



Verbal memory is associated with adherence to COVID-19 protective behaviors in community dwelling older adults

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Abstract

Background Adherence to protective behaviors is central to limiting the spread of COVID-19 and associated risk of serious illness and mortality in older populations. Whether cognition predicts adherence to protective behaviors has not been examined in older adults.

Aims To examine whether specific cognitive abilities predict adherence to COVID-19 protective behaviors in older adults, independent of other relevant factors.

Methods Data from 431 older adults (i.e., ≥ 65 years) who took part in the COVID-19 module of the Health and Retirement Study were included in the present study. Separate binary logistic regression models were used to examine whether performance on measures of immediate and delayed recall and working memory predicted adherence to COVID-19 protective behaviors, controlling for demographics, level of COVID-19 concern, depressive symptoms, and medical conditions.

Results For every unit increase in immediate and delayed recall, the probability of adhering to COVID-19 protective behaviors increased by 47% and 69%, respectively. There was no association between the measure of working memory and adherence.

Discussion It is of public interest to understand the factors that reduce adherence to protective behaviors so that we can better protect those most vulnerable and limit community spread. Our findings demonstrate that reduced memory predicts non-adherence to COVID-19 protective behaviors, independent of virus concern, and other relevant demographic and health factors.

Conclusions Public health strategies aimed at increasing adherence to COVID-19 protective behaviors in community dwelling older adults, should account for the role of reduced cognitive function in limiting adherence.

Keywords Aging · Memory · COVID-19 · Adherence

Introduction

Since the outbreak of a novel strain of the coronavirus (SARS-CoV-2) in December 2019 which caused the COVID-19 pandemic, over 575,980 people in the US have died from the virus and approximately 3.3 million worldwide (World Health Organization [WHO], 2021), at the time this manuscript was written (May, 2021). Approximately, 81% of those deaths in the US are adults aged 65 years and older (WHO, 2021). The risk of severe illness necessitating

hospitalizations involving intensive care are greater for older adults (Centers for Disease Control and Prevention [CDC], 2020). Although, the long-term consequences of severe COVID-19 infection following recovery is yet unknown, prior investigations have shown that critical illness from any cause is associated with extended functional impairment that can last several years [1, 2].

Fortunately, several promising vaccines are either under development or currently being rolled out. As of 5/10/2021 about 34.8% of the total US population have received two vaccine doses, while 71.5% of adults over 65 years have received both doses (CDC, 2021). Nevertheless, it will likely take several more months before all older adults in the US have access to a vaccine and even longer until the true efficacy of these vaccines can be evaluated. In the interim, the CDC has provided guidelines and recommendations on

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behaviors that are protective, and limit community spread of the virus. Some of these behaviors include wearing a face mask around others, social distancing, and increase hand washing (CDC, 2020). These recommendations are supported by recent research findings showing that mask usage is effective in reducing community transmission of COVID-19 [3–8] and may be most effective when used in conjunction with other CDC guidelines [9]. However, despite the evidence for the efficacy of these behaviors in limiting COVID-19, adherence has been inconsistent and variable [10, 11].

Numerous studies have identified factors related to adherence to these behaviors in community populations. Health beliefs, health literacy, gender, education, urbanicity, personality, occupation and level of distress are among some of the factors associated with adherence to one or more COVID-19 protective behaviors [12–17]. One largely underexplored factor in relation to adherence behaviors is cognitive ability. This is surprising given that cognition is a well-established source of individual differences linked to a range of health outcomes [18–23]. In younger adults (i.e., > 65 years), one study showed that better working memory was associated with greater adherence to social distancing, independent of income, education or gender [24]. While another study showed that better self-reported cognition was associated with increased adherence to COVID-19 protective behaviors [25]. In older adults, lower cognitive function has been linked to lower adherence to other types of health behaviors including medication management [26], healthy diets [27], and management of diabetes [28]. Specifically, memory and executive functions play a key role in the initiation and maintenance of health behaviors and the formation of habits more generally [29–31]. For example, lapses in memory can result in missing medication doses, medical appointments or forgetting an important piece of verbal instruction necessary to managing an aspect of health. Executive functions broadly refer to the ability to sustain attention, organize/manipulate information, and engage in goal directed behavior [32]. Thus, if we consider adherence to COVID-19 protective behaviors as a form of behavioral change that requires repeated daily practice, it is plausible that variability in memory and executive functions may influence the degree of adherence. Whether cognitive function predicts adherence to COVID-19 protective behaviors in older adults has not yet been examined. In the current study, we hypothesized that better verbal memory and working memory in older adults would be associated with increased adherence to COVID-19 protective behaviors compared to those with lower performances on these measures.

Methods

Participants

Data for the present study were derived from the 2020 COVID-19 module of the Health and Retirement Study (HRS) database (<https://hrs.isr.umich.edu/>). The HRS is a biennial longitudinal panel study of the health, financial, social, and cognitive status of adults aged 50 years or older living in the United States. The HRS is sponsored by the National Institute on Aging and led by researchers at the University of Michigan, Ann Arbor. Participants come from an ethnically diverse population (i.e., African American, Hispanic, and non-Hispanic White). Further details and information on the study design and procedures have been described elsewhere. There was a total of 3266 participants interviewed in the 2020 wave of the study. Only individuals aged 65 years or older, who were not currently living in a nursing home with full data on the variables of interest were included in the present study ($n = 431$).

Measures

COVID-19 protective behaviors

Each participant was asked four questions regarding how frequently they engaged in specific behavioral recommendations aimed at preventing and containing the COVID-19 pandemic. The questions probed frequency of mask usage, hand washing, social distancing and use of hand sanitizers. This information was gathered from mail-in questionnaires that followed their telephone assessment.

Cognition

Cognitive testing was conducted via telephone. Memory performance was assessed using a 10-word list. The interviewer read one of four possible word lists to the participant. The word lists were adapted from the Iowa Established Populations for Epidemiological Study of the Elderly (EPESE) [33]. Participants were read a word at a rate of 2 s. After a five-minute delay, participants were then asked to recall as many words as possible. During this five-minute delay, participants were asked other survey questions. Immediate recall was the total number of correct words recalled immediately following the reading of the word list. Delayed recall was the total number of correctly recalled words after the five-minute delay. The serial seven subtraction test [34] was used as the measure of working memory. Participants were asked to subtract 7 from 100 and continue subtracting

7 from each subsequent trial for 5 consecutive trials. Scores range from 0 to 5, with higher scores indicating better performances. Additional detail on how these measures were selected and validated for the HRS has been published elsewhere [33].

Covariates

Covariates included age (continuous), sex (coded as “1” for male, and “0” for female), years of education, race (coded as 1 for white, 2 for black and 3 for other), ethnicity (coded as 1 for Hispanic and 0 for non-Hispanic). Current depression was assessed using the 8-item Center for Epidemiologic Studies-Depression Scale [35], with a binary “yes” (coded as 1) and “no” (coded as 0). Items were reversed scored as indicated and summed to generate participants’ average level of current depressive symptoms. Reliability of the scale in the current study sample had a Cronbach’s alpha of 0.79. Level of concern for the coronavirus was also included as a covariate and was assessed based on participant’s ratings of their concern on a scale of 1–10, with higher scores indicating greater concern. To control for chronic and current medical conditions, we included a sum score of self-reported presence (coded as 1) or absence (coded as 0) of the following conditions: hypertension, diabetes, a heart condition, high cholesterol, lung disease, cancer, or trouble with pain. Body mass index, self-rated health and memory (scale of 1–5, with higher scores indicating worse self-report of health and memory), and whether they lived with a partner, which may influence adherence to health behaviors [36], were also included as covariates.

Ethics statement

The HRS was approved by the Behavioral Science Committee institutional review board, University of Michigan. The data included in this study are publicly available to registered researchers.

Statistical analyses

All analyses were conducted using IBM SPSS for Windows (Version 26.0, Armonk, NY: IBM Corp). Descriptive statistics were generated to characterize the study sample shown in Table 1. Scores for each of the four items comprising the COVID-19 behavior scale were reverse scored so that higher scores indicated higher adherence. As shown in Table 2, there was a skewed distribution of responses to the Likert categories such that those that were “always” adherent to all four behaviors included 65% of the sample, $n = 281$. To optimize statistical power, a new variable was created to reflect two broad categories; those that were adherent to all the behaviors and

Table 1 Sample characteristics, $N = 431$

	Mean	SD	Range
Age	77.12	7.82	65–99
Female %	81.2		
Education	13.21	2.51	1–17
Race%			
White	75.2		
Black	20		
Other	4.8		
Hispanic %	9.3		
Medical conditions	2.31	1.35	0–6
BMI	28.70	6.29	14.48–64.41
Rate health	2.872	0.98	1–5
Rate memory	3.142	0.88	1–5
Live-in partner-NO	$n = 418$	97%	
COVID-19 concern	8.218	2.37	1–10
CESD-8	1.52	1.98	0–8
Immediate recall	5.44	1.74	0–10
Delayed recall	4.46	2.16	0–10
COVID-19 behavior			
Adherent	$n = 281$	65.2%	
Non-adherent	$n = 150$	34.8%	

CESD-8 Center for Epidemiologic Studies Depression (8 item scale), *BMI* Body Mass Index

those that were inconsistent or non-adherent (i.e., responded either “sometimes” or “never” to at least one of the questions). This new binary variable was coded as 1 (to indicate full adherence) and 0 (to indicate those that were “sometimes/never” adherent). All variables used in the analyses were z-scored to facilitate interpretation. A one-way analysis of variance (ANOVA) was performed to first examine the differences between the (Table 3) two groups (adherent vs. non-adherent) and the covariates. Separate binary logistic regression models were then used to examine whether the measures of memory and working memory (Table 4) predicted adherence (our main aim). Covariates were entered in the first block and one of the three variables in the second block. Secondary analyses, again using binary logistic regressions to explore associations between cognition and adherence to each of the four behaviors to better understand which specific behaviors may be more dependent on the measures of cognition. In these analyses, similar models were constructed such that covariates were included in the first block and cognitive variables in the second block. Results of these analyses are shown in Table 5.

Table 2 “Since the coronavirus pandemic, have you:” Number of responses (%) to each question asked

	1. Worn a mask around other people outside your home (e.g., in shops)?	2. Washed your hands with soap more frequently?	3. Kept distance from others when you went outside your home?	4. Used special hand sanitizers or disinfectants?
Never	1 (0.2)	3 (0.7)	5 (1.2)	11 (2.6)
Sometimes	51 (11.8)	41 (9.5)	50 (11.6)	100 (23.2)
Always	379 (87.9)	387 (89.8)	376 (87.2)	320 (74.2)

Table 3 Summary of binary logistic regressions using immediate recall as the predictor variable

	<i>B</i>	<i>(S.E.)</i>	95% CI		
			Odds ratio	Lower	Upper
Non-adherent (0) vs. adherent (1)					
Intercept	21.466	(8142.242)			
Age	−0.170	(0.129)	0.844	0.656	1.085
Male = 1, female = 0	−1.185	(0.297)***	0.306	0.171	0.547
Education	−0.238	(0.130)	0.788	0.611	1.017
White vs black	−20.734	(8142.242)	0.000	0.00	–
White vs. other	−20.060	(8142.242)	0.000	0.000	–
Hispanic = 1, non-hispanic = 0	0.067	(0.396)	1.070	0.492	2.325
Live-in partner, Yes = 1, No = 0	−0.018	(0.682)	0.983	0.258	3.737
Rate health	0.111	(0.137)	1.118	0.855	1.461
Rate memory	−0.052	(0.125)	0.949	0.742	1.213
COVID-19 concern	0.626	(0.123)***	1.870	1.470	2.379
Health conditions	−0.091	(0.132)	0.913	0.705	1.182
BMI	−0.145	(0.123)	0.865	0.680	1.100
CESD-8	−0.0042	(0.123)	0.959	0.754	1.220
Immediate recall	0.383	(0.133)**	1.467	1.129	1.904

N = 431. *CI* confidence interval, *CESD-8* Center for Epidemiologic Studies Depression (8-item scale), *BMI* Body Mass Index, $R^2 = 0.207$ (Cox and Snell), 0.286 (Nagelkerke)

** $p < 0.01$, *** $p < 0.001$

Results

Descriptive statistics, displayed in Table 1, showed a total sample mean age of 77 years, $SD = 7.82$. Most of the sample self-identified as “female” (81%) and “non-Hispanic White” (75.2%). Of participants identifying as “Black” (20%) or “other” race (4.8%), less than half (9.3%) identified as Hispanic. On average, participants had 13.2 years of education ($SD = 2.5$).

Results from the ANOVA revealed that those in the adherent group tended to be younger [$M = 76.32$; $SD = 7.86$, $F(1, 430) = 8.475$, $p < 0.004$] compared to those in the non-adherent group ($M = 78.61$; $SD = 7.5$) and female [$F(1, 430) = 4.013$, $p < 0.001$]. There was a significant group difference in concern for COVID-19 [$F(1, 430) = 41.140$, $p = 0.0001$] such that those who were adherent had higher average concern ($M = 8.72$, $SD = 2.00$) compared to those who were categorized as non-adherent

($M = 7.26$, $SD = 2.69$). There were no other statistically significant group differences on any of the other covariates.

Model with covariates only

For every standard unit increase in age, there was an associated 23% decrease in the likelihood of being in the adherent group, $\beta = -0.266$, Wald $\chi^2(1) = 4.625$, $p < 0.05$, $OR = 0.766$, 95% *CI* [0.601, 0.977]. Being male decreased the likelihood of being in the adherent group by approximately 72%, $\beta = -1.268$, Wald $\chi^2(1) = 18.998$, $p < 0.001$, $OR = 0.282$, 95% *CI* [0.159, 0.498]. For every standard unit increase in COVID-19 concern, there was an associated 80% increase in the likelihood of being in the adherent group, $\beta = 0.586$, Wald $\chi^2(1) = 24.085$, $p < 0.001$, $OR = 1.796$, 95% *CI* [1.1421, 2.269]. There were no other statistically

Table 4 Summary of binary logistic regressions using delayed recall as the predictor variable

	<i>B</i>	<i>(S.E.)</i>	95% CI		
			Odds ratio	Lower	Upper
Non-adherent (0) vs. adherent (1)					
Intercept	21.737	(8007.463)			
Age	−0.128	(0.130)	0.880	0.682	1.135
Male = 1, female = 0	−1.175	(0.298)***	0.309	0.172	0.554
Education	−0.250	(0.131)	0.779	0.602	1.008
White vs black	−21.027	(8007.463)	0.000	0.000	–
White vs. other	−20.258	(8007.463)	0.000	0.000	–
Hispanic = 1, non-hispanic = 0	0.152	(0.401)	1.164	0.530	1.135
Live-in partner, yes = 1, no = 0	0.120	(0.694)	1.127	0.289	4.390
Rate health	0.092	(0.136)	1.097	0.840	1.433
Rate memory	−0.038	(0.126)	0.963	0.752	1.232
COVID-19 concern	0.614	(0.123)***	1.848	1.452	2.353
Health conditions	−0.073	(0.133)	0.930	0.716	1.207
BMI	−0.140	(0.127)	0.869	0.678	1.114
CESD-8	0.001	(0.124)	1.001	0.785	1.276
Delayed recall	0.523	(0.136)**	1.687	1.293	2.202

N 431, *CI* confidence interval, *CESD-8* Center for Epidemiologic Studies Depression (8 item scale), *BMI* Body Mass Index; $R^2 = 0.221$ (Cox and Snell), 0.304 (Nagelkerke)

Table 5 Summary of binary logistic regressions for each protective behavior, *N* = 431

Model		<i>B</i>	<i>(S.E.)</i>	Odds ratio	95% CI	
					Lower	Upper
Mask use						
1	Intercept	21.617	(8117.808)			
	Immediate recall	0.330	(0.185)	1.391	0.968	1.998
2	Intercept	21.734	(8026.005)			
	Delayed recall	0.301	(0.182)	1.351	0.945	1.931
Wash hands						
3	Intercept	21.266	(8228.887)			
	Immediate recall	0.301	(0.190)	1.352	0.931	1.963
4	Intercept	21.284	(8183.321)			
	Delayed recall	0.351	(0.187)	1.420	0.984	2.051
Socially distance						
5	Intercept	21.965	(7891.999)			
	Immediate recall	0.463	(0.178) **	1.589	1.120	2.254
6	Intercept	22.119	(7880.146)			
	Delayed recall	0.370	(0.177) *	1.448	1.024	2.048
Special hand sanitizer						
7	Intercept	21.187	(8398.885)			
	Immediate recall	0.186	(1.37)	1.204	0.920	1.576
8	Intercept	21.264	(8298.790)			
	Delayed recall	0.382	(0.140) **	1.466	1.115	1.927

CI confidence interval

***p* < 0.01

significant effects of any of the other covariates on group membership.

Verbal memory and working memory performances

Results of binary logistic models with immediate and delayed memory recall are summarized in Table 3 and Table 4, respectively. Age was no longer a significant predictor of adherence with the inclusion of the cognitive variables. Both gender and level of concern remained significant predictors in the models with their effects only marginally attenuated by the inclusion of the cognitive variables. There was a significant main effect of immediate and delayed recall on predicting adherence group membership. For every standard unit increase in immediate recall, the likelihood of being in the adherent group increased by 47%, $\beta=0.383$, Wald $\chi^2(1)=8.249$, $p<0.01$, $OR=1.467$, 95% CI [1.129, 1.904]. Similarly, for every standard unit increase in delayed recall, the likelihood of being in the adherent group increased by 69%, $\beta=0.523$, Wald $\chi^2(1)=14.834$, $p<0.001$, $OR=1.687$, 95% CI [1.293, 2.202]. The overall results remained unchanged, and even strengthened, when we excluded those with the lowest delayed memory scores (i.e., $z < -1.5$, or number of words recalled < 2 , $n=40$). There was no statistically significant association with the measure of working memory in predicting adherence to COVID-19 protective behaviors ($\beta = -0.212$, Wald $\chi^2(1)=0.839$, $p=0.360$).

COVID-19 specific behavior

Social distancing: Results from the binary logistic regressions revealed that for every standard unit increase in immediate recall performances increased the probability of being adherent to social distancing by 59%, $\beta=0.463$, Wald $\chi^2(1)=6.740$, $p<0.0001$, $OR=1.589$, 95% CI [1.120, 2.254]. A unit increase in delayed recall increased the probability of adherence by 59%, $\beta=0.370$, Wald $\chi^2(1)=4.378$, $p<0.05$, $OR=1.589$, 95% CI [1.024, 2.048].

Use of hand sanitizers or disinfectants: A standard unit increase in delayed recall (but not immediate recall) was associated with a 47% increased likelihood of being in the group that always uses special hand sanitizers or disinfectants, $\beta=0.382$, Wald $\chi^2(1)=7.503$, $p<0.001$, $OR=1.466$, 95% CI [1.115, 1.927].

Discussion

The primary aim of the present study was to investigate whether verbal memory and working memory performances could discriminate between those who were most likely to adhere to COVID-19 protective behavior guidelines and those that did not/or did so less often. We found that both

immediate and delayed recall performances, but not the measure of working memory, discriminated between individuals that were adherent and non-adherent to COVID-19 protective behaviors. Better immediate and delayed memory performances were associated with more frequent adherence to COVID-19 protective behaviors, independent of demographic variables, indicators of health status and level of concern for COVID-19. This is the first study to show an association between memory performances and adherence to COVID-19 protective behaviors in community dwelling older adults.

These findings are in line with previous findings that have shown a link between memory function and adherence to other health behaviors including medication management, diet, and exercise [26, 27, 29, 37]. Recommended COVID-19 protective behaviors represent a relatively new set of distinct guidelines for decreasing the risk of serious viral infection with longstanding health consequences and even death. Public healthcare message campaigns have been strongly directed at older adults and those with specific underlying medical conditions, since the onset of the pandemic. The findings from the present study lend support for the efficacy of these public healthcare messages in that approximately 80% of the sample were adherent to at least one of these protective behaviors. However, the corollary of this statistic is that a subgroup of older adults was non-adherent or minimally so to these guidelines, potentially due to memory impairment. It is of public interest to understand the factors that reduce adherence to protective behaviors so we can better protect those most vulnerable and limit community spread more generally.

In a comprehensive review, Davis et al. [38], identified 83 health behaviors theories and models that seek to explain the process of behavioral change. Common to all these theories, is the assumption that there are multiple levels of influences involving environmental and psychosocial factors. For example, the health behavioral model posits that an individual is motivated to make behavioral change by the perceived threat or value that behavior will have on the individual. Consistent with this theory, our findings showed that increased concern for COVID-19 was predictive of increased adherence to protective behaviors. The health behavioral model also emphasizes the role of decision-making in weighing up the pros and cons of implementing a behavioral change. Inherent in this model, and many other theories of health behavior change, is the potential for individual differences in cognitive processes to influence decision-making and specifically the related concept of health literacy. Health literacy is defined by the Institute on Medicine as “The degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions” [39]. Higher health literacy has been shown to be related to better health outcomes,

healthcare utilization and greater adherence to health behaviors in older adults [40, 41]. Converging findings from other studies show that even subtle memory dysfunction is associated with lower health literacy, independent of education or health status in older adults [42, 43]. These findings highlight the importance of accounting for the influence of cognitive variability on health outcomes. We can consider these effects as indirect (i.e., as a mediator in the association between health literacy and adoption of healthy behaviors) or direct (i.e., via limiting the acquisition of new healthy habits due to impaired processes) or both. Although health literacy was not assessed in the current study, memory performance was associated with adherence to COVID-19 protective behaviors, independent of level of concern, education, health status as well as multiple other demographic factors which have been shown to be associated with health literacy [26]. This suggests that the association between verbal memory and adherence in the current study is unlikely explained by level of health literacy. Instead, our findings more likely reflect the direct effects of memory function on the acquisition and translation of behavioral guidelines into routine practice.

There are several limitations to the current study that future studies can readily address. First, the measures of memory and executive function used in the present study may be considered gross proxies of these constructs rather than comprehensive measures. It is possible that we did not find an association with the measure of executive function as our measure captured only one aspect of executive functioning, namely working memory. Similarly, the measure of verbal memory was also limited, not only for the brief delay period between the learning and recall trials, but also for the lack of a recognition trial which would have permitted a more nuanced perspective of what memory components are most predictive of adherence behaviors. Future research focused on understanding the specific cognitive processes underlying behavior change in the context of the current pandemic would benefit from a more comprehensive characterization of cognition. Additionally, adherence was assessed via self-report and therefore may not accurately reflect actual adherence, especially for those with more severe memory impairment whose report/insight may be reduced. However, our results remained unchanged when we excluded those with the lowest memory scores (i.e., $z < -1.5$) suggesting this is less likely. Furthermore, self-report is a standard form of measurement in large scale public health studies and has recently been employed by the CDC COVID-19 response team in their investigation into mask use and social distancing [44]. Nevertheless, future research would benefit from incorporating informant report of adherence to COVID-19 protective behaviors. Despite the caveats of brief assessment and self-report, the current study indirectly demonstrates the utility of brief telephone based-assessments of cognition and

relevant health behaviors in identifying community dwelling older adults who may be at an increased risk of COVID-19 infection and transmitting the virus. Overall, the brief nature of these assessments permits a more rapid and wide scale reach in the community that more comprehensive testing would not.

Conclusion

Older adults with reduced memory ability may be less adherent to COVID-19 protective behaviors, placing them at an even higher risk of COVID-19 infection and spreading the virus. It is estimated that more than 5 million people over 70 in the US have some form of cognitive impairment without dementia [45], and that many older adults living with cognitive impairment go undetected [46]. Notably, one study showed that age-associated memory loss may be present in 85% of community dwelling older adults, depending on how it is assessed [47]. These findings highlight the need to tailor public health care strategies aimed at older adults that may have reduced cognitive function. Such strategies may include a more focused effort on minimizing/simplify use of medical jargon where possible, as well as establishing guidelines for healthcare professionals and family members on how to systematically monitor patient adherence to these behaviors. Finally, the findings from this study also provide preliminary support for including cognitive impairment more generally as a qualifying medical condition for prioritizing vaccine distribution. Informed recommendations for obtaining vaccine consent are also needed to ensure ethical but safe administration of vaccines to older adults.

Author contributions All authors contributed to the study conception and design. Material preparation and data analysis were performed by: DOS. The first draft of the manuscript was written by DOS and all authors commented on previous versions of the manuscript. All authors read and approved the final version of the manuscript.

Declarations

Conflict of interests The authors declare that there is no conflict of interest to declare that are relevant to the content of this article.

Statement of human and animal rights HRS protocols were approved by the University's Behavioral Sciences Committee Institutional Review Board.

Informed consent Written informed consent was provided by participants before entering the HRS.

References

- Herridge MS (2002) Long-term outcomes after critical illness. *Curr Opin Crit Care* 8:331–336
- Brummel NE et al (2017) Frailty and subsequent disability and mortality among patients with critical illness. *Am J Respir Crit Care Med* 196:64–72
- Ueki H et al (2020) Effectiveness of face masks in preventing airborne transmission of SARS-CoV-2. *mSphere* 5:1–5
- Li T et al (2020) Mask or no mask for COVID-19: a public health and market study. *PLoS ONE* 15:e0237691
- Lerner AM, Folkers GK, Fauci AS (2020) Preventing the spread of SARS-CoV-2 with masks and other “low-tech” interventions. *JAMA* 324:1935
- Davies A et al (2013) Testing the efficacy of homemade masks: would they protect in an influenza pandemic? *Disaster Med Public Health Prep* 7:413–418
- Eikenberry SE et al (2020) To mask or not to mask: modeling the potential for face mask use by the general public to curtail the COVID-19 pandemic. *Infect Disease Modelling* 5:293–308
- Leung NH et al (2020) Respiratory virus shedding in exhaled breath and efficacy of face masks. *Nat Med* 26:676–680
- Cowling BJ et al (2020) Impact assessment of non-pharmaceutical interventions against coronavirus disease 2019 and influenza in Hong Kong: an observational study. *Lancet Publ Health* 5:e279–e288
- Fischer CB et al (2021) Mask adherence and rate of COVID-19 across the United States. *PLoS ONE* 16:e0249891
- Latkin CA et al (2021) Mask usage, social distancing, racial, and gender correlates of COVID-19 vaccine intentions among adults in the US. *PLoS ONE* 16:e0246970
- Coroiu A et al (2020) Barriers and facilitators of adherence to social distancing recommendations during COVID-19 among a large international sample of adults. *PLoS ONE* 15:e0239795
- Gautam V et al (2021) Health literacy, preventive COVID 19 behaviour and adherence to chronic disease treatment during lockdown among patients registered at primary health facility in urban Jodhpur, Rajasthan. *Diabetes Metab Syndr: Clin Res Rev* 15:205–211
- Vally Z (2020) Public perceptions, anxiety and the perceived efficacy of health-protective behaviours to mitigate the spread of the SARS-Cov-2/COVID-19 pandemic. *Public Health* 187:67–73
- Aschwanden D et al (2020) Psychological and behavioural responses to coronavirus disease 2019: the role of personality. *Eur J Pers* 35:51
- Ayre J et al (2021) COVID-19 prevention behaviour over time in Australia: patterns and long-term predictors from April to July 2020. *medRxiv*. <https://doi.org/10.1101/2021.02.04.21251165>
- Wolff W et al (2020) High boredom proneness and low trait self-control impair adherence to social distancing guidelines during the COVID-19 pandemic. *Int J Environ Res Pub Health* 17:5420
- Hunt E, Frost N, Lunneborg C (1973) Individual differences in cognition: A new approach to intelligence. *Psychology of learning and motivation*. Elsevier, pp 87–122
- Gustafsson JE, Undheim JO (1996) Individual differences in cognitive functions. In: Berliner DC, Calfee RC (eds) *Handbook of educational psychology*. Macmillan Library Reference USA, New York, pp 186–242
- Gatto NM et al (2020) Observed physical function is associated with better cognition among elderly adults: the Adventist Health Study-2. *Am J Alzheimers Dis Other Dement* 35:1533317520960868. <https://doi.org/10.1177/1533317520960868>
- Wang S, Blazer DG (2015) Depression and cognition in the elderly. *Ann Rev Clin Psychol* 11:331–360
- Davis JC et al (2015) Mobility and cognition are associated with wellbeing and health related quality of life among older adults: a cross-sectional analysis of the Vancouver Falls Prevention Cohort. *BMC Geriatr* 15:1–7
- Hayat SA et al (2018) Understanding the relationship between cognition and death: a within cohort examination of cognitive measures and mortality. *Eur J Epidemiol* 33:1049–1062
- Xie W, Campbell S, Zhang W (2020) Working memory capacity predicts individual differences in social-distancing compliance during the COVID-19 pandemic in the United States. *Proceed Natl Acad Sci* 117:17667–17674
- Thoma V et al (2021) Cognitive predictors of precautionary behavior during the COVID-19 Pandemic. *Front Psychol* 12:325
- Insel K et al (2006) Executive function, working memory, and medication adherence among older adults. *J Gerontol Ser B: Psychol Sci Soc Sci* 61:P102–P107
- Berendsen AM et al (2018) Association of long-term adherence to the mind diet with cognitive function and cognitive decline in American women. *J Nutr Health Aging* 22:222–229
- Sinclair AJ, Girling AJ, Bayer AJ (2000) Cognitive dysfunction in older subjects with diabetes mellitus: impact on diabetes self-management and use of care services. *Diabetes Res Clin Pract* 50:203–212
- Allom V et al (2018) Breaking bad habits by improving executive function in individuals with obesity. *BMC Publ Health* 18:1–8
- Allan JL, McMinn D, Daly M (2016) A bidirectional relationship between executive function and health behavior: evidence, implications, and future directions. *Front Neurosci* 10:386
- Gaffan D (1985) Hippocampus: memory, habit and voluntary movement. *Philosophical Transactions of the Royal Society of London. B, Biol Sci* 308:87–99
- Gilbert SJ, Burgess PW (2008) Executive function. *Curr Biol* 18:R110–R114
- Langa KM et al (2005) The aging, demographics, and memory study: study design and methods. *Neuroepidemiology* 25:181–191
- Karzmark P (2000) Validity of the serial seven procedure. *Int J Geriatr Psychiatry* 15:677–679
- Steffick DE (2000) Documentation of affective functioning measures in the health and retirement study. University of michigan, Ann Arbor, MI
- DiMatteo MR (2004) Social support and patient adherence to medical treatment: a meta-analysis. *Health psychol* 23:207
- Ettenhofer ML et al (2009) Aging, neurocognition, and medication adherence in HIV infection. *Am J Geriatr Psychiatry* 17:281–290
- Davis R et al (2015) Theories of behaviour and behaviour change across the social and behavioural sciences: a scoping review. *Health Psychol Rev* 9:323–344
- Kindig DA, Panzer AM, Nielsen-Bohlman L (2004) *Health literacy: a prescription to end confusion*. National academic press, Washington, DC
- Berkman ND et al (2011) Low health literacy and health outcomes: an updated systematic review. *Ann Intern Med* 155:97–107
- Kooshyar H et al (2014) Health literacy and its relationship with medical adherence and health-related quality of life in diabetic community-residing elderly. *J Mazandaran Univ Med Sci* 23:134–143
- Federman AD et al (2009) Health literacy and cognitive performance in older adults. *Journal Am Geriatr Soc* 57:1475–1480

43. Nguyen HT et al (2013) Cognitive function is a risk for health literacy in older adults with diabetes. *Diabetes Res Clin Prac* 101:141–147
44. Fisher KA et al (2020) Community and close contact exposures associated with COVID-19 among symptomatic adults \geq 18 years in 11 outpatient health care facilities—United States, July 2020. *Morb Mort Wkl Rep* 69:1258
45. Plassman BL et al (2008) Prevalence of cognitive impairment without dementia in the United States. *Ann Intern Med* 148:427–434
46. Sternberg SA, Wolfson C, Baumgarten M (2000) Undetected dementia in community-dwelling older people: the Canadian Study of Health and Aging. *J Am Geriatr Soc* 48:1430–1434
47. Smith G et al (1991) Age-associated memory impairment diagnoses: problems of reliability and concerns for terminology. *Psychol Aging* 6:551

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