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Lifestyle Behavior Pattern Predicts Incident Dementia and Alzheimer's Disease. The Cache County Study

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Abstract

BACKGROUND—Cognitive decline and dementia risk have been associated with diet, exercise, social interaction, church attendance, alcohol consumption and smoking.

OBJECTIVES—To identify distinct behavioral patterns, and to examine their association with subsequent dementia risk.

DESIGN—Longitudinal, population-based dementia study.

SETTING—Rural county in northern Utah, at-home evaluations.

PARTICIPANTS—2,491 non-demented participants (51% male) initially reported no problems in activities of daily living and no stroke or head injury within past five years. Average age was 73.01 (SD=5.69) years and average education 13.67 (SD=4.10) years.

MEASUREMENTS—Six dichotomized lifestyle behaviors included: *Diet*: high = above median on the Dietary Approaches to Stop Hypertension scale; *Exercise*: 5+ hours/week of light activity and at least occasional moderate/vigorous activity; *Church attendance*: attending church services

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Dr. Norton: obtaining funding, conception and design, acquisition of the data, analysis and interpretation of the data, preparation of paper

Dr. Dew: conception and design, analysis and interpretation of the data, preparation of paper

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at least weekly; *Social Interaction*: spending time with family/friends at least twice weekly; *Alcohol*: currently drinking alcoholic beverages 2+/week; *Non-smoker*: no current use (or former if < 100 cigarettes ever). Latent Class Analysis (LCA) identified patterns among these behaviors. Proportional hazards regression modeled time to dementia onset as a function of behavioral class, age, gender, education, *APOE* status. Follow-up averaged 6.32 (SD=5.31) years, revealing 278 cases of incident dementia (200 AD).

RESULTS—LCA identified four distinct lifestyle classes. “*Unhealthy-Religious*” (UH-R; 11.5%), “*Unhealthy-Non-Religious*” (UH-NR; 10.5%), “*Healthy-Moderately Religious*” (H-MR; 38.5%), and “*Healthy-Very Religious*” (H-VR; 39.5%). Compared to UH-R class, UH-NR (*Hazard Ratio*, $HR=.54$, $p=.028$), H-MR ($HR=.56$, $p=.003$), and H-VR ($HR=.58$, $p=.005$) had significantly lower dementia risk. Results were comparable for AD, except that UH-NR was less definitive.

CONCLUSION—Functionally independent older adults appear to cluster into subpopulations having distinct patterns of lifestyle behaviors with different levels of risk for subsequent dementia and AD.

Keywords

Lifestyle; health-related behaviors; dementia

INTRODUCTION

By the year 2050, the number of persons with dementia is expected to reach 115 million worldwide, with Alzheimer’s disease (AD) being the most common form¹. If current trends continue, the number of Americans with AD will rise to 7.7 million by 2030 and 11–16 million by 2050². With no proven interventions for altering effects of genetic susceptibility to AD, it is important to identify, and improve modifiable lifestyle risk factors for cognitive decline and dementia risk. In community samples, for example, frequent participation in cognitive^{3–7}, social^{3,4,6} and physical activity^{3,4} has been associated with reduced rates of dementia. Involvement in mental, social, and productive (e.g., gardening, volunteering) activities have also been associated with reduced incidence of dementia⁶. A composite measure that included social, service, domestic, and household maintenance activities was similarly associated with better cognitive status⁸. Physical, self-maintenance, social, and passive, integrative, and novel information processing activities were associated with better cognitive status⁹. Other studies found no association of dementia risk and physical activities, but greater cognitive activities were significantly associated with lesser risk of dementia^{5,7}. Some studies have focused entirely on physical activities, reporting significant association with dementia risk only among women¹⁰, or among *APOE* ε4 allele non-carriers¹¹. The above studies were longitudinal with 5–6 years of follow-up.

Frequent church attendance has been associated with slower cognitive decline¹², and inversely associated with cognitive dysfunction¹³. High vegetable consumption and adherence to a “Mediterranean diet” of high vegetable, fruit, whole-grain and monounsaturated fatty acid intake have also been associated with less cognitive decline (over 4–11 years)^{14,15} and reduced risk of dementia^{15,16}. Low to moderate alcohol consumption^{17,18} and abstention from smoking¹⁹ have similarly been associated with reduced risk of dementia.

Collectively, these studies have shown that individual behaviors may influence the probability of dementia onset, but little work has attempted simultaneous examination of a wide range of lifestyle behaviors for their collective influence. Because additive or interactive relationships among multiple lifestyle behaviors might affect underlying

neurodegenerative processes, it is important to study their combined effects. The identification of lifestyle behavioral *patterns* can identify subpopulations that may have different risks of dementia, suggesting specific dementia prevention interventions.

While risk of dementia, particularly AD, depends strongly on biological and genetic factors²⁰, lifespan developmental theory argues for flexibility (plasticity) in development, suggesting that individuals may influence late-life cognitive outcomes via lifestyle choices²¹. This theory supports multivariate approaches to study multivariate developmental phenomena²². We suggest that behavior clusters may better capture the multivariate nature of behavior that influences late-life developmental outcomes such as dementia. Such behavioral clusters may contribute to development of “cognitive reserve,” via exposure to cognitively stimulating educational, occupational, and leisure activities. Cognitive reserve is hypothesized to allow more efficient use of brain networks and to compensate for disruption of standard processing networks when a normal network is damaged²³.

Study Purpose

We examined six lifestyle behaviors in a community sample of older adults residing in Cache County, Utah, where residents generally had a high prevalence of most attributes thought to contribute to healthy aging²⁴. We sought behavioral subgroups, based on combinations of: diet, exercise, smoking, alcohol consumption, social interaction, and church attendance. We examined association between subgroup and subsequent dementia risk, hypothesizing that participants with healthier behavioral patterns would have lower dementia rates.

METHODS

Sample for this Study

The Cache County Memory Study (CCMS) is a population-based epidemiological study of dementia in relation to genetic and environmental risk factors. The study completed four triennial waves of dementia ascertainment, beginning in 1995, when 5,092 (90% of eligible) individuals aged 65 and older participated in a baseline interview. From these, we sought a subsample of participants who were generally healthy and without functional impairments, ostensibly able to choose freely among the various behaviors under investigation. Exclusion of functionally impaired participants thereby ensures that functional status would not be confounded with behaviors or behavioral clusters. We first excluded 359 cases of prevalent dementia, and another 2,100 subjects reporting functional impairment. Another 89 persons reporting stroke or head injury within five years of baseline were excluded, yielding a final sample of 2,544 subjects. Of these, 278 individuals subsequently developed incident dementia, 200 with AD.

Dementia Diagnostic Procedures

The CCMS utilized a multi-stage dementia ascertainment protocol described elsewhere²⁵. Briefly, screening began with an in-person interview that included the Modified Mini-Mental State examination (3MS)²⁶. Participants who screened positive for possible dementia per 3MS score or Informant Questionnaire for Cognitive Decline in the Elderly²⁷ completed an in-depth clinical assessment (CA), as did a 19% sub-sample of all respondents, regardless of screening results. Specially trained nurses and psychometric technicians administered the CA that included a brief physical evaluation, a detailed history of medical and cognitive symptoms, a structured neurological examination, and a one-hour battery of neuropsychological tests.

A geriatric psychiatrist and neuropsychologist reviewed these data; subjects with a working diagnosis of dementia (per Diagnostic and Statistical Manual of Mental Disorders Third Edition-Revised, DSM-III-R)²⁸ were selected for psychiatrist examinations and neuroimaging, as well as an 18-month follow-up CA. A consensus panel of experts in neurology, geriatric psychiatry, neuropsychology, and cognitive neuroscience reviewed all available data and assigned final consensus diagnoses. AD diagnoses followed the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association criteria²⁹. Dementia onset age was noted as age when participants unambiguously met DSM-III-R criteria for dementia.

Informed consent was obtained for each interview. All procedures were approved by the Institutional Review Boards of Utah State University, Duke University, and the Johns Hopkins University.

Lifestyle Behaviors

Six domains of lifestyle behaviors were measured at baseline either in person (smoking, alcohol consumption, church attendance) or via mailed questionnaire (diet, exercise, social interaction). Each measure was then dichotomized to facilitate latent class analysis³⁰.

Diet was measured by asking how often participants consumed 142 foods during the past year (correlation from .50–.70 over 1–10 years)³¹. Dietary Approaches to Stop Hypertension (DASH) diet is recommended as a balanced eating pattern within energy needs in the current Dietary Guidelines for Americans³². DASH score was obtained by coding high intake of fruits, vegetables, low-fat dairy products, nuts and legumes, and whole grains; and low intake of sodium, sweets and sweetened beverages, and red and processed meat³³. “Healthy diet” was operationalized as a DASH diet score above the median value.

Exercise—Questions were asked about frequency and average time spent in past 12 months: walking for exercise, heavy housework, garden or yard work, use of an exercise machine, calisthenics or weight-lifting, or any moderate to vigorous exercise. Following the example of Lensegrav-Benson et al³⁴, who found that sedentary lifestyle (≤ 5 hours activity per week) was significantly associated with more than double the risk for dementia, “physically active” was operationalized as 5+ hours/week of light activity and at least occasional moderate/vigorous activity.

Church Attendance—Frequency of church attendance was measured on a scale of: never, less than once/month, 1–2 times/month, once/week, or more than once/week. “Frequent church attendance” was defined as church attendance at least weekly (only 27% of this cohort attended church less often).

Social Interaction—Social interaction was measured with three items extracted from the Social Interaction Subscale of the Duke Social Support Index (DSSI)³⁵. These items captured frequency of talking on the telephone and socializing in person with family and friends, and attending meetings of clubs or social groups. Being “socially active” was defined as frequency of engagement in at least one of these activities at least twice weekly (to capture social engagement beyond the weekly church service).

Alcohol consumption—Frequency of consumption of regular/light beer, red/white wine, or liquor was captured in the Food Frequency Questionnaire, with one serving of beer equivalent to 12 oz (12.8g of alcohol), one serving of wine equivalent to 4 oz (11g of alcohol), and one liquor serving equivalent 1.5 oz (14g of alcohol). Current consumer of alcohol was coded if consumption was at least twice/week in any category. Past research

suggests lowest dementia risk among those with lower levels of alcohol consumption (1–6 drinks/week), compared to abstinence, with a trend toward highest risk at high levels (2+ drinks/day).³⁶ Given negligible rates (0.2%) of our sample consumed alcohol at 2+ drinks/day, our criterion of 2+ drinks/week suggests a potential protective factor.

Non-smoker—Participants were asked if they ever had smoked cigarettes or cigars. “Non-smoker” was coded if the participant was not a current user of tobacco products, or if a former user, having smoked fewer than 100 cigarettes over a lifetime.

Covariates and Eligibility Criteria

Covariates—Participant’s age, gender, education, and *APOE* genotype were included as covariates. *APOE* genotype was determined from buccal DNA using polymerase chain reaction amplification, and a restriction isotyping method, described by Saunders and colleagues³⁷, dichotomized as $\epsilon 4$ present/absent. Age and educational attainment as of baseline interview were measured in years.

Eligibility Criteria—At baseline, subjects were asked if they had ever been told by a doctor or nurse they had experienced a stroke, or head injury with loss of consciousness or amnesia. To exclude participants with functional impairment, we asked about seven activities of daily living (ADL) and 11 instrumental activities of daily (IADL) living. ADLs included eating, bathing/grooming, walking long distances, mobility without cane or walker, getting up/down, toileting, need for reminders for toileting, with a point assigned for each ADL with which the participant needed help. IADLs included: traveling beyond walking distance, meal preparation, laundry, light housework, heavier chores, using telephone, shopping, grocery shopping, shopping for other things, taking medications, and managing finances.

Statistical Analyses

The six domains of lifestyle behaviors, reported at baseline, were analyzed using latent class analysis (LCA) using SAS, version 9.1.3. LCA identifies subgroups, thus characterizing the heterogeneity of the population. It assumes conditional independence, i.e., after conditioning on latent class membership, behavioral indicators are assumed to be uncorrelated. The purpose of LCA is to explain the correlation between the behavioral variables by identifying underlying subgroups, using maximum likelihood techniques to generate estimates of the likelihood of an individual being in a class and the likelihood of response, given class membership (conditional likelihood)^{38,39}. The LCA subgroups indicate a latent “lifestyle,” accounting for interconnections between the indicators that the literature has demonstrated to be associated with lower AD risk.

Best-fitting class solution (e.g., relative fit) was determined using Akaike’s Information Criterion (AIC) and Bayesian information criterion (BIC). Lower AICs indicate a better fitting model as do BICs, though BIC scores promote parsimony by penalizing models with large numbers of parameters.

We used a multinomial logistic regression predicting class assignment to evaluate the relationship of lifestyle behavior latent classes to age, gender, education, and *APOE* status. Cox proportional hazards regression was used to model time to dementia onset or right-censoring after removal of all prevalent cases of dementia, starting from age 65 (lower bound for virtually all late-onset dementia cases), as a function of lifestyle behavioral subgroup and covariates of age, gender, education and *APOE* status. Even with modeling time from this starting point, there remained potential differences by birth cohort, because some subjects had survived only to age 65 without dementia while others survived past 100

without dementia as of baseline interview, the latter of more proven vitality than the former, especially given reduced average longevity of earlier birth cohorts. To permit the examination of potential differences of behavioral pattern, net of these confounding factors, we retained baseline age in the models. Additionally, moderation by *APOE* status was tested via interaction term with behavioral latent class. Analyses were repeated for AD where, in Cox regression models, subjects developing non-AD dementia were excluded.

RESULTS

The final sample comprised 51% male subjects with age mean ($\pm$ SD) of 73.0 (5.7) years and education 13.7 (4.1) years. Length of follow-up mean was 6.3 (5.3) years. Proportion of the sample exhibiting each of the six behaviors is presented separately by gender in Table 1.

Lifestyle Behavior Patterns

We compared the fit of latent class models with between 2–5 classes, seeking a model that minimized both AIC and BIC. We computed AIC values of: 598.16, 175.36, 91.40, and 91.62, and BIC values of: 674.10, 292.19, 249.12, and 290.23, for models with two through five classes, respectively. Based on these criteria, the four-class solution was chosen as the best fitting, most parsimonious.

Four distinct behavioral patterns

The four-class LCA model identified distinct lifestyle classes. We examined the extent to which class membership assignment was unambiguous. LCA assigned four posterior probabilities, corresponding to likelihood of membership in each class. For 97% of the sample, the likelihood of being in the category to which we assigned them was at least 15% higher than of being in the second highest category (for 80% of the sample, the difference was $\geq 50\%$). Consequently we feel confident that our class assignment was unambiguous for the majority of the participants.

The “*Unhealthy-Religious*” class constituted 11.5% of the sample, exhibiting extremely low probability of social interaction, exercise, alcohol, and healthy diet but higher probability of frequent church attendance and abstinence from smoking. The “*Unhealthy-Non-Religious*” class was 10.5% of the sample, with members exhibiting low probability of social interaction, non-smoking, frequent church attendance, healthy diet and exercise, but higher probability of alcohol consumption, a presumed protective factor. The “*Healthy-Moderately Religious*” class made up 38.5% of the sample, exhibiting high probability of social interaction, and moderately high probabilities of non-smoking, alcohol consumption, frequent church attendance, healthy diet, and exercise. The “*Healthy-Very Religious*” class constituted the remaining 39.5% of the sample, exhibiting extremely high probabilities of social interaction, non-smoking, and frequent church attendance, moderately high probabilities of healthy diet and exercise, and very low probability of alcohol consumption. Table 2 gives posterior probabilities of each of the six lifestyle behaviors for each of four behavioral classes (see also Figure 1).

Predicting behavioral class membership

In a multinomial logistic regression model, men were significantly more likely to be assigned to the Unhealthy-Religious (OR=1.23, 95% CI = 1.07 – 1.42), Unhealthy-Non-Religious (OR=3.03, 95% CI = 2.53 – 3.63), and Healthy-Moderately Religious (OR=1.80, 95% CI = 1.63 – 1.99) classes than were women, relative to the Healthy-Very Religious class. Education was negatively associated with assignment to the Unhealthy-Non-Religious class (OR=0.86, 95% CI = .81 – .91) and the Healthy-Moderately Religious class (OR=0.91,

95% CI = .88 – .95), relative to assignment in the Healthy-Very Religious class. Age and APOE status were not significantly associated with behavioral latent class.

Predicting incident dementia hazard

We next tested the association between latent class and time to onset of all-cause dementia starting at age 65, before and after adjustment for the four covariates of baseline age, gender, education and APOE status, using the *Unhealthy-Religious* class as reference category. The assumption of proportional hazards was tested via interaction between time until dementia/censoring and each of the independent variables; interaction terms were non-significant, confirming proportional hazards ⁴⁰.

Compared to the reference category, the *Unhealthy-Non-Religious*, the *Healthy-Moderately Religious*, and *Healthy-Very Religious* classes each had significantly lower dementia risk (Table 3). Findings did not differ significantly by APOE status, nor gender ($p > .05$ for all interactions). Models were repeated with each of the other three latent classes as the reference category with adjusted Hazard Ratios (aHR) ranging from .93–1.04 (examining pairwise contrasts between *Unhealthy-Non-Religious*, *Healthy-Moderately Religious* and *Healthy-Very Religious* on all-cause dementia; all $p > .05$). Thus, only the *Unhealthy-Religious* group differed from the other three, which did not differ from each other. [Not surprisingly, baseline age had a negative parameter coefficient, reflecting that, the older the individual's dementia-free survival years as of baseline interview, the greater the vitality, given that time from age 65 to dementia onset was the metric being modeled.]

Results were comparable for AD, except that the *Unhealthy-Non-Religious* class did not meet conventional criteria for statistical significance ($p = .11$; Table 4). Likewise, APOE status did not moderate the behavioral class/AD association ($p > .05$ for all interactions).

DISCUSSION

To our knowledge, this is the first study that has identified distinct behavioral patterns across all six of the examined behavioral domains in a population-based sample of generally healthy older adults. We found significantly reduced risk for incident dementia in three behavioral classes, as compared to the *Unhealthy-Religious* class, with two of these three classes also showing significantly reduced risk for AD. A recent NIH report indicated that there was no single known modifiable lifestyle factor consistently associated with significant reduction in AD risk ⁴¹. Our findings suggest that, instead of examination of individual factors, a multivariate or “behavioral cluster” approach may be more informative, revealing subpopulations at varying risk levels.

Participants reported a high frequency of church attendance, with 90% members of the Church of Jesus Christ of Latter-Day Saints (LDS) ⁴². The LDS church has strict proscriptions against alcohol consumption and smoking. Accordingly, individuals who were frequent church attenders were much less likely to consume alcohol or to smoke. However, even among groups reporting very high probability of frequent church attendance, there were two subgroups based on healthy diet, exercise and social interaction. These latter three behaviors also tended to cluster together so that, among the religious/non-smoker/non-alcohol group, a subsample had high probability of healthy diet, exercise and social interaction, while another subsample was low on all three of these behaviors. A similar dichotomy existed in the low-to-moderate probability frequent church attendance group who were also more apt to smoke or consume alcohol. Thus, our identified behavioral patterns could be conceptualized as the very high probability religious/non-smoker/non-alcohol participants who formed two groups based on being either high or low on the other healthy behaviors, with a parallel low-to-moderately high probability religious/smoker/alcohol

group who likewise formed two groups based on being either high or low on the other healthy dimensions. Cox regression analyses revealed that the *Unhealthy-Religious* group had nearly double the dementia risk of all other groups. Individuals in the *Unhealthy-Non-religious* group were at significantly reduced risk for all-cause dementia, and showed trend-level reduction in risk for AD.

The Healthy-Very Religious and Healthy-Moderately Religious subgroups differed only in that the former were somewhat more likely to attend church and abstain from alcohol than the latter. Both had significantly reduced risk for both all-cause dementia and AD. While both of these subgroups were highly likely to be religiously active, this behavior alone appears insufficient to predict reduced risk of dementia or AD, as evidenced by the *Unhealthy-Religious* subgroup. In sum, a pattern of abstinence from smoking, eating a healthy diet, exercising and staying socially engaged was associated with lower risk of AD. These findings are also consistent with clinical intervention studies on the effect of exercise⁴³ and diet⁴⁴ on neurocognitive performance.

Strengths and Limitations

The current study has several strengths. First, it utilized a population-based sample, more generalizable than studies using clinic-based samples that tend to be younger, more highly educated, with higher occupational status, and more often married and living with a spouse⁴⁵. The participation rate in Cache County was exceptionally high (90% at baseline), limiting response bias⁴⁶. APOE genotypes permitted examination of gene-environment interactions including possible moderation by presence of the $\epsilon 4$ allele. Rather than relying on a cognitive measure alone, we used well-characterized diagnoses based on expert panel consensus. The lengthy period of follow-up improved our ability to capture both short-term and long-term effects of behavioral patterns on dementia risk. By construction of a baseline sample with no ADL limitations, we attempted to control for potential confounding due to the inability of sick and functionally impaired elders to participate in healthy behaviors (e.g. exercise) even when desiring to do so. Finally, perhaps the study's greatest strength is our inclusion of the widest array of lifestyle behaviors encountered in a single study of dementia risk, combined with our novel multivariate approach to use of latent class analysis that identified distinct behavioral patterns.

Limitations include the absence of behavioral measures of leisure activities clearly involving novel information processing (shown to be significantly associated with cognitive speed⁸). While some of the activities captured in our social interaction measure involved cognitive components (e.g. card games, going to the opera), we also lacked an instrument specifically targeting "cognitively stimulating activities." Additional measures of religious involvement beyond our measure of church attendance would have been desirable, as the latter does not capture such aspects as perceived spirituality that has also been associated with better cognitive performance⁴⁷. Having only four subjects as current "heavy drinkers" (20+ drinks/week, equivalent to the Rotterdam study's highest category) precluded our ability to examine heavy drinkers⁴⁸.

Our sample was 99% Caucasian, precluding the study of potential confounding factors associated with ethnic diversity. Possibly, additional behavioral patterns may exist in more diverse groups with varied cultural contexts. National Census records in 2000 show that among persons aged 75 and older, 36.6% had only a high school education (vs. 36.7% in Cache County) and 26.3% had less education (vs. 19.6% in Cache County),⁴⁹ thus educational attainment in this cohort was not substantially atypical. Finally, our study was limited to current behaviors and did not examine differential effects of lifelong vs. variable patterns of behavior, some of which may be related to prodromal stages of AD. While we were therefore unable to probe critical thresholds as to timing, duration, or intensity of

behaviors over the lifespan, our results enhance understanding as to how the six examined behaviors are *collectively* associated with AD risk, among functionally independent older adults.

Conclusions

We conclude that generally healthy and functionally independent older adults appear to cluster into subpopulations with distinct lifestyle behavior patterns. One subgroup exhibited moderate to high probability of frequent church attendance with abstinence from smoking and alcohol. However, one-fifth of frequent church goers were almost completely without social interaction, healthy diet and exercise. Because the least healthy behavioral pattern has nearly a two-fold higher risk for AD, clinicians could target this behavioral pattern in their patients to encourage behavioral changes that could delay or prevent the onset of disease, particularly in the presence of a genetic predisposition.

The multidimensional pattern of behaviors in the four subgroups identified in this population may not look identical in other cultural settings. However, even in a healthy, long-lived population^{24,25}, we found behavioral pattern variability that predicts dementia. This novel approach may prove valuable when applied in more heterogeneous populations, with the goal of identifying particularly vulnerable subgroups.

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Figure 1.
 Posterior probabilities of exhibiting each of six lifestyle behaviors, for each of four behavioral classes
 UH-R = unhealthy, religious
 UH-NR = unhealthy, non-religious
 H-MR = healthy, moderately religious
 H-VR = healthy, very religious

Table 1

Proportion of the sample exhibiting each of six lifestyle behaviors, by gender

Behavior	Threshold	Percent of the sample exhibiting behavior above threshold level (N, column percent)		
		Males	Females	Total
Social Activity	2+ times/week contact with family, friends	866 (66.7)	978 (78.5)	1,844 (72.5)
Smoking Abstinence	never smoked, or if former smoker total # cigarettes < 100	681 (52.5)	1107 (89.0)	1,788 (70.4)
Alcohol Use	drank alcoholic beverages 2+ times/week	542 (41.8)	376 (30.2)	918 (36.1)
Church Attendance	at least weekly church attendance	932 (71.8)	1,007 (80.8)	1,939 (76.2)
Diet	above median value on DASH diet score	451 (34.7)	598 (48.0)	1,049 (41.2)
Physical Activity	5+ hours/week of light activity and at least occasional moderate/vigorous activity	530 (40.8)	664 (53.3)	1,194 (46.9)

Table 2

Percent of the sample in each lifestyle behavioral group, median time to dementia onset and posterior probability of exhibiting each behavior, by behavioral group

	Unhealthy- Religious	Unhealthy- Non- Religious	Healthy- Moderately Religious	Healthy- Very Religious
# Subjects Assigned to class	290	269	981	1004
% with <i>incident</i> dementia	12.5%	8%	11%	11%
Median time to dementia onset (yrs)	5.54	6.72	7.0	6.04

Behavior	ρ Coefficients *	ρ Coefficients	ρ Coefficients	ρ Coefficients
Social Activity	.01	.24	.87	.93
Smoking Abstinence	1.00	.24	.52	.95
Alcohol Use	.21	.51	.69	.06
Church Attendance	.83	.37	.64	.99
Diet	.06	.04	.46	.58
Physical Activity	.01	.11	.57	.61
γ Coefficient	.10	.13	.36	.41

* ρ Coefficients give the probability of having above mean levels of the characteristic

Table 3

Cox proportional hazards regression predicting survival time (in years) to dementia onset, as a function of behavioral latent class and covariates.

	Coefficient	Standard Error	Hazard Ratio	95% Confidence Interval for Hazard Ratio
Class Membership				
Unhealthy-Not Religious ^a	-.62	.28	.54	.31 – .93
Healthy-Moderately Religious ^a	-.58	.20	.56	.38 – .84
Healthy-Very Religious ^a	-.55	.19	.58	.40 – .84
Age (years)	-.15	.02	.86	.82 – .90
Female ^b	-.09	.13	.92	.71 – 1.17
APOE ε4 Carrier ^c	.80	.12	2.22	1.76 – 2.82
Education (years)	-.01	.01	.99	.97 – 1.01

^aReference category is *Unhealthy- Religious*.

^bReference category is male

^cReference category is APOE ε4 non-carrier.

Table 4

Cox proportional hazards regression predicting survival time (in years) to Alzheimer's disease onset, as a function of behavioral latent class and covariates.

	Coefficient	Standard Error	Hazard Ratio	95% Confidence Interval for Hazard Ratio
Class Membership				
Unhealthy-Not Religious ^a	-.53	.33	.59	.31 – 1.12
Healthy-Moderately Religious ^a	-.62	.24	.54	.34 – .86
Healthy-Very Religious ^a	-.58	.23	.56	.36 – .88
Age (years)	-.12	.02	.88	.85 – .92
Female ^b	.15	.15	1.16	.87 – 1.56
APOE ε4 Carrier ^c	.96	.14	2.62	1.98 – 3.44
Education (years)	-.01	.01	.99	.97 – 1.01

^aReference category is *Unhealthy-Religious*.

^bReference category is male

^cReference category is APOE ε4 Allele non-carrier.