the country. The BRFSS is a cross-sectional survey by design, and therefore limits our ability to conclude that the association between non-cognitive disability and cognitive decline is a causal one. We integrated the temporal aspects of the questions to construct a temporal sequence (by limiting our analysis to participants with disability lasting more than one year), but there may have been temporal overlap that our questions did not pick up. If so, the results we found may have been attenuated by the measurement error. Second, as noted above, the relationship between self-reported worsening memory and actual memory loss is incompletely understood. Therefore, there is the potential for misclassification bias. It is possible that individuals do not want to report, or are unaware of, perceived worsening memory. This would presumably bias our results toward the null. It is also possible that we may be including participants as experiencing worsening memory that would otherwise not be classified by more objective measure. Because of the nature of the BRFSS, participants must be physically and cognitively able to complete a telephone interview. As a result, individuals with the most severe levels of disability and cognitive impairment may be excluded. Finally, it is possible that a sufficient selection of confounders was not included or that confounders were imperfectly measured. As an example, the question used to measure physical activity asks participants: “During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?” It's possible that very high or low levels of physical activity, or specific type of physical activity, explains a significant portion of the relationship between disability and worsening memory or confusion; however, this question does not allow us to investigate such a relationship.

This study also has several strengths. This paper describes and quantifies, at the population level, the prevalence and association of an important risk factor for worsening memory. Second, although our study is cross-sectional in design, the questions used enabled us to examine temporality to our analysis. While this is not a replacement for a longitudinal design, it does strengthen the credibility of our results.

Third, because we make use of publicly available survey questions and data, other investigators can reproduce these analyses (or augment analytic optional module measures) with other BRFSS state data.

## Conclusions

Quality of life is significantly reduced for those who are living with worsening confusion and memory, as well as their families and caregivers.<sup>1</sup> Our results suggest that people with disabilities are at greater risk of worsening memory than people without disabilities – even among people whose primary disabling condition is non-cognitive. Further, if self-reported worsening memory is a proxy for mental health, as some have suggested, then perhaps increased surveillance and mental health treatment for people with non-cognitive disability is warranted.

While more research is needed, we hope to inspire other researchers to investigate possibility of disability leading to worsening memory in their research, the creation of better measures of potentially important risk factors, and cognitive measures incorporated into intervention studies in related populations. The long-term benefits of understanding the contribution of non-cognitive disability to worsening memory and confusion might include lower costs to the US health care system and reduced burden of morbidity and caregiving responsibilities to American families through decreased incidence of cognitive impairment.<sup>43</sup>

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