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Understanding Health Beliefs and Health Behaviors in Older Adults at Risk for Alzheimer's Disease

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Abstract.
Background: There are significant public health benefits to delaying the onset of Alzheimer's disease (AD) in individuals at risk. However, adherence to brain healthy behaviors is low. The Health Belief Model proposes that specific beliefs are mediators of behavior change.
Objective: To characterize health belief measures from the Science of Behavior Change Research Network (SBCRN) in an older adult population and associations between health beliefs, AD risk, and current health behaviors.
Methods: A total of 172 individuals from the Rhode Island AD Prevention Registry participated. SBCRN health belief measures included assessments of future time perspective, self-efficacy, deferment of gratification, and consideration of future consequences. Outcome measures included individual AD risk index score, dementia risk awareness, and lifestyle behaviors including physical, cognitive, and social activity.
Results: Participants who were older had higher scores for AD risk, lower future time perspective, and lower generalized self-efficacy (all at $p < 0.001$). Higher generalized self-efficacy was related to increased physical activity ($p < 0.010$). Higher future time perspective ($p < 0.001$) and generalized self-efficacy ($p = 0.48$) were associated with lower AD risk score. Subjective cognitive decline (SCD) was associated with lower self-efficacy, ability to delay gratification, and a less expansive future time perspective.
Conclusions: Greater self-efficacy and perceived future time remaining were associated with lower AD risk and greater engagement in physical activity. SCD was associated with health beliefs that may negatively affect engagement in positive brain health behaviors. Assessment of and psychoeducation about these intrapersonal health belief constructs may be important targets for behavioral interventions to reduce AD risk.

Keywords: Alzheimer's disease, clinical trial, genetic risk testing, prevention, subjective cognitive decline

INTRODUCTION

By 2050, an estimated 13.8 million people in the United States alone will be living with Alzheimer's disease (AD). Health care and long-term care costs are estimated in the U.S. to exceed $1.1 trillion by this time [1]. Delaying the onset of AD by 5 years

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would reduce total health care payments by 33%, making prevention of AD a public health priority. A recent commission on dementia reported that 40% of dementias worldwide could be prevented or delayed through modification of 12 different risk factors [2]. These modifiable factors include maintaining good physical and mental health (treating hearing loss, diabetes, hypertension, depression, and obesity and preventing smoking, excessive alcohol use, head injury and air pollution), as well as promoting education, social connections, and frequent exercise. Correctly timed primary prevention or risk reduction interventions targeted to these risk factors could substantially prevent or delay AD onset.

Given that preclinical accumulation of AD pathology is estimated to occur 20–30 years prior to onset of clinical symptoms, the timing for effective interventions for AD is now considered best when directed at mid- or early late life, prior to the onset of cognitive decline [2, 3]. Encouragingly, recent research shows that since 1998, there have been significant global reductions in incidence of dementia which can at least be partially attributed to an increase in dementia risk education and interventions [4, 5]. However, engagement in positive health behaviors among Americans in mid-to-late life is still generally poor. While there have been steady increases in self-reports of engagement yearly, as of 2016, only approximately half of adults reported they meet recommended aerobic activity guidelines [6]. These findings are likely overestimates, as research on wearable technology demonstrates individuals tend to overestimate their level of activity [7, 8]. Poor adherence to healthy diets [6]; higher than recommended alcohol use, especially in women [9]; poorly managed hypertension, which has increased in low and middle income countries [10]; difficulties with social isolation and loneliness [11, 12]; and other modifiable risk factors continue to be significant public health concerns throughout the lifespan.

There have been a few large-scale intervention studies that have attempted to address modifiable dementia risk factors. However, at best each study has only managed modest behavioral changes in their specific areas of intervention [13–16]. A large, intensive multi-domain AD prevention trial, the FINGER trial, reported 25% improvements in cognitive measures and lower cognitive decline after two years, but only 19% of participants were able to adhere to all the trial components in the intervention [14]. These adherence concerns are pervasive across the various behavioral intervention trials and demonstrate a need for theoretically grounded approaches to increase adherence in interventions. Additionally, the majority of these trials measure improvements in cognitive functioning as key outcome measures; however, improvements in current cognition may not relate to true decreases in time to onset or long-term behavior change. Examining the underlying mechanisms of behavior change is needed for sustained health behavior change to reduce dementia risk.

One of the most widely used models for health promotion and disease prevention is the Health Belief Model [17]. This model frames health beliefs such as perceived threat of disease, perceived benefits and barriers to behavioral change, and self-efficacy as key mediators of engagement in health behaviors. However, the Health Belief Model has rarely been applied to AD directly and to date has never been applied to work in the United States. The limited research on AD risk and the Health Belief Model indicates that while younger individuals tend to report higher perceived benefits, more cues to action, and higher self-efficacy, they are less likely to implement change [18–20]. This is consistent with research from Australia, which reported that fewer people take action to reduce dementia risk than express intent to implement these actions [19]. This research does support that increased threat, as defined by having prior contact with someone with dementia, increased the likelihood of behavior change [18–20].

Validated health belief constructs from the Science of Behavior Change Research Network can be integrated into the Health Belief Model (HBM) and adapted to AD-relevant risk factors (Fig. 1). Intrapersonal health belief constructs that may be particularly relevant for AD prevention include future time perspective, self-efficacy, deferment of gratification, and consideration of future consequences. Developing individual profiles of these features, or a behavioral phenotype, could be useful targets to enhance and maintain engagement with behavioral interventions [21]. There have been studies in Australian, Dutch, and Turkish samples which have examined health beliefs in relation to key HBM constructs and AD risk factors. Across these studies, motivation for change factors were related to perceived susceptibility to dementia, with the Australian sample having higher motivation than the Dutch or Turkish samples [18, 22, 23]. However, to our knowledge measures of these health beliefs have not yet been examined in an older adult population in the United States in the context of AD prevention.

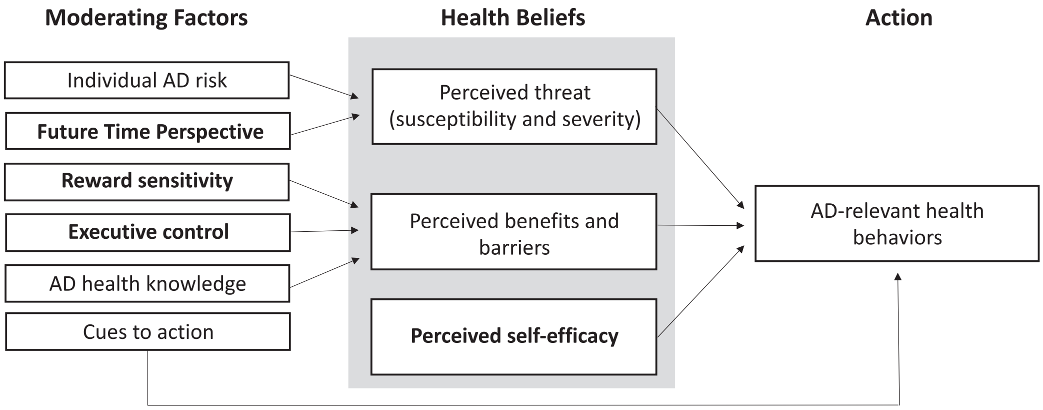

Fig. 1. Adapted Health Belief Model. Constructs in bold are assessed using measures from the Science of Behavior Change Research Network.

The aim of this descriptive, hypothesis-generating study was to gain additional information on current health behaviors and beliefs for older adults in an AD prevention registry. Understanding the associations between these health beliefs and outcome measures such as risk for AD, physical activity, cognitive activity, and social connectedness in a United States sample is an important first step in developing behavioral interventions and individualized strategies to improve health behaviors that may reduce AD risk or delay symptom onset. As such, we performed confirmatory analyses (e.g., expected relationships between age, education, and AD risk index scores) as well as exploratory relationships between our variables in service of a full description of our findings. The aims of this study were to 1) characterize descriptive statistics of validated instruments from the Science of Behavior Change Research Network in older adults at risk for AD; and 2) examine associations between health beliefs and demographic factors, AD risk, subjective cognitive decline (SCD), and engagement in three individualizable and modifiable AD-relevant health behaviors (i.e., physical activity, cognitive activity, social activity) that are important for late-life dementia risk reduction.

METHODS

Participants

We invited participants enrolled in the Rhode Island Alzheimer Prevention Registry (the Registry) to complete a series of questionnaires via email. As part of the study, registrants were informed that participation would include linking their responses to previously collected data by the Registry. The Registry consists of healthy, community-dwelling individuals in southern New England who are over the age of 45, English speaking, and interested in participating in AD prevention and intervention studies. After enrollment into the Registry, participants are contacted annually by telephone for cognitive screening and receive quarterly newsletters about brain health, dementia prevention topics, and current research studies associated with the Registry (for full descriptions of the Registry, please see [24–26]). Individuals are deemed ineligible for the Registry after enrollment if they report untreated major psychiatric disorder(s), significant neurodevelopmental or learning disability, current substance use disorder, have a history or current neurological condition known to affect cognition, or score below psychometric cut-offs for dementia on telephone administered screens. Registrants are telephone-screened for cognition at baseline and annually afterwards using the Minnesota Cognitive Acuity Screen (MCAS [27]). Individuals who scored below clinical cut-offs for mild cognitive impairment (MCI,<52.5 [28]) on the MCAS were not invited to participate in the current study. All participants provided informed consent to participate, and study procedures were approved by the Rhode Island Hospital institutional review board (IRB Organization [29] #000237).

Questionnaires

Individuals who met eligibility criteria were sent links to all questionnaires via a web-based clinical research database (Research Electronic Data Capture [Redcap]). Participants were first asked demographic information including age, gender, race, ethnicity, education, occupational status, native language, and marital status. Current SCD was assessed by asking participants the following question, which has been deployed in other longitudinal cohort studies [30, 31]: “Do you feel like your memory is becoming worse?” [32]. Response options were 1) “No”, 2) “Yes, but this does not worry me”, or 3) “Yes, and this worries me.” All responses were merged with previously obtained Registry information, including family history of dementia and cognitive performance (MCAS) to ensure cognitively unimpaired status.

The survey measures given consisted of questionnaires on health beliefs and lifestyle factors. A series of empirically validated assessment measures from the Science of Behavior Change Research Network were selected to assess specific health belief factors. These included: 1) the Future Time Perspective Scale [33], a questionnaire which measures an individual’s perception of the future as time-limited, an aspect of perceived susceptibility to disease. Scores range between one and seven with higher scores suggesting a more expansive view of the future. 2) The Deferment of Gratification Scale [34] measures preference to pursue more remote goals over immediate gratification. Scores range between 12 and 84 with higher scores indicating greater willingness to defer gratification. 3) The Consideration of Future Consequences scale [35] has scores ranging between 14 and 98 with higher scores indicating a greater consideration of future consequences, or forward-looking behavior. 4) The Generalized Self-Efficacy scale measures one’s perceived ability to accomplish goals and solve problems [36]. Scores range between 12 and 84 with higher scores indicating greater general self-efficacy beliefs.

Outcome variables included measures of AD risk, dementia awareness, and current engagement in AD-relevant health behaviors. The Australian National University AD Risk Index (ANU-ADRI) [37] is a self-report measure that has been validated to predict AD risk. The survey uses key risk factors (age, low education, diabetes, traumatic brain injury, depressive symptoms, smoking, low social networks) and protective factors (cognitively stimulating activities, alcohol consumption, physical activity, fish intake) to calculate a weighted risk score where higher scores are indicative of higher AD risk [37, 38]. Given that non-modifiable demographic characteristics such as age and education are significant risk factors for AD, we also calculated an AD risk index score that did not include age and education ($\text{ANU-ADRI}_{\text{adj}}$). This allowed us to separately covary for these demographic factors in analyses and separately quantify an AD risk score based on modifiable risk factors alone. Knowledge of AD risk was measured using the Dementia Awareness Questionnaire [39], which assesses understanding of risk factors for dementia. Scores range from one to five, with lower scores indicating greater knowledge of dementia risk factors. A measure of current physical activity, the CHAMPS Activities Questionnaire for Older Adults [40], assesses the frequency and duration of physical, cognitive, and social activities in older adults. Each of these items were rated on a five-point ordinal scale with 1 = engaging in that activity once or less a year, to 5 = engaging in the activity every day or almost every day, yielding three domain scores for physical, cognitive, and social activity (higher scores equal greater activity). Although there is partial overlap between content domains of the ANU-ADRI and CHAMPS, the former is used as to calculate a total AD risk score by briefly assessing risk within many individual domains, while the latter provides a more detailed assessment of physical, cognitive, and social engagement using a comprehensive list of potential activities. Thus, both were included as outcome measures despite their partial overlap in content.

Analysis

The aim of this study was primarily descriptive for hypothesis generation and characterization of descriptive statistics of the health belief measures in an older adult population. As such, descriptive analyses were conducted for all survey responses. Bivariate Pearson correlations were conducted comparing demographic information, health belief measures, and outcome measures (health behaviors, AD risk), but we did not correlate the outcome measures (health behaviors and AD risk) together due to the amount of overlap in behaviors between these measures. Instead, these are used as discrete outcome measures to better assess their utility with the SBC questionnaires and development of behavioral phenotypes in the future. Hierarchal linear regressions were used to covary demographic information and assess which survey scores were most strongly associated with AD risk index scores and currently reported levels of physical, cognitive, and social activities. As an exploratory analysis, we conducted ANOVAs based on SCD status to determine if memory concerns differentiated individual responses to health belief measures.

RESULTS

The survey was sent to 633 Registry participants who consented to be contacted by email (85% of the 748 total participants in the Registry). A total of 172 individuals (27%) completed the consent and at least some of the questionnaires in the overall survey. Only data from fully completed individual surveys were included in analyses; there were slightly lower completion rates for Dementia Risk Awareness and CHAMPS activity questionnaires (Table 1). The majority of participants were white females (68% female; 92.5% white and non-Hispanic), aged 50 to 86 (*M*age = 69, *SD* = 7.9). On average, participants were college educated (*M*edu = 16 years, *SD* = 2.2) and 58% were retired. Most of the sample, 74%, reported a family history of dementia (117/158). In respect to the question about SCD, 46 (26%) reported no SCD, 60 (35%) reported SCD with no worry, and 71 (39%) individuals reported SCD with worry. Compared to individuals who did not respond to the survey, respondents were more likely to be men, $\chi^2 = 9.11$, $p = 0.003$, identify as a racial/ethnic minority, $\chi^2 = 4.40$, $p = 0.04$, and have higher educational attainment, $t(627) = 3.64$, $p < 0.001$. There were no differences in age between survey respondents and non-respondents, $t(627) = 1.24$, $p = 0.22$.

In each survey given, the response patterns were normally distributed, without significant clustering of responses or skewing, with the exception of the physical activity duration tending towards zero (Table 1). Overall means also fell largely within the midpoint of each scale. Physical activity duration and frequency had the largest range across the sample with the average frequency of any physical activity (regardless of intensity) occurring 21.4 times per week and the average duration of these activities taking 14.3 minutes. Vigorous physical activities (e.g., heavy lifting, digging, aerobics) were typically done 2.3 times per week ($sd = 3.3$) and moderate physical activities (e.g., bicycling at a regular pace, doubles tennis) were performed 4.28 times per week ($sd = 15.8$). None of the health belief measures correlated with one another above $r = 0.6$ suggesting statistical independence between scales and age and education were included for both AD risk and adjusted AD risks scores to describe the overall relationships between and education to the original and adjusted measure score. The AD risk index (ANU-ADRI) total score correlated highly but not perfectly with the risk index score adjusted for age and education (ANU-ADRI$_{adj}$) ($r = 0.6$, $p < 0.001$).

Bivariate Pearson correlations between demographic factors and health belief measures (Table 1) showed that participants who were older had higher unadjusted AD risk index scores ($r = 0.8$, $p < 0.001$) but no association for the demographically adjusted AD risk index. Age was also associated with lower future time perspective ($r = -0.3$, $p < 0.001$) and lower generalized self-efficacy ($r = -0.3$, $p < 0.001$). Higher education correlated with higher consideration of future consequences ($r = -0.31$, $p < 0.001$), lower unadjusted AD risk index score ($r = -0.2$, $p = 0.006$, as expected given the inclusion of education in this unadjusted variable), and lower adjusted AD risk index score ($r = -0.3$, $p < 0.001$). There were no differences in responses based on gender.

Higher scores on all health belief measures indicate higher levels of a positive trait. Lower scores on the Dementia Awareness Scale reflect better understanding of dementia risk. Associations between health belief measures and outcome measures (Table 2) showed that higher self-efficacy ($r = 0.2$, $p < 0.001$) and lower scores on the dementia risk awareness (i.e., better dementia risk awareness; $r = -0.2$, $p < 0.05$) were associated with higher frequency of physical activities. Higher self-efficacy ($r = 0.3$, $p < 0.001$), higher deferment of gratification ($r = 0.2$, $p < 0.001$) were associated with higher duration of physical activities throughout a week. Higher education ($r = 0.2$, $p < 0.001$), and higher self-efficacy ($r = 0.16$, $p = 0.045$) were associated with more regular cognitive activities. Finally, higher self-efficacy ($r = 0.2$, $p < 0.01$), higher deferment of gratification ($r = 0.2$, $p < 0.001$), and higher consideration of future consequences ($r = 0.2$, $p < 0.001$) were associated with greater social connectedness.

To determine whether the health belief measures uniquely contributed to variance in outcome measures (AD risk, physical activity, cognitive activity, and social activity), we conducted two-step hierarchical linear regression, controlling for age and education in the first block. The second block included self-report measures of future time perspective, self-efficacy, deferment of gratification, consideration of future consequences and dementia risk awareness with the demographically adjusted AD risk index score (ANU-ADRI$_{adj}$) as the primary outcome measure (Table 3). A total of 21% of the variance in AD risk index scores was explained by the overall model ($R^2 = 0.21$, $R^2{}_{adjusted} = 0.17$, $\Delta R^2 = 0.21$, $F(7, 141) = 5.1$, $p < 0.001$). More years of education in the first step ($t = -2.4$, $B = -0.53$,

Table 1
Basic descriptive statistics of survey response measures

Survey	*N*	Mean	SD	Range	Skew	Kurtosis	Correlation with age (*r*)	Correlation with education (*r*)
Future time perspective	172	4.12	1.16	5.5	0.2	–0.3	–0.33**	–0.07
Generalized self-efficacy	170	64.4	10.2	55.0	–1.0	1.4	–0.23**	0.13
Deferment of gratification	169	62.7	9.1	55.0	–0.4	0.5	0.05	0.17*
Consideration of future consequences	166	72.5	12.0	67.0	–0.9	1.8	0.05	0.36**
Dementia risk awareness	153	2.5	0.4	2.5	0.1	1.1	–0.03	–0.25**
Unadjusted AD risk index (ANU-ADRI)	172	4.3	11.6	52.0	0.3	–0.6	0.76**	–0.02
Adjusted AD risk index ($\text{ANU-ADRI}_{\text{adj}}$)	171	–5.1	6.4	28.0	0.2	–0.6	0.01	–0.28**
CHAMPS activities frequency per week	153	21.4	11.6	52.0	0.7	–0.2	–0.06	0.07
CHAMPS physical activity duration per week (min)	154	14.3	9.6	56.3	1.2	1.9	–0.03	0.09
CHAMPS cognitive activity	158	2.9	0.5	2.9	–0.3	0.4	–0.08	–0.10
CHAMPS social activity	155	3.7	1.1	5.0	–0.2	–0.4	0.11	0.25**

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

Table 2
Associations between health belief measures and AD health behaviors (correlation *r* values)

	Unadjusted AD risk index (ANU-ADRI)	Demographically adjusted AD risk index ($\text{ANU-ADRI}_{\text{adj}}$)	Sum of frequency of ALL activities per week	Sum of duration of ALL activities per week	Cognitive activity per week	Social activity per week
Future time perspective	–0.36**	–0.21**	0.06	0.02	0.15	0.10
Generalized self-efficacy	–0.31**	–0.26**	0.24**	0.28**	0.16*	0.26**
Deferment of gratification	–0.15	–0.29**	0.15	0.21**	0.13	0.21**
Consideration of future consequences	–0.10	–0.23**	0.05	0.11	0.01	0.22**
Dementia risk awareness	0.06	0.09	–0.19*	–0.12	0.04	–0.15

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

$\beta = -0.20$, $p = 0.018$) and lower deferment of gratification scores in the second step ($t = -2.3$, $B = -0.15$, $\beta = -0.25$, $p = 0.022$) were related to lower overall risk scores.

We also conducted parallel two-step hierarchical linear regression to examine the contribution of health beliefs to overall physical activity, with separate models for physical activity frequency and duration. A total of 11% of the variance in weekly frequency of physical activity was explained by the overall model ($R^2 = 0.107$, $R^2{}_{adjusted} = 0.06$, $\Delta R^2 = 0.10$, $F(7, 141) = 2.2$, $p = 0.032$). Higher self-efficacy ($t = 2.4$, $B = 0.28$, $\beta = 0.25$, $p = 0.018$) and lower scores indicating better understanding of dementia risk awareness ($t = -2.4$, $B = -6.2$, $\beta = -0.22$, $p = 0.017$) significantly explained the variance in frequency of physical activity. Regarding duration of weekly physical activity, 10% of the variance was explained by the overall model ($R^2 = 0.104$, $R^2{}_{adjusted} = 0.06$, $\Delta R^2 = 0.10$, $F(7, 141) = 2.2$, $p = 0.037$). In this model, only higher self-efficacy ($t = 2.6$, $B = 0.26$, $\beta = 0.27$, $p = 0.009$) was significantly associated with duration of physical activity.

Despite the ranges for social and cognitive activities being relatively constrained due to the ordinal nature of item responses, their calculated scores were assessed at two decimal points and had normal distributions. Thus, hierarchical linear regressions were conducted as with the outcome measures above. The model for cognitive activities was significant with 14% of the variance explained ($R^2 = 0.142$, $R^2{}_{adjusted} = 0.06$, $\Delta R^2 = 0.10$, $F(7, 141) = 3.2$, $p = 0.004$); self-efficacy was the only significant predictor after adjustment for age and education ($t = 2.2$, $B = 0.01$, β=0.22, $p = 0.031$). Health belief measures were not significantly associated with social activity ($R^2 = 0.067$, $R^2{}_{adjusted} = 0.10$, $\Delta R^2 = 0.05$, $F(7, 141) = 1.4$, $p = 0.217$).

Given the importance of SCD as a possible prodromal symptom of AD, we wanted to determine if ratings of subjective memory affected individual health beliefs. The three SCD subgroups were relatively balanced in this sample: 42 (26%) of respondents reported no SCD, 58 (36%) reported SCD without worry, and 61 (38%) reported SCD with worry. ANOVAs showed no differences in age and education between the

Table 3
Model information for predictors of key dementia risk scores and activity types

Model	Variables	$ANU\text{-}ADRI_{adj}$ scores		Physical activity frequency		Physical activity duration		Cognitive activities		Social activities	
		β	t	β	t	β	t	β	t	β	t
1	Intercept		0.02		1.99*		1.23		3.79**		5.21**
	Age (y)	0.10	1.21	–0.06	–0.72	–0.03	–0.37	0.06	0.73	–0.09	–1.02
	Education (y)	–0.26	–3.08**	0.07	0.79	0.08	0.93	0.20	2.41*	–0.09	–1.06
2	Intercept		2.33*		1.52		0.21		1.21		2.32*
	Age (years)	0.04	0.45	–0.02	–0.19	–0.00	–0.02	0.14	1.63	–0.06	–0.62
	Education (years)	–0.20	–2.40*	0.01	0.16	0.02	0.26	0.13	1.47	–0.10	–1.06
	Future time perspective	–0.13	–1.37	–0.04	–0.42	–0.09	–0.94	0.09	0.99	0.03	0.28
	Generalized self-efficacy	–0.15	–1.50	0.25	2.39*	0.27	2.65**	0.22	2.18*	0.12	1.11
	Deferment of gratification	–0.25	–2.33*	0.12	1.02	0.16	1.40	0.03	0.30	0.18	1.53
	Consideration of future consequences	0.03	0.30	–0.18	–1.55	–0.13	–1.09	0.04	0.34	–0.11	–0.95
	Dementia risk awareness	–0.01	–0.18	–0.22	–2.42*	–0.11	–1.22	–0.07	–0.80	0.02	0.18

**Significant at the 0.01 level; *Significant at the 0.05 level.

three groups, and groups did not significantly differ on health behavior outcome measures (physical, cognitive, or social activity; all $ps > 0.05$). Of the health belief measures examined, there were group differences in future time perspective ($F = 7.4$, $p < 0.001$, $\eta_p^2 = 0.16$), self-efficacy ($F = 5.0$, $p = 0.008$, $\eta_p^2 = 0.13$), and deferment of gratification ($F = 3.5$, $p = 0.033$, $\eta_p^2 = 0.11$). Bonferroni-corrected post-hoc analyses showed that compared to both SCD groups, the no SCD group had higher future time perspective, self-efficacy and deferment of gratification; there were no differences between SCD with or without worry (Fig. 2). The no SCD group also had higher consideration of future consequences than the SCD without worry group ($p < 0.05$), though the SCD+worry group did not differ from either of the other groups.

DISCUSSION

This study examined intrapersonal health belief factors that may be key mediators of health behavior change for AD risk reduction. Although large scale behavioral interventions that include exercise, social activity, and cognitive activity have shown efficacy for delaying cognitive decline [13, 15], adherence to these interventions remains a significant challenge. Examining mechanisms of health behavior change is critical to inform the development of personalized interventions that can generate sustained health behavior change. We report that health beliefs of future time perspective, self-efficacy, ability to defer gratification, and consideration of future consequences are associated with lower overall AD risk and engagement in brain health-relevant behaviors. These findings may help to identify specific behavioral phenotypes and new targets in behavioral interventions to increase engagement in health behavior change that could reduce dementia risk and/or delay dementia onset.

The first goal of this study was to examine descriptive statistics of the Science of Behavior Change Research Network scales in an older sample of individuals living in the United States who are at risk for AD, as these measures have primarily been validated in samples outside of the United States. We found that each scale was normally distributed, had mean scores near the midpoint of the scoring range, and was only moderately correlated with the other health belief measures. This provides preliminary normative data to guide interpretation of these measures in

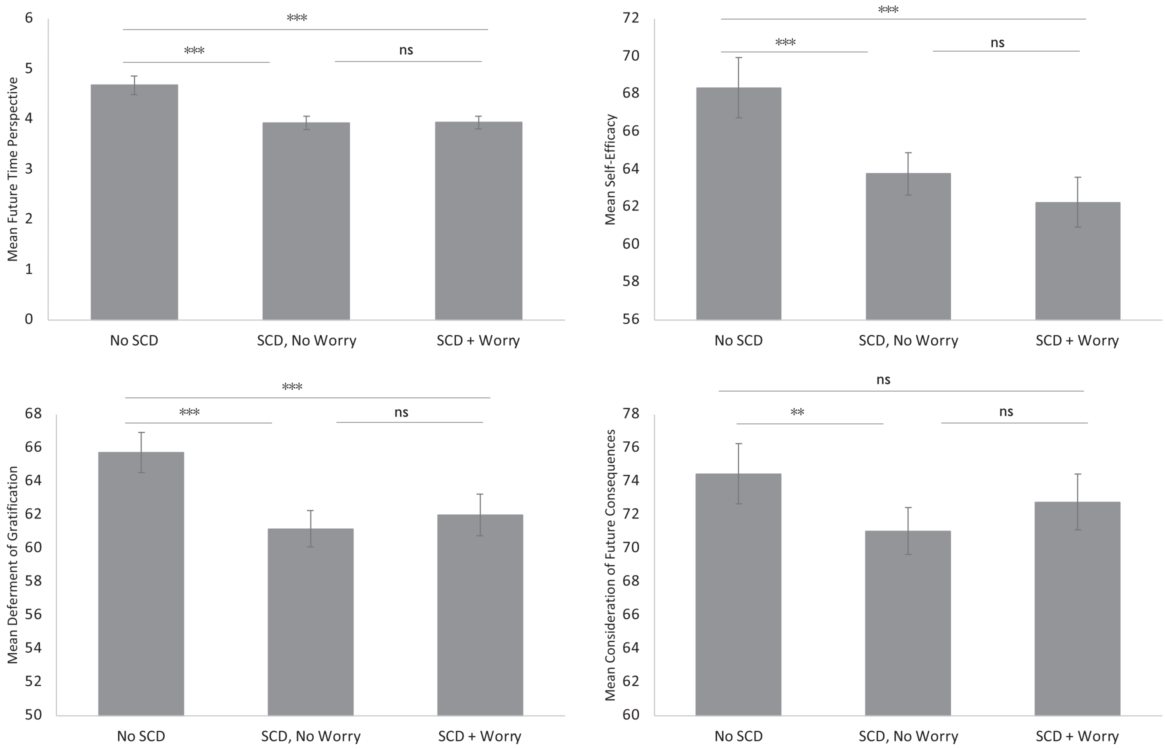

Fig. 2. Groups based on reported SCD. SCD = subjective cognitive decline; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$, error bars represent ± 2 standard error. For all associations, higher mean scores reflect higher levels of a positive trait.

older adult populations. It also suggests that the measures have some degree of statistical independence and capture unique aspects related to health beliefs.

The second aim of the study was to examine associations between health beliefs and demographic factors, AD risk, SCD status, and engagement in AD-relevant health behaviors. We found expected associations between the health belief measures and demographic characteristics such as age and education. For example, older age was associated with a lower future time perspective, which may affect a variety of behaviors including motivation and risk taking [41]. Older age was also associated with lower self-efficacy, the belief that one is capable of achieving a goal. This is consistent with research indicating younger individuals report higher levels of self-efficacy, though this is not always associated with taking action [18, 20]. Higher education was also related to higher self-reported ability to defer gratification, better understanding of future consequences, and better dementia risk awareness.

Regarding objective risk for AD, we found that individuals with higher AD risk scores (ANU-$ADRI_{adj}$) reported lower future time perspective, ability to delay gratification, consideration of future consequences, and self-efficacy. This is consistent with previous work done internationally in Australia, Turkey, and the Netherlands [18, 22]. Given the cross-sectional nature of previous international work, as well as correlational nature of this study, we cannot determine the timing and direction of these effects. For example, individuals with less adaptive health beliefs may have engaged in a lifetime of less healthy behaviors that increased their overall AD risk [18–20]. Alternatively, having higher AD risk may cause changes in health beliefs, such as a shift toward lower self-efficacy, a tendency to place less weight on future consequences of actions, or a shortened perspective of future time remaining [18, 19]. One recent study in Australia by Bartlett et al. [42] did find that increases in self-efficacy reduced dementia risk factors over time. Longitudinal research incorporating additional scales, such as the Motivation to Change Lifestyle and Health Behavior for Dementia Risk Reduction Scale [43], which assesses specific HBM constructs, as well as replication of the recent Bartlett et al findings in the United States and the SOBC measures used in the present study is needed to probe these questions [42].

To determine whether health belief factors are associated with brain health-relevant behaviors, we examined them in simple correlations and in regression models that accounted for the relative contribution of each health belief. Correlation analysis showed that self-efficacy, deferment of gratification, consideration of future consequences, and dementia risk awareness were associated with at least one of physical, cognitive, or social activity. In regression analyses, self-efficacy was most consistently associated with self-reported physical and cognitive activity level. This is consistent with a large body of research in the field of behavioral medicine that implicates self-efficacy as a critical factor in motivating health behavior change [22, 44]. Self-efficacy and related constructs have been less well studied in the context of aging and AD prevention, although several studies report that higher self-efficacy is associated with the intention to adopt a healthier lifestyle [18, 19, 45]. One recent meta-analysis indicated that older adults with lower self-efficacy were less likely to engage in health behaviors in various health care settings [46]. In addition, among older adults with MCI or mild dementia, higher self-efficacy was associated with lower rates of depression and anxiety [47], which could themselves be important mediators of behavior change. This makes self-efficacy an important treatment target in multidomain lifestyle interventions for AD prevention.

Given that our sample is one potentially at higher risk for development of dementia due to self-selection as part of the Rhode Island Alzheimer's Disease Registry as having high rates of family history and AD risk related genotyping [23–25], we wanted to examine how SCD may affect health belief scores. Recent research suggests that SCD is a very early indicator of AD risk and may be an early prodrome of the disease [48, 49]. One study in Turkey found that individuals with subjective memory complaints were more likely to see themselves as at risk for dementia but also reported greater perceived barriers to health behavior change [18]. In the current study, we found that individuals reporting SCD had lower self-efficacy, less ability to delay gratification, and a less expansive future time perspective compared to participants without SCD. However, scores did not meaningfully differ between those who experienced worry about their subjective cognitive symptoms and those who did not. It is unclear if these less adaptive health beliefs represent pre-existing beliefs prior to any subjective decline or if they are a consequence of subjective cognitive changes. Regardless, because intervention studies tend to recruit individuals who have concerns about developing cognitive decline, the existence of these less adaptive health beliefs may be a barrier to an individual's ability to engage in and adhere to intervention components.

This study has several important limitations. This sample may not be representative of older adults more generally. Participants were recruited from the Rhode Island Alzheimer's Disease Prevention Registry, the majority have a personal family history of dementia, and the sample was highly educated and majority white. Future research is needed to explore variability in health belief factors among people with a broader range of racial, ethnic, educational, and socioeconomic backgrounds. This is particularly important, as structural barriers (e.g., finances, access to resources, racism) play a major role in health behavior change and may interact with individual health beliefs. Furthermore, this is a relatively small sample obtained to provide the first descriptive data and exploration of these scales in a United States sample. Validation of these findings in a larger sample with more age and AD risk variation and stricter statistical control of type 1 error is a key next step, as is determining the clinical significance of differing health belief scores in terms of willingness or ability to make health behavior changes. Finally, as this study relied on self-report measures of physical, cognitive, and social activity, it will be important to examine correspondence between health beliefs and objective measures of these AD-relevant health behaviors as well as additional health behaviors highlighted by the Lancet Commission on Dementia Prevention that were not included here (e.g., hearing loss, traumatic brain injury, hypertension, alcohol overuse, smoking, depressed mood).

This is the first study of its kind to apply the Health Belief Model and empirically-validated measures from Science of Behavior Change Research Network to the topic of AD prevention in the United States. This study characterized the initial descriptive statistical properties of health belief measures in an older adult population, providing preliminary normative data to guide future work. It also showed associations between health beliefs and AD risk, engagement in brain health behaviors, and subjective cognitive decline. This hypothesis-generating study lays a strong groundwork for assessing intrapersonal health belief factors that may mediate or moderate health behavior change. Given low adherence rates in large, multidomain lifestyle interventions for AD [14] and positive health behaviors in general [4–8], intrapersonal health beliefs may be important targets to increase engagement in health behaviors that may reduce AD risk. Individual health belief profiles used in conjunction with known AD risk factors may be a method for developing health education interventions to modify AD risk. Future work addressing the potential clinical utility of these scales could also give providers new insight into increasing factors such as self-efficacy within clinical contexts.

AUTHOR CONTRIBUTIONS

Jessica Zakrzewski (Data curation; Formal analysis; Writing – original draft; Writing – review & editing); Jennifer D. Davis (Conceptualization; Investigation; Project administration; Supervision; Writing – review & editing); Zachary T. Gemelli (Data curation; Project administration; Writing – review & editing); Laura E. Korthauer (Conceptualization; Formal analysis; Project administration; Supervision; Writing – original draft; Writing – review & editing).

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CONFLICT OF INTEREST

The authors have no conflict of interest to report.

DATA AVAILABILITY

The data supporting the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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