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Patterns of Recommended Dietary Behaviors Predict Subsequent Risk of Mortality in a Large Cohort of Men and Women in the United States[1–3]

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Abstract

Recommendations for intake of fruits and vegetables, whole grains, lean meats, and low-fat dairy form the underpinning of dietary guidance for health promotion. We examined the association of a summary index of food consumption behaviors compatible with the spirit of prevailing dietary guidance and mortality. We used data from the NIH-American Association of Retired Persons cohort (n = 350,886), aged 50–71 y and disease free at baseline in 1995–1996, to examine the association of a dietary behavior score (DBS) with mortality after 10.5 y of follow-up (deaths, n = 29,838). The DBS included 6 equally weighted components derived from responses to questions on usual dietary behaviors related to consumption of fruits, vegetables, low-fat dairy, whole grains, lean meat and poultry, and discretionary fat. The covariate-adjusted association of DBS and mortality from all causes, cancer, and coronary heart disease was examined using Cox proportional hazards regression methods. Compared with those in the lowest one-fifth of DBS, the multivariate-adjusted relative risk of mortality in the highest one-fifth of the DBS was 0.75 (95% CI, 0.70–0.80) in women and 0.79 (95% CI, 0.75–0.83) in men (P-trend < 0.0001). The inverse association of DBS and mortality was significant in both genders in nearly all categories of covariates. Similar trends were observed for DBS associations with mortality from cancer and heart disease. Nearly 12% of the covariate-adjusted population risk of mortality was attributable to nonconformity with dietary recommendations. Adoption of recommended dietary behaviors was associated with lower mortality in both men and women independent of other lifestyle risk factors. J. Nutr. 139: 1374–1380, 2009.

Introduction

Recent interest in understanding the association of health outcomes and dietary patterns reflects the increasing recognition of the multidimensional nature of diets consumed by free-living populations (1–3). The intent of the dietary pattern approach is to examine multiple food group and nutrient characteristics of the diet as a single exposure. Most published reports have used 1 of 2 methods to characterize dietary patterns: diet indexes or scores based on compliance with current dietary guidance, or empirically derived combinations of foods or nutrients from factor or cluster analysis (1–3). Complex dietary indexes such as the Healthy Eating Index and the Diet Quality Index, which evaluate diets for meeting quantitative goals for several individual nutrients and food groups, have generally shown weak or no association with major chronic diseases or mortality in U.S. cohorts (4–6). Dietary patterns based on characteristics of the Mediterranean diet were shown to predict all-cause mortality in European cohorts (1,7,8) and in the US (9). We and others found relatively simpler indexes that capture the spirit of dietary guidance to predict mortality in a screening cohort (10) and in 3 national cohorts (11–14). Data-driven dietary patterns from factor or principal components analysis predicted mortality in European, Japanese, and Chinese cohorts (1,15,16), but results were inconsistent in a national U.S. cohort (11). Cluster analysis-derived patterns did not predict mortality in a national U.S. cohort (11).

In the present study, we used a different approach to assess healthy diet patterns. With the continuing debate about possible limitations of FFQ to accurately determine dietary exposures, we wanted to avoid determination of dietary patterns using prevalent approaches based on frequency of consumption and amounts consumed of a large number of individual foods and nutrients (17–20). Also, given the evidence of the gap between dietary recommendations and self-reported dietary intakes

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reported in national surveys in the US (21–24), it appears unlikely that the average consumer can understand and implement complex dietary guidance that includes numerical goals for nutrient and food group intake. Therefore, rather than focus on health characteristics of individual foods/nutrients and their reported amounts to assess overall dietary patterns, we focused on responses to global questions about key dietary behaviors to identify healthy dietary patterns. Consistent with our previous approaches (10,12,13) and in agreement with the proposal of Kristal et al. (18), we hypothesized that recall of usual dietary behaviors may be less prone to recall errors than specific types and amounts of foods; therefore, individuals who report adoption of food selection and consumption behaviors compatible with the spirit of the dietary guidance will have healthier diet patterns. In this study, we report on the association of one such indicator with the risk of mortality from all causes and specific major causes in a large cohort of American men and women.

Methods

The NIH-American Association of Retired Persons (AARP)[7] Diet and Health Study was initiated in 1995–1996 to address several methodological problems that affect the interpretability of results obtained from epidemiologic studies of diet and cancer (25). The Special Studies Institutional Review Board of the National Cancer Institute approved the study and all participants provided written consent. Baseline questionnaires were returned by 617,119 AARP members, aged 50–71 y, residing in 6 U.S. states (California, Florida, Louisiana, New Jersey, North Carolina, and Pennsylvania) and 2 metropolitan areas (Atlanta and Detroit). The vital status of cohort members was ascertained via annual linkage to the Social Security Administration's Master Death File on deaths in the United States through December 31, 2006. Relative accuracy of this data set for ascertainment of mortality status has been reported to be 89–96% (26–28). The underlying cause of death was determined by linkage with the National Death Index Plus of the National Center for Health Statistics.

Dietary behavior score. The baseline questionnaire completed by the participants included a FFQ developed after extensive cognitive testing and calibration against 2 24-h dietary recalls (25,29–31). The FFQ queried about usual consumption of 124 food items over the past 12 mo. Also included were several questions on dietary behaviors pertaining to usual food group and fat intake. The FFQ defined "usual" as more than half the time. The dietary behavior score (DBS) developed for this study was mostly derived from responses to behavioral questions and reflects the key recommendations about intake of fruits, vegetables, whole grains, low-fat dairy, and low-fat meats of the Dietary Guidelines for Americans (32). The DBS included the following 6 categories: servings of vegetables (excluding salads and potatoes) consumed per week; servings of fruit (excluding juice) consumed per week; usual consumption of whole-grain cereals and breads as such or in sandwiches; usual consumption of lean meat and poultry without skin; usual consumption of low-fat dairy as a drink or in cereal; and usual practice of addition of solid fat after cooking or at the table to a number of commonly consumed foods (pancakes, waffles, French toast; potatoes; rice; pasta; cooked vegetables; and gravy to meat). There were no global behavior queries about cereal and milk use; we used responses to FFQ items on types of cereals and milk usually consumed to derive these components. We made all decisions about the potential DBS components and their scoring prior to the examination of any outcomes. The score for each individual component ranged from 0 to 6; the DBS was the sum of the scores of the individual components and ranged from 0 to 36. Further details about the 6 DBS components are provided in the Supplemental Appendix.

[7] Abbreviations used: AARP, American Association of Retired Persons; CHD, coronary heart disease; DBS, dietary behavior score; ICD, International Classification of Diseases.

Covariate information. Demographic, anthropometric (self-reported height and weight), self-assessed overall health status, history of disease, and health-risk behavior information was reported by respondents in the self-administered, mailed questionnaire at baseline in 1995–96. From this information we created variables that may be related to our exposure and outcome.

Analytic cohort. After exclusions for incomplete questionnaires, withdrawals, death, and move before entry, 566,402 respondents remained eligible for inclusion in our study. From this eligible cohort, we excluded: questionnaires completed by proxies (15,760); respondents with any self-reported cancer, except nonmelanoma skin (51,125); self-reported diabetes, stroke, or heart disease at baseline (100,523); poor self-reported overall health (8366); self-reported end-stage renal disease (769); death at entry (3); those with 1 or more errors or ≥5 missing responses on questions contributing to the estimation of the dietary exposure variable (25,510); and outliers (defined as individuals with >2 times the sex-specific interquartile ranges of Box-Cox log-transformed values of these variables) for energy intake (2731) and BMI (10,729). With these exclusions, the final analytic cohort comprised 199,874 men and 151,012 women.

Statistical analysis. The person-time (in years) was calculated from the date of return of the initial questionnaire in 1995–1996 to date of death or December 31, 2006, whichever came first. We used Cox proportional hazards regression analyses with age at entry as the underlying time metric to examine the independent association of DBS with sex-specific, age-adjusted, and multivariate-adjusted risk of mortality. The analyses used the PROC PHREG procedure in the SAS software package (version 9.1.3, SAS Institute). We categorized the DBS into quintiles based on its distribution in the entire analytic cohort, and the risk of mortality in each of the upper quintiles was compared with the risk in the first quintile. The tests for DBS-associated linear trend modeled DBS quintiles as a trend variable, as median DBS for each quintile as a trend variable, and as a continuous variable. All trends were very similar; the results presented are for the DBS quintiles as a trend variable.

All covariates in regression models were decided apriori based on known associations of these factors with diet and health. Multivariate regression models included: race-ethnicity, level of education, smoking status, level of physical activity, alcohol use, BMI, exogenous hormone use in women, and energy intake. To determine whether the association of DBS and mortality was modified by covariates, we also examined DBS and mortality associations stratified by categories of these covariates. We used the likelihood ratio test statistics to compare models with and without the cross-product of DBS and each covariate to test for interaction of DBS with the covariates mentioned above. The possibility of bias due to reverse causation was examined by stratifying follow-up time to identify events occurring in the first 5 y or after 5 y of follow-up. We also examined DBS and mortality association with adjustment for supplement use; results were similar to those included in the tables (without this adjustment). We determined the multivariate-adjusted population risk of all-cause mortality attributable to dietary moderation from Cox proportional hazards regression models (33).

We also examined the association of DBS with mortality from specific causes. The person-time (in years) was calculated from the date of return of the initial questionnaire in 1995–1996 to date of death or December 31, 2005, for death from cancer, coronary heart disease (CHD), and all other causes. The all-sites cancer mortality included all malignant cancers (International Classification of Diseases or ICD-9 codes 140–208 or ICD-10 codes C00–97); CHD included ICD-9 codes 410–414, 429.2, or ICD-10 codes I20–25. Analytic procedures followed were similar to those mentioned above.

Results

Respondents with higher DBS were slightly older, more likely to be non-Hispanic White, had lower BMI, were college graduates, more physically active, and were less likely to be current smokers (**Table 1**). DBS was a strong correlate of nutrient intake

TABLE 1 Characteristics of men and women in the NIH-AARP cohort by quintiles of DBS

	Men					Women				
	Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
Range	0–18	18.25–22.75	23–26	26.25–29.0	29.25–36.0	0–18	18.25–22.75	23–26	26.25–29.0	29.25–36.0
Median	15	20.7	24.5	27.5	31	15	21	24.5	27.5	31
n	45,995	44,333	41,216	35,984	32,346	23,810	27,255	30,948	32,526	36,473
Mean y of follow-up	10.05	10.17	10.22	10.27	10.31	10.19	10.29	10.33	10.36	10.39
Non-Hispanic White, %	90.5	93.2	94.0	94.8	94.8	86.2	90.1	91.5	92.7	93.5
Non-Hispanic Black, %	4.3	2.6	2.0	1.5	1.3	8.5	5.4	4.3	3.5	2.7
Hispanic, %	2.5	1.8	1.5	1.4	1.5	2.4	1.9	1.7	1.5	1.5
Others,[1] %	1.7	1.5	1.8	1.6	1.5	1.5	1.5	1.6	1.3	1.2
Baseline age 50–55 y, %	21.8	20.0	18.8	18.0	17.1	24.2	21.3	20.0	19.1	17.8
Baseline age 56–60 y, %	25.8	25.5	24.9	25.1	24.6	26.3	26.1	25.1	25.1	24.6
Baseline age 61–65 y, %	28.4	28.7	29.3	28.9	29.7	28.0	28.7	29.2	29.6	28.9
Baseline age 66–70 y, %	24.0	25.8	26.9	27.9	28.5	21.5	23.8	25.6	26.1	28.7
College and Postgraduate, %	33.2	44.2	49.9	55.1	60.6	18.7	26.6	31.8	36.5	41.7
Current smokers, %	20.4	12.3	8.0	6.0	4.0	28.8	18.5	12.6	9.8	7.1
BMI < 25, %	28.7	27.8	29.9	33.1	38.2	44.2	44.3	45.4	47.7	52.6
BMI 25–29.9, %	50.1	51.9	51.4	49.9	48.1	32.2	33.3	33.3	33.6	31.7
BMI ≥ 30, %	21.2	20.3	18.7	17.0	13.7	23.6	22.4	21.2	18.7	15.7
No physical activity, %	4.9	2.8	2.0	1.4	1.0	10.3	6.0	4.0	3.0	2.1
Physical activity ≥ 3–4 times/wk, %	37.2	44.9	50.8	57.2	64.5	26.3	33.9	41.4	47.3	56.5
Postmenopausal, %						92.9	93.0	92.6	92.8	93.0
Never used hormones, %						51.7	47.9	43.6	41.4	40.6

[1] Others include Asian, Pacific Islanders, and American Indians.

estimated from the FFQ (**Table 2**). DBS was an inverse correlate of total and saturated fat and alcohol intake but a positive correlate of estimated intakes of fiber, carotene, folate, vitamin C, potassium, and calcium ($P < 0.0001$). The DBS was a weak inverse correlate of energy intake in men only. The maximum scores on added solid fat and whole-grain components of DBS were reported by the smallest percentage of the cohort (<10% for added solid fat and <20% for whole grain), whereas maximum vegetable and fruit scores were reported by >60% of the cohort (**Table 3**).

All-cause mortality. Over a median follow-up of 10.55 y (total of 3,596,491 person-years), there were 19,435 deaths due to all causes among men and 10,403 deaths among women in the analytic cohort. In age-adjusted models, men and women in the highest one-fifth of the DBS had ~50% (95% CI, 0.49–0.54)

TABLE 2 Age, BMI, and daily dietary nutrient intakes of men and women in the NIH-AARP cohort by quintiles of DBS[1]

	Men						Women					
	Q1	Q2	Q3	Q4	Q5	Pearson r^2	Q1	Q2	Q3	Q4	Q5	Pearson r^2
Range	0–18	18.25–22.75	23–26	26.25–29.0	29.25–36.0		0–18	18.25–22.75	23–26	26.25–29.0	29.25–36.0	
n	45,995	44,333	41,216	35,984	32,346		23,810	27,255	30,948	32,526	36,473	
DBS	15	20.7	24.5	27.5	31		15	21.0	24.5	27.5	31	
Age, *y*	61.4	61.8	62.2	62.3	62.5	0.05	60.9	61.5	61.9	62.0	62.4	0.07
BMI, *kg/m*^{2}	26.6	26.6	26.5	26.3	25.8	−0.07	25.8	25.8	25.6	25.3	24.8	−0.07
Energy, *kJ*	7950	7950	8004	7933	7803	−0.04	5908	6016	6155	6167	6165	0.002
Energy from fat, %	34.2	32.5	31.0	29.0	25.5	−0.35	34.8	32.7	30.6	28.6	24.8	−0.43
Energy from saturated fat, %	10.9	10.1	9.5	8.7	7.5	−0.37	10.8	10.0	9.2	8.6	7.3	−0.41
Alcohol, *g*	4.3	4.7	4.5	4.8	4.4	−0.09	0.9	1.1	1.1	1.1	1.1	−0.06
Fiber, *g*	14.0	17.0	19.0	21.0	23.0	0.35	11.1	13.8	16.0	17.6	19.7	0.35
Folate, *μg*	245	284	311	333	360	0.26	193	231	260	279	306	0.28
Vitamin C, *mg*	97	124	143	157	176	0.25	84	112	131	144	161	0.24
Vitamin E,[3] *mg ATE*	7.8	8.4	8.7	8.8	8.5	0.06	6.5	7.0	7.3	7.3	7.1	0.04
Carotene,[3] *μg RE*	420	553	656	755	896	0.26	394	554	690	802	983	0.27
Calcium, *mg*	598	661	704	755	868	0.19	472	535	590	651	789	0.27
Potassium, *mg*	2938	3208	3416	3593	3846	0.23	2361	2651	2884	3060	3359	0.28

[1] Values are medians.
[2] Pearsons's r: Correlation of the variable in a row with DBS as a continuous variable. All correlations except that of DBS with energy intake in women, were significant at $P <$ 0.0001.
[3] ATE, α tocopherol equivalents; RE, retinol equivalents.

TABLE 3 Percentage of men and women reporting minimum and maximum score on the 6 dietary behavior components in the NIH-AARP cohort by quintiles of DBS

	Men						Women					
	All	Q1	Q2	Q3	Q4	Q5	All	Q1	Q2	Q3	Q4	Q5
Range		0–18	18.25–22.75	23–26	26.25–29.0	29.25–36.0		0–18	18.25–22.75	23–26	26.25–29.0	29.25–36.0
n		45,995	44,333	41,216	35,984	32,346		23,810	27,255	30,948	32,526	36,473
						% with minimum score of 0						
Vegetable servings/d	9.8	32.3	7.8	2.5	0.6	0.1	8.2	35.9	9.8	3.1	0.7	0.05
Fruit servings/d	27.2	72.5	35.1	11.2	2.0	0.1	18.0	68.8	28.6	8.3	1.2	0.05
Usually consume lean meat	4.3	12.7	4.3	1.9	0.4	0.01	1.7	7.3	2.1	0.7	0.1	0.01
Usually consume low-fat dairy	12.9	32.3	14.4	7.6	3.4	0.6	12.8	35.9	20.1	11.7	4.6	0.8
Usually consume whole grains	7.7	20.7	7.8	5.1	1.1	0.1	6.4	21.4	8.5	5.6	1.4	0.1
Usually no added solid fat	8.3	16.0	10.7	7.1	3.7	0.6	7.2	16.8	11.3	7.6	3.9	0.5
						% with maximum score of 6						
Vegetable servings/d	72.4	33.9	66.7	83.7	92.8	97.9	77.5	31.8	65.0	83.1	93.0	98.3
Fruit servings/d	55.3	9.2	36.5	66.6	87.0	97.1	67.9	11.0	43.6	73.2	91.1	98.2
Usually consume lean meat	31.8	11.0	21.8	29.9	41.9	66.6	41.6	15.8	27.1	35.9	47.2	69.1
Usually consume low-fat dairy	32.1	14.3	24.6	31.2	39.3	61.1	33.9	11.8	20.0	26.2	36.7	62.7
Usually consume whole grains	16.6	4.6	9.1	16.1	21.0	39.8	18.2	4.3	7.6	13.8	18.6	38.6
Usually no added solid fat	6.4	1.4	2.6	4.1	7.1	20.9	8.4	1.4	2.8	4.5	7.0	21.6

lower risk of mortality than those in the lowest one-fifth. After adjustment for potential confounders, the risk estimate was attenuated and the relative risk was 0.75 (95% CI, 0.70–0.80) in women and 0.79 (95% CI 0.75–0.83) in men (χ^2 for trend in women = 83.8, men = 99.02; P-trend < 0.0001) (**Table 4**). Approximately 12% of the covariate-adjusted population risk of mortality was attributable to poor compliance with recommended dietary behaviors.

The association of DBS and mortality was stronger in respondents aged 56–71 y at baseline than in those aged 50–55 y and in non-Hispanic Whites than in other ethnic groups (**Supplemental Tables 1** and **2**). Given the small numbers of respondents with ethnicities other than non-Hispanic White or Black, the number of cases in these groups were small and DBS was not associated with the risk of mortality ($P > 0.05$). DBS and risk of mortality were inversely related in all categories of follow-up time, education, BMI, and smoking status in both men and women. DBS was not associated with the risk of mortality in men and women who reported no physical activity and no alcohol use ($P > 0.05$). In all other categories of physical activity and alcohol use, the DBS and mortality associations were inverse and significant ($P \leq 0.001$).

Cause-specific mortality. The multivariate-adjusted relative risk of mortality from all malignant cancers, CHD, and all other causes declined with increasing DBS in both men and women (P-trend ≤ 0.003) (**Table 5**). Compared with the lowest quintile of DBS, the risk of all-sites cancer mortality in the highest quintile was ~20% lower and was ~23–30% lower for CHD and all other causes of mortality.

Discussion

The results of this study suggest that reported adoption of recommended dietary behaviors consistent with prevailing dietary guidance was associated with 20–25% lower risk of mortality after 10 y of follow-up in older men and women. Relative to respondents reporting the least amount of desirable dietary behaviors (first quintile), the risk reduction was noted in all categories of DBS. These results suggest benefits of even small changes in dietary behaviors in the expected direction as well as higher reduction in mortality risk with greater compliance.

All methods for assessing diet contain substantial measurement error (34). The accuracy of ascertainment of dietary exposures using FFQ in particular has been the subject of recent debate (17–20). In a commentary on this topic, Kristal et al. (18) suggested that individuals may more reliably provide information on general dietary behaviors than "the frequencies and portion sizes of a long list of foods." The DBS in the present study represents that approach, because it does not require frequency (or quantity) of consumption of individual items in the FFQ. All score components use responses to global queries about usual intake. Other published assessments of a "healthful diet pattern" contain multiple food and nutrient components with quantitative cutoffs and benchmarks. Nevertheless, the extent of reduction in the risk of all-cause mortality in the present study was consistent with that reported from other studies that utilized different methods and detailed food or nutrient intake information to determine dietary patterns (1,7–16).

Most published indexes of diet quality and "healthy" dietary patterns show a positive association with micronutrient intake (1). Because both the dietary patterns and nutrient intakes are based on the same dietary measurement, the reported positive associations of dietary patterns with micronutrients are not surprising. The DBS, however, is derived from estimates of reporting of certain dietary behaviors and does not utilize the reported amount of individual foods or nutrients from the FFQ but nevertheless predicted intakes of dietary fat, fiber, and protective micronutrients in the expected direction. Unlike the often-observed positive association of dietary patterns with energy intake (1), the relative independence of the DBS and energy intake suggests that higher micronutrient intakes associated with the DBS are not merely a result of variations in the amount of food consumed (energy intake) but are due to higher nutrient density of diets.

Expectedly, lower BMI and health risk behaviors such as smoking and physical activity were clustered with desirable dietary behaviors in this cohort. However, it is unlikely that the observed DBS and mortality associations are accounted for by

TABLE 4 Age-adjusted and multivariate-adjusted risk of all-cause mortality by quintiles of DBS in men and women in the NIH-AARP Diet and Health Study cohort[1,2]

	Men						Women					
	Q1	Q2	Q3	Q4	Q5	*P*-trend[3]	Q1	Q2	Q3	Q4	Q5	*P*-trend[3]
Range	0–18	18.25–22.75	23–26	26.25–29.0	29.25–36.0		0–18	18.25–22.75	23–26	26.25–29.0	29.25–36.0	
n	45,995	44,333	41,216	35,984	32,346		23,810	27,255	30,948	32,526	36,473	
Deaths, *n*	5884	4469	3778	2922	2382		2328	2101	2119	1924	1931	
Age-adjusted mortality rate[4]	1327	1004	887	771	686		1024	768	660	562	468	
Age-adjusted relative risk	1.0	0.75	0.66	0.58	0.51	<0.0001	1.0	0.74	0.64	0.54	0.47	<0.0001
95% CI		0.72–0.78	0.64–0.69	0.55–0.60	0.49–0.54			0.70–0.79	0.60–0.68	0.51–0.58	0.44–0.50	
Multivariate relative risk	1.0	0.90	0.88	0.83	0.79	<0.0001	1.0	0.90	0.87	0.80	0.75	<0.0001
95% CI		0.86–0.94	0.85–0.92	0.79–0.87	0.75–0.83			0.85–0.95	0.82–0.93	0.75–0.86	0.70–0.80	
Length of follow-up <5 y [*n* = 199,874 (men), 151,012 (women); deaths 6489 (men), 3296 (women)]												
Deaths, *n*	2044	1525	1230	945	745		787	654	637	594	624	
Multivariate relative risk	1.0	0.91	0.86	0.81	0.76	<0.0001	1.0	0.84	0.80	0.76	0.75	<0.0001
95% CI		0.85–0.97	0.80–0.93	0.75–0.88	0.69–0.83			0.76–0.93	0.72–0.89	0.68–0.85	0.67–0.84	
Length of follow-up ≥5 y [*n* = 192,732 (men), 147,251 (women); deaths 12,946 (men), 7107 (women)]												
Deaths, *n*	3840	2944	2548	1977	1637		1541	1447	1482	1330	1307	
Multivariate relative risk	1.0	0.88	0.88	0.82	0.79	<0.0001	1.0	0.91	0.88	0.79	0.71	<0.0001
95% CI		0.84–0.93	0.83–0.92	0.77–0.86	0.74–0.84			0.84–0.98	0.81–0.94	0.73–0.86	0.66–0.77	

[1] Values are relative risk estimates and 95% CI from Cox proportional hazards regression models.
[2] Multivariate models included: race (non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific/Islander/American Indian/Alaskan native, unknown); education (<8, 8–11, 12 y, some college, college/postgraduate, unknown); 30-level smoking status (nonsmoker; former smoker, stopped ≥10 y ago, 1–10 cigarettes/d; former smoker, stopped ≥10 y ago, 11–20 cigarettes/d; former smoker, stopped ≥10 y ago, 21–30 cigarettes/d, former smoker, stopped ≥10 y ago, 31–40 cigarettes/d; former smoker, stopped ≥10 y ago, 41–60 cigarettes/d; former smoker, stopped ≥10 y ago, >60 cigarettes/d; former smoker, stopped 5–9 y ago, 1–10 cigarettes/d; former smoker, stopped 5–9 y ago, 11–20 cigarettes/d; former smoker, stopped 5–9 y ago, 21–30 cigarettes/d; former smoker, stopped 5–9 y ago, 31–40 cigarettes/d; former smoker, stopped 5–9 y ago, 41–60 cigarettes/d; former smoker, stopped 5–9 y ago, >60 cigarettes/d; former smoker, stopped 1–4 y ago, 1–10 cigarettes/d; former smoker, stopped 1–4 y ago,11–20 cigarettes/d; former smoker, stopped 1–4 y ago, 21–30 cigarettes/d; former smoker, stopped 1–4 y ago, 31–40 cigarettes/d; former smoker, stopped 1–4 y ago, 41–60 cigarettes/d; former smoker, stopped 1–4 y ago, >60 cigarettes/d; former smoker, stopped within last year, 1–10 cigarettes/d; former smoker, stopped within last year, 11–20 cigarettes/d; former smoker, stopped within last year, 21–30 cigarettes/d, former smoker, stopped within last year, 31–40 cigarettes/d; former smoker, stopped within last year, 41–60+ cigarettes/d; current smoker 1–10 cigarettes/d; current smoker 11–20 cigarettes/d; current smoker 31–40 cigarettes/d; current smoker 51–60 cigarettes/d; current smoker >60 cigarettes/d; unknown smoking status); BMI (<18.5, 18.5–24.9, 25–29.9, ≥30 kg/m^2); physical activity lasting ≥20 min and resulting in sweating or increased breathing and heart rate over the past 12 mo (never, rarely, 1–3 times/mo, 1–2 times/wk, 3–4 times/wk, ≥5times/wk); alcohol intake in g/d (0, 0.01–4.9, 5.0–14.9, ≥15); energy intake (quintiles); and in women only, hormone use (never used, current user, former user, unknown user).
[3] *P*-trend DBS quintiles as a trend variable, 1–5.
[4] Mortality rate is per 100,000 person-years and standardized to the age distribution of men and women in the AARP cohort.

confounding, as these associations were observed in virtually all BMI, smoking, and physical activity categories. However, similar to other such observational studies, all data were self-reported and thus are subject to reporting errors and possible misclassification. The extent to which our results reflect residual confounding due to poorly measured or unknown confounders cannot be determined from the available data.

The DBS was not associated with risk of mortality in race/ethnic groups other than non-Hispanic Whites and Blacks and those who reported no alcohol intake or who never exercised in the past year. At least 2 possible explanations for the lack of a DBS-mortality association in ethnic groups other than non-Hispanic Whites and Blacks can be considered. First, due to small number of Hispanics, Asians, Pacific Islanders, American Indians, and Alaskan natives in our cohort, the study may have insufficient power to examine the DBS-mortality association in these ethnic groups. Second, questions about food behaviors in the baseline FFQ may not be representative of culture-specific dietary patterns of these ethnic groups. The reasons for the lack of any DBS-associated risk reduction in respondents who reported that they never engaged in any physical activity or reported no alcohol intake are not clear. We can speculate that respondents without any physical activity may have such an aggregation of poor risk behaviors as to preclude the benefits of dietary moderation. And those reporting no alcohol intake in our study may include those with a previous history of heavy alcohol use. The possibility that respondents in categories of no physical activity and no alcohol use may be in poor health relative to other categories cannot be excluded.

Our analytical sample excluded all who considered their health to be poor or reported clinical conditions such as diabetes, cancer, and heart disease at baseline. Therefore, the possibility of reverse causation where higher mortality but poor dietary intakes in this group may account for the observed associations is not likely. We further explored the possibility of preclinical disease confounding the DBS-mortality association by stratifying follow-up time; the DBS mortality association remained virtually unchanged when follow-up was limited to deaths within the first 5 y or deaths after 5 y or later.

The large size of the AARP cohort is a strength of our study; however, the study cohort is more likely to be non-Hispanic White and has a higher level of education. The reference period for usual dietary behaviors and food intake queries in the FFQ was for the past 1 y. It is evident from the results that the profile of dietary behaviors over this time period among middle aged men and women was related to survival. Nevertheless, we are aware that there is likely to be variability in the duration of compliance to recommended dietary behaviors before the study baseline and some respondents may change their dietary behaviors over the ~10-y follow-up period. We were unable to examine the possible survival differential due to this variability. Some misclassification of respondents into DBS categories remains a possibility and may have attenuated the DBS-mortality associations. Finally, due to the large number of subgroup

TABLE 5 Multivariate-adjusted risk of cause-specific mortality by quintiles of DBS in all men and women in the NIH-AARP Diet and Health Study cohort[1]

	Men						Women					
	Q1	Q2	Q3	Q4	Q5	*P*-trend[2]	Q1	Q2	Q3	Q4	Q5	*P*-trend[2]
Range	0–18	18.25–22.75	23–26	26.25–29.0	29.25–36.0		0–18	18.25–22.75	23–26	26.25–29.0	29.25–36.0	
n	45,995	44,333	41,216	35,984	32,346		23,810	27,255	30,948	32,526	36,473	
All-sites cancer[3] [*n* = 199,874 (men), 151,012 (women); deaths = 7422 (men), 4274 (women)]												
Multivariate relative risk[3]	1.0	0.90	0.93	0.88	0.79	<0.0001	1.0	0.84	0.88	0.81	0.81	<0.0001
95% CI		0.84–0.96	0.87–0.99	0.81–0.94	0.73–0.86			0.76–0.92	0.80–0.97	0.73–0.89	0.73–0.90	
CHD[4] [*n* = 199,874 (men), 151,012 (women); deaths = 2695 (men), 951 (women)]												
Multivariate relative risk	1.0	0.91	0.79	0.74	0.77	<0.0001	1.0	0.95	0.92	0.90	0.70	0.003
95% CI		0.82–1.01	0.71–0.89	0.65–0.84	0.67–0.88			0.78–1.16	0.75–1.12	0.73–1.11	0.56–0.87	
All-other causes [*n* = 199,874 (men), 151,012 (women); deaths = 5541 (men), 3270 (women)]												
Multivariate relative risk	1.0	0.90	0.85	0.79	0.77	<0.0001	1.0	0.92	0.82	0.76	0.67	<0.0001
95% CI		0.84–0.97	0.78–0.92	0.72–0.86	0.70–0.84			0.83–1.02	0.74–0.92	0.68–0.85	0.59–0.75	

[1] Values are relative risk estimates and 95% CI from Cox proportional hazards regression models. Multivariate models included: race (non-Hispanic white, non-Hispanic black, Hispanic, Asian/Pacific/Islander/American Indian/Alaskan native, unknown); education (<8, 8–11, 12 y, some college, college/postgraduate, unknown); 30-level smoking status (nonsmoker; former smoker, stopped ≥10 y ago, 1–10 cigarettes/d; former smoker, stopped ≥10 y ago, 11–20 cigarettes/d; former smoker, stopped ≥10 y ago, 21–30 cigarettes/d, former smoker, stopped ≥10 y ago, 31–40 cigarettes/d; former smoker, stopped ≥10 y ago, 41–60 cigarettes/d; former smoker, stopped ≥10 y ago, >60 cigarettes/d; former smoker, stopped 5–9 y ago, 1–10 cigarettes/d; former smoker, stopped 5–9 y ago, 11–20 cigarettes/d; former smoker, stopped 5–9 y ago, 21–30 cigarettes/d; former smoker, stopped 5–9 y ago, 31–40 cigarettes/d; former smoker, stopped 5–9 y ago, 41–60 cigarettes/d; former smoker, stopped 5–9 y ago, >60 cigarettes/d; former smoker, stopped 1–4 y ago, 1–10 cigarettes/d; former smoker, stopped 1–4 y ago,11–20 cigarettes/d; former smoker, stopped 1–4 y ago, 21–30 cigarettes/d; former smoker, stopped 1–4 y ago, 31–40 cigarettes/d; former smoker, stopped 1–4 y ago, 41–60 cigarettes/d; former smoker, stopped 1–4 y ago, >60 cigarettes/d; former smoker, stopped within last year, 1–10 cigarettes/d; former smoker, stopped within last year, 11–20 cigarettes/d; former smoker, stopped within last year, 21–30 cigarettes/d, former smoker, stopped within last year, 31–40 cigarettes/d; former smoker, stopped within last year, 41–60+ cigarettes/d; current smoker 1–10 cigarettes/d; current smoker 11–20 cigarettes/d; current smoker 31–40 cigarettes/d; current smoker 51–60 cigarettes/d; current smoker >60 cigarettes/d; unknown smoking status); BMI (<18.5, 18.5–24.9, 25–29.9, ≥30 kg/m^2); physical activity lasting ≥20 min and resulting in sweating or increased breathing and heart rate over the past 12 mo (never, rarely, 1–3 times/mo, 1–2 times/wk, 3–4 times/wk, ≥5times/wk); alcohol intake in g/d (0, 0.01–4.9, 5.0–14.9, ≥15); energy intake (quintiles); and in women only, hormone use (never used, current user, former user, unknown user).
[2] *P*-trend: DBS quintiles 1–5 as a trend variable.
[3] Cancer = ICD-9 codes 140–208 or ICD-10 codes C00–97.
[4] CHD = ICD-9 codes 410–414, 429.2 or ICD-10 codes I20–25.

analyses completed in this study, it is possible that some of the observed associations may be due to chance.

Of all the examined dietary behaviors, compliance with advice about avoiding discretionary solid fat and consuming whole grains was lowest in both men and women (reported by <20% of the cohort) (Table 3). The reasons for relatively poor compliance with these 2 recommendations cannot be explored with the data available for this study but may reflect the importance of taste and cost of whole grains as determinants of food selections (35,36). The dietary information for this study was collected over 10 y ago. Recent studies on secular trends in dietary intake in the U.S. population have found little evidence of major improvements in key dietary behaviors related to fruit, vegetable, and fat intakes since 1995 (21,23,24).

The findings of this study have practical implications for nutrition interventions. Emphasizing simple approaches to dietary change by promoting generally desirable behaviors that consumers may find easier to understand and implement may lead to higher compliance. The dietary guidance messages may need to specifically target men, as they were less likely to report all desirable dietary behaviors than women. Researchers interested in studying diet and health associations, should consider the inclusion of global dietary behavior questions along with other dietary assessments that are more prone to dietary measurement error.

In conclusion, reported adoption of recommended dietary behaviors was associated with lower risk of mortality in older men and women in the NIH-AARP cohort and these associations were not modified by other risk factors of mortality.

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