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RESEARCH ARTICLE

Scam susceptibility is associated with a markedly accelerated onset of Alzheimer's disease dementia

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Abstract

INTRODUCTION: The association of scam susceptibility with the timing of Alzheimer's disease (AD) dementia onset is unknown.

METHODS: One thousand ninety-two older adults without dementia underwent assessments of scam susceptibility and annual clinical evaluations to document incident AD dementia. Accelerated failure time models examined the relation of scam susceptibility with dementia onset.

RESULTS: During a mean of 5 years of follow-up (standard deviation = 3.1), 188 individuals (17%) were diagnosed with incident AD dementia. A higher level of scam susceptibility was associated with a considerably earlier dementia onset ($\beta = -0.039$; 95% confidence interval: −0.061, −0.017); those with a high level of susceptibility developed AD dementia at a mean age of 90.9 years compared to 98.2 for those with a low level. Results persisted after controlling for global cognition, sex, and education.

DISCUSSION: Scam susceptibility is associated with a markedly earlier onset of AD dementia. Assessment of susceptibility may facilitate early identification of individuals at risk of developing dementia.

KEYWORDS
Alzheimer's disease, cognitive aging, dementia, fraud, scam

Highlights

- We examined whether scam susceptibility among older adults is associated with an accelerated onset of Alzheimer's disease dementia.
- Participants came from a large ongoing cohort study of aging.
- Scam susceptibility was assessed using a validated measure.
- Scam susceptibility was associated with a marked acceleration in dementia onset.
- Assessment of susceptibility may facilitate early identification of dementia.

1 | BACKGROUND

Alzheimer's disease (AD) dementia poses a major public health challenge, affecting > 6 million individuals in the United States and > 55 million worldwide.[1] Associated financial costs are staggering, in excess of $300 billion in the United States and $1 trillion worldwide, and the non-financial costs to individuals, families, and society are immeasurable.[2] Although a cure remains elusive, the advent of disease-modifying therapies (i.e., anti-amyloid) offers some promise for reducing the burden of AD dementia. However, these therapies appear most beneficial in the very early stages of disease, and there remains a critical need for efficient methods to identify the earliest behavioral manifestations of AD dementia—those that occur prior to the onset of cognitive impairment. We previously reported that scam susceptibility is associated with an increased risk of developing incident AD dementia and related to the presence of early AD pathology (i.e., amyloid beta [Aβ]) in the brain.[3,4] To date, however, no studies have examined the relation of scam susceptibility with the timing of AD dementia onset.

In this study, we tested the hypothesis that scam susceptibility is associated with an earlier onset of AD dementia among community-dwelling older persons from the Rush Memory and Aging Project (MAP). Participants underwent baseline assessments of scam susceptibility and detailed annual clinical evaluations thereafter to document incident AD dementia. Accelerated failure time (AFT) models were used to examine the association of baseline scam susceptibility with the subsequent age of dementia onset and determine whether this association was relatively independent of cognition and demographics.

RESEARCH IN CONTEXT

1. **Systematic review**: The authors conducted a literature search on the association of scam susceptibility with dementia.
2. **Interpretation**: Findings show that scam susceptibility is related to an earlier onset of Alzheimer's disease dementia.
3. **Future directions**: Future work should examine whether assessment of scam susceptibility may facilitate earlier identification of individuals at risk of dementia.

2 | METHODS

2.1 | Participants

Participants were from the Rush MAP, an ongoing cohort study of aging that began in 1997. At the time of these analyses, 2192 older persons were enrolled in MAP.[5] Of those, 1215 individuals were also enrolled in a study of decision making that was added to MAP in 2010 and had completed a scam susceptibility measurement;[6,7] the first visit with a valid scam susceptibility score was considered the analytic baseline. Of the 1215 individuals, we excluded 41 who had AD dementia or no available dementia diagnosis at the analytic baseline and 82 who did not have a follow-up evaluation. The remaining 1092 older persons comprised the final analytic dataset. Of note, the MAP attempts to recruit as diverse a sample as possible; however, most participants are White and non-Latinx. To address this, we are conducting a study of scam susceptibility and decision making in another Rush-based cohort of > 500 older Blacks, the Minority Aging Research Study. Thus, we hope to be able to better address the association of scam with incident AD in more diverse populations in the future as sufficient data accrue.

2.2 | Measurement of scam susceptibility

Scam susceptibility was measured using a 5-item scale that consists of statements that assess the behaviors and characteristics that, according to leading authorities on elder fraud (e.g., the AARP and the Financial Industry Regulatory Authority), are associated with scam and fraud victimization.[6–10] Specifically, participants were asked to rate their level of agreement with statements regarding their tendency to answer the phone when it rings regardless of knowing the caller, remain on the phone with an unknown caller, and listen to a telemarketer. Other statements assessed awareness that fraudsters commonly target persons over the age of 65, and more general concepts such as "if something is too good to be true, it usually is." Ratings are made using a 7-point Likert scale from strongly agree to strongly disagree. Higher average ratings across items indicate greater scam susceptibility. This measure has been used in several prior studies and shown to have adequate psychometric properties and be associated with a variety of adverse health outcomes.[6,7,11,12] Further, scores on the scam susceptibility measure were associated with the likelihood of engaging with a potential fraudster in a behavioral experiment that mimicked a real-world imposter scam, thus providing evidence of the validity of the measure.[13]

2.3 | Clinical classification of AD dementia

Participants underwent structured annual clinical evaluations that included a medical history, neurological examination, and 19 cognitive tests covering a range of cognitive domains.[5] Based on the clinical evaluation, a clinician experienced in working with older adults diagnosed AD dementia using the guidelines of the joint working group of the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association.[14,15] The diagnosis of AD dementia required a history of cognitive decline and impairment in memory and at least one additional cognitive domain. Mild cognitive impairment (MCI) was rendered for

individuals with evidence of mild impairment deemed insufficient for a diagnosis of dementia, as previously reported.[16]

2.4 | Other covariates

Age, sex, and education were adjusted for due to their associations with both scam susceptibility and AD dementia risk. Age in years was determined using date of birth and dates of annual clinical assessments. Participants reported their sex (male or female) and education (years of schooling) at their initial MAP evaluation. Global cognition at analytic baseline (i.e., the date that participants completed the baseline assessment of scam susceptibility) was measured via 19 individual, performance-based tests, as previously described.[5] Raw scores on individual tests were converted to *z* scores using the parent study baseline mean and standard deviation (SD). The *z* scores of individual tests were averaged to generate a measure of global cognition.[17,18]

2.5 | Statistical analysis

First, to examine bivariate associations of demographic variables with scam susceptibility and dementia diagnosis, we used Pearson/Spearman correlation coefficients, *t* tests, and chi-square tests as appropriate. Data preprocessing and descriptive analysis were performed using SAS software, version 9.4 for Linux (SAS Institute). Statistical significance was determined at a level of 0.05.

Next, to examine the association of scam susceptibility with the timing of incident AD dementia diagnosis, we used an AFT model as it provides a direct estimation of the mean age at dementia diagnosis and its model parameters have intuitive interpretation.[19] The AFT models were fitted by R programs version 3.6.0 (R Core Team) using the package flexsurv.[20] The AFT model predicting the age of AD diagnosis T_i for individual i was specified as follows:

$$\log T_i = \beta_0 + \beta_1 X_{i1} + \cdots + \beta_k X_{ik} + \varepsilon_i,$$

where X_{i1}, …, X_{ik} were the values of the covariates for individual i (e.g., scam susceptibility), and ε_i was the error variance of predicted log-survival time. The coefficient β characterizes the effect of the corresponding covariate on the mean age of AD dementia diagnosis. The transformed value $100(e^{\beta} - 1)$ characterizes the percent increase in the expected age at AD diagnosis for each 1-unit increase in X. The distribution of ε_i was modeled by the gamma distribution for its flexibility, which included the commonly used Weibull, log-normal, and gamma distributions as special cases.[21]

From this model, we can numerically derive the mean age at AD dementia diagnosis given a particular scam susceptibility score and thus quantify the effects of scam susceptibility by years of age decreased at the time of diagnosis. We adjusted for left-truncation in all analyses. Finally, in supporting analyses, we further adjusted for education, sex, and global cognition score at the analytical baseline; we also repeated the core analyses among only those participants with intact cognitive function at baseline (i.e., no dementia or even MCI).

TABLE 1 Descriptive properties of the sample.

Characteristics	Mean or #	SD or %
Age, baseline	80.89	7.49
Average # of follow-ups	5.38	3.10
Female	828	75.8%
Education	15.62	3.09
Scam susceptibility, baseline	2.67	0.76
Apolipoprotein E ε4 carrier[a]	189	17.3%
Income, baseline[a]	7.56	2.39
Well-being, baseline[a]	5.59	0.58
Temporal discounting (large stakes), baseline[a]	0.62	0.79
Temporal discounting (small stakes), baseline[a]	0.02	0.02
Risk aversion, baseline[a]	0.29	0.31
Loneliness, baseline[a]	2.15	0.59
Activities of daily living, baseline[a]	0.22	0.72
Instrumental activities of daily living, baseline[a]	0.96	1.47
MMSE, baseline	28.32	1.65
Global cognition, baseline	0.22	0.52

Abbreviations: MMSE, Mini-Mental State Examination; SD, standard deviation.
[a]Variables marked with letter "a" are presented for descriptive purposes but were only included in secondary analyses (data not shown).

3 | RESULTS

3.1 | Characteristics of study participants

Participants ($n = 1092$) in these analyses had a mean age at baseline of 80.9 years (SD = 7.5, range: 58.8–100.2) and a mean of 15.6 years of education (SD = 3.1, range: 5–30); 264 (24.2%) were men, 1000 were White and non-Latinx (91.6%). The mean scam susceptibility score at baseline was 2.67 (SD = 0.76; range: 1.00–5.20), with higher scores indicating a higher level of susceptibility (Table 1). The mean global cognition score at baseline was 0.20 (SD = 0.52). In bivariate analyses, older age ($r = 0.316$, $P < 0.001$), lower education ($r = -0.180$, $P < 0.001$), lower global cognition ($r = -0.266$, $P < 0.001$), and male sex (mean difference = 0.09, *t* statistic = 2.00, df = 439.8, $P = 0.046$) were associated with a higher level of scam susceptibility.

3.2 | Scam susceptibility and age of AD dementia onset

During a mean of 5.0 years of annual follow-up evaluations (SD = 3.1; range: 0.6–11.0), 188 individuals (17.2% of 1092) developed incident AD dementia with an average age of 89.5 years (SD = 6.2 years) at the time of diagnosis. Those who developed AD dementia were older at baseline (mean age = 85.1 vs. 80.0, *t* statistic = 10.18, df = 326.1, $P < 0.001$); however, those who developed dementia did not differ from

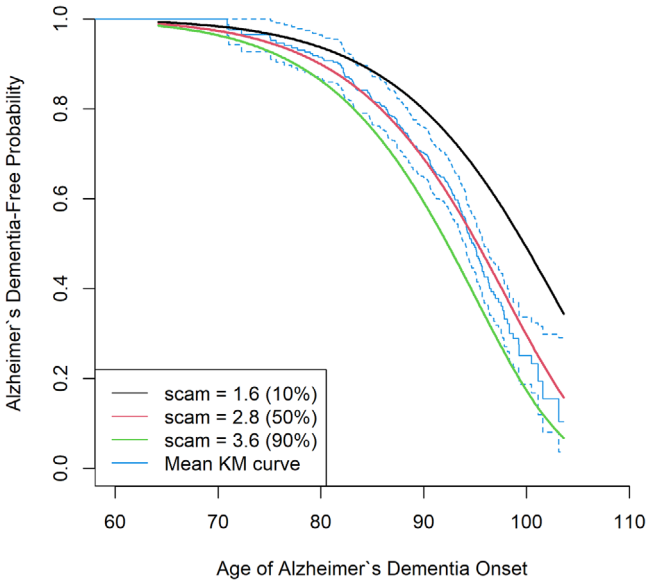

FIGURE 1 Alzheimer's disease dementia-free probability curves estimated by AFT model: scam susceptibility = 1.6 (10% quantile; black), 2.8 (50% quantile; red), and 3.6 (90% quantile; green). The solid blue curve is the Kaplan–Meier curve with 95% confidence intervals (dashed blue curve). AFT, accelerated failure time.

those who did not in terms of education (AD group = 15.4 vs. non-AD group = 15.7, *t* statistic = −0.83, df = 252.8, *P* = 0.406) or sex (proportion of men who developed AD = 17.4% [*n* = 46] and women = 17.1% [*n* = 142]; chi-square = 0.011, df = 1, *P* = 0.918).

We used an AFT model to estimate the association of the baseline level of scam susceptibility with age of incident AD dementia diagnosis. In this analysis, a higher level of scam susceptibility was associated with a younger mean age at diagnosis (mean estimate $\beta = -0.039$; 95% confidence interval [CI]: −0.061, −0.017). The β coefficient indicates that per 1-unit increase in the scam susceptibility score, on average the age of the onset of AD dementia was younger by 3.9%. Figure 1, which is based on this analysis, shows the dementia-free survival probabilities associated with different starting levels of scam susceptibility. Specifically, individuals with a high level of scam susceptibility (score = 3.6, 90th percentile) developed AD at a mean age of 90.9 years compared to a mean age of 93.7 for those with a moderate level of scam susceptibility (score = 2.8, 50th percentile) and a mean age of 98.2 for persons with a low level of scam susceptibility (score = 1.6, 10th percentile).

3.3 | Association of scam susceptibility with dementia after controlling for cognitive function and demographics

Cognitive impairment is the hallmark of AD dementia, occurs prior to diagnosis, and correlates with scam susceptibility; thus, we repeated the core model after adjusting for the baseline level of global cognitive function, as well as sex and education. In this analysis, global cognitive function ($\beta = 0.198$; 95% CI: 0.145, 0.251) was significantly related to the age of dementia onset (as expected), but the association of scam susceptibility with the age of AD dementia onset persisted and remained essentially unchanged ($\beta = -0.031$; 95% CI: −0.055, −0.007). To further verify the robustness of the association of scam susceptibility with dementia above and beyond cognition, we further restricted our analysis to the subsample of participants who were entirely cognitively intact at baseline (i.e., without dementia or MCI, *n* = 770). Again, the association of scam susceptibility with the age of AD dementia onset persisted and remained essentially unchanged ($\beta = -0.036$; 95% CI: −0.064, −0.008). Individuals with a high level of scam susceptibility (score = 3.6, 90th percentile) developed dementia at a mean age of 93.6 years compared to a mean age of 96.3 for those with a moderate level (score = 2.8, 50th percentile) and a mean age of 100.2 for those with a low level (score = 1.6, 10th percentile).

3.4 | Secondary analyses

In secondary analyses, we examined whether additional covariates (noted with asterisks in Table 1) impacted the association of scam susceptibility with incident AD dementia. Notably, the association persisted after controlling for each of these covariates.

4 | DISCUSSION

In a group of > 1000 older persons initially free of dementia who underwent assessment of scam susceptibility and detailed annual clinical evaluations for up to 11 years, we found that individuals who were highly susceptible to scams developed incident AD dementia ≈ 7 years earlier than those who were not and ≈ 3 years earlier than those who were moderately susceptible. Further, the association of scam susceptibility with age of dementia onset persisted even after controlling for global cognitive function, sex, and education, and separately even among those with entirely intact cognition at baseline. These findings suggest that scam susceptibility is a harbinger of dementia and assessment of scam susceptibility may facilitate early identification of at risk individuals.

The present findings are highly novel and have several important implications. First, they provide an estimate of the potency of scam susceptibility as an early indicator of dementia by demonstrating that a higher level of susceptibility is associated with a markedly earlier onset of AD dementia. We previously reported that scam susceptibility was associated with an increased risk of AD dementia and its precursor, MCI.[3] Moreover, we reported that scam susceptibility was related to the pathology of AD, particularly Aβ, an early marker.[3,4] Those findings suggested that scam susceptibility is an early behavioral manifestation of AD pathology and may signal impending dementia. The present findings confirm that scam susceptibility is a harbinger of AD dementia. Importantly, they also provide quantification of the number of years by which susceptibility is associated with an earlier onset of dementia. This approach offers a considerable advantage in terms of the interpretability of findings and may confer noteworthy

clinical benefits. Notably, a difference of 7 years in age of onset for those with high versus low scam susceptibility is quite significant. Awareness that one is at risk of an earlier onset of dementia may motivate better planning in terms of personal and financial matters (e.g., will preparation, intergenerational transfers of wealth) and health-care services (e.g., selection of long-term care facilities or caregiving arrangements if needed). Advanced planning also is associated with lower health-care costs in general compared to planning made under duress and thus may offer considerable benefit to society at large.[22]

Second, the present findings provide additional evidence that the association of scam susceptibility with dementia is relatively independent of cognition.[3] At first pass, this may seem counterintuitive. However, scam susceptibility is a complex behavior that requires not only traditional cognitive abilities but also social cognitive skills including the ability to detect the deceitful intentions of another, recognize unrealistic claims or promises (e.g., "guaranteed" high rates of return), regulate emotions, and resist temptation in the face of intense pressure.[3,10,23] Scam susceptibility likely is an early and sensitive indicator of dementia due to the multidimensional and integrated skills and emotion regulation needed to recognize and resist scams. In our view, scam susceptibility among older adults reflects compromised judgment due in part to aging-related changes in the brain (i.e., early pathologic changes) that lead to degraded rationality but perhaps are not sufficient to cause more overt changes in cognition or behavior.[24] The present results provide strong support for this by showing that, among persons who are highly susceptible to scams but who do not have overt cognitive impairment, the onset of dementia is accelerated by several years.

Third, these findings suggest that assessment of scam susceptibility may facilitate early identification of individuals most likely to develop dementia. Aging researchers have long struggled to identify efficient and promising methods to determine who is at highest risk of developing cognitive impairment and likely to develop it in the relatively near future—a struggle that has yet to be resolved.[25] Although the measure used in this epidemiologic study to assess scam susceptibility may not be optimal for prediction of impairment at an individual level, our findings suggest that appropriately validated measures of scam susceptibility may be very useful, particularly when used in conjunction with other measures (e.g., biomarkers). Further, although the measure of susceptibility used herein does not necessarily equate to victimization, this measure has been validated as an indicator of actual vulnerability in prior work in which we conducted a behavioral experiment simulating a real-world government impersonation scam.[13]

Fourth, the present findings have implications for other behaviors and measures that may also facilitate early identification of dementia and enable better targeting of disease-modifying therapies. We conceptualize scam susceptibility as an aspect of the broader construct of decision making, which involves judgement, insight, literacy, and other skills and abilities.[24] Investigation of the degree to which related behaviors (e.g., financial or other aspects of decision making) are similarly associated with the timing of dementia onset will be important in future work and will offer a more comprehensive understanding of the importance of decision making as both an early sign of dementia and area of focus for new and more robust clinical assessment tools. This would represent a major advance for the field and for patients and families alike.

Fifth, these findings extend our understanding of the economic and public health implications of scam susceptibility among older adults. That is, it is already well established that that scam susceptibility has major financial consequences, particularly as it relates to fraud victimization. According to the Federal Trade Commission, > $10 billion (and by other estimates, much more) are lost each year to financial fraud and, although individuals of all ages are at risk, older adults suffer the largest losses likely due to their greater wealth.[26] What is not as widely recognized, however, is that scam susceptibility among older adults commonly occurs among individuals without cognitive impairment and may indicate accumulating disease pathology—hence its association with the onset of cognitive decline. That is, to the degree that scam susceptibility portends dementia, it is also a very early sign of impending cognitive decline.

This study has strengths and limitations. First, the assessment of scam susceptibility using a previously validated measure among a large group of older persons who underwent detailed annual clinical evaluations for up to 11 years allowed us to accurately identify incident dementia and precisely estimate its onset. Second, using incident rather than prevalent dementia allowed us to estimate age of AD dementia onset from prospective observation rather than retrospective informant report, thereby eliminating a major source of bias. A limitation is that analyses were based on a selected group of mostly White older-old adults. The MAP attempts to recruit as diverse a sample as possible; however, most participants are White and non-Latinx. Notably, we are conducting a study of scam susceptibility and decision making in another Rush-based cohort of > 500 older Blacks, the Minority Aging Research Study, and we hope to be able to better address the association of scam with incident AD in more diverse populations in the future as sufficient data accrue. Further, although this paper focuses on incident AD dementia and builds on our prior work showing an association of scam susceptibility with AD disease pathology in the brain, we recognize that AD dementia is most commonly the result of mixed pathologies. Finally, a recent study of a relatively younger cohort demonstrated that carriers of the apolipoprotein E ε4 allele were more susceptible to phishing scams, but we did not focus on this association in the current article.[27] The pathologic and genetic bases of scam susceptibility are of great interest and will be comprehensively examined in future work. This study lays the foundation for such work and provides compelling evidence that scam susceptibility (and likely decision making more broadly) is a harbinger of dementia and an important area for investigation regarding new approaches to early detection of cognitive syndromes.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest. Author disclosures are available in the supporting information.

DATA AVAILABILITY STATEMENT

The data used in these analyses and a description of the studies can be accessed at the Rush Alzheimer's Disease Center Research Resource Sharing Hub at https://www.radc.rush.edu. Qualified users can request data and obtain a Data Use Agreement.

CONSENT STATEMENT

This study was approved by the Rush Institutional Review Board and all participants provided written informed consent.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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