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Health Behaviors and Survival among Middle-Aged and Older Men and Women in the NHANES I Epidemiologic Follow-Up Study[1,2]

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Background. **Since the 1960s there has been a decline in mortality rates for older U.S. adults, suggesting the importance of examining the role of prevention and health promotion in improving the health and survival of older adults. Epidemiologic studies of age and gender differences in the impact of health behaviors on survival for older U.S. adults are needed to provide information for intervention and health promotion efforts for older Americans.**

Methods. **We examined whether health behavior risk factors (smoking, drinking, physical activity, and body weight) for mortality vary by age and gender among 6,109 adults 45–74 years old in the National Health and Nutrition Examination Survey 1971–1975 (NHANES I) who were traced during the 1982–1984 NHANES I Follow-up Survey.**

Results. **For middle-aged men (45–54 years old) and for older men (65–74 years old), both smoking and nonrecreational physical activity were predictors of survival time. Additionally, for older men, drinking and low body mass index were associated with shorter survival time. Among women, there was less consistency of associations across age groups. As with men, nonrecreational physical activity and low body mass index were associated with shorter survival among older women.**

Conclusions. **These findings suggest that health behaviors are associated with survival in older adults as well as in middle-aged adults, although the specific behavioral risk factors may vary by age and gender.**

INTRODUCTION

Since the 1960s, men and women 65 years and older have experienced the largest absolute declines in mortality for U.S. adults (1). A substantial portion of the decline in mortality rates of older adults reflects declines in the rates of death from cardiovascular and cerebrovascular diseases (1). These declines are thought to be due, in part, to changes in lifestyle and health behaviors (2). This declining trend in the mortality rates of older U.S. adults suggests the importance of examining the role of prevention and health promotion in improving the health and survival of older adults.

Recently a number of studies have focused on identifying social and behavioral risk factors for chronic disease and for mortality among older adults (3–20), resulting in growing evidence that behavioral, social, and socioeconomic factors influence the health and survival of older adults (3–20). Most studies have been limited in that they focus on a single risk factor such as physical activity or obesity, have not investigated gender differences, or have been limited to a single geographic area. Furthermore, because of the known greater longevity of women, it is important to learn about sex differences in variables influencing health and longevity in older adults. Therefore studies that are able to investigate the importance of a number of behavioral risk factors in a national sample including both middle-aged and older men and women are important in providing more comprehensive information for basing clinical intervention and health promotion efforts for older adults.

In this report, we contribute to this line of investigation by examining whether behavioral risk factors known to influence survival time in younger adults also predict survival time in older adults and investigate whether there are gender differences. Using a representative national sample, we examine the association of health behaviors (smoking, drinking, physical activity, and body weight) among U.S. adults age 45–74 years in the first National Health Nutrition Examination Survey (NHANES I, 1971–1975) with subsequent mortality to the NHANES I Epidemiologic Follow-up Study (NHEFS 1982–1984). Specifically, we address two research questions: (a) Are health behaviors that are predictive of survival among middle-aged adults also predictive of survival among older adults?

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(b) Are the associations of health behaviors and survival for middle and older age adults similar for men and women? Although previous studies have suggested that more men than women experience health behavior risks of smoking and drinking, less is known about whether there are gender differences in the strength of the association of these as well as additional health behaviors with longevity.

MATERIALS AND METHODS

Study Sample

The NHANES I, a national probability sample of the civilian, noninstitutionalized population age 1 to 74 years, collected demographic, nutritional, medical history, clinical, and laboratory information in a two-stage process (Basic Survey and Augmentation Survey), each of which were designed to be representative of the U.S. population (21). The NHEFS 1982–1984 attempted to trace all 14,407 NHANES I persons age 25 to 74 years to determine whether they were still alive, to conduct in-depth interviews, to collect selected physical measurements, and to obtain health facility records and death certificates (22). Analyses in this report are restricted to the 6,109 persons age 45 to 74 years in the basic sample of NHANES I who were traced at follow-up (93%). The Augmentation Sample was not analyzed because some variables used in our analyses were not available for that sample. Among those traced in the basic survey, 4,416 (72%) were alive and 1,693 (28%) had died. Death certificates were obtained for 96% of the deaths, and proxy reports of death were obtained for the remainder (22).

Figure 1 presents the estimated Kaplan–Meier survival curves for the sample by age and sex. Table 1 presents the sample sizes and number of deaths by age and sex. Madans and colleagues have reported that the survival experience of the 1982–1984 NHEFS cohort is representative of the survival experience of the total U.S. population (23).

Variables

Data on all variables other than death were collected at baseline (NHANES I). Health behavior variables included body mass index (weight [kg]/height [m^2]), physical activity, alcohol consumption, and smoking. The measures of physical activity were self-reported nonrecreational activity (e.g., "In your usual day, aside from recreation are you physically very active, moderately active or quite inactive?") and recreational activity ("Do you get much, moderate or little or no exercise in the things you do for recreation?"). Daily alcohol consumption was divided into four categories: none, one drink per day, two drinks per day, or more than two drinks per day, based on questions about usual 24-hr frequency of alcohol consumption.

Smoking was categorized as having never smoked, having formerly smoked, or currently smoking. Only a random subsample of the NHANES I sample was asked about smoking (n = 3,968 for those in this report), whereas all respondents or proxies for decedents were asked about smoking at the follow-up. For those persons not asked about smoking at baseline (n = 3,080 for those in this report), baseline smoking status was determined from a lifetime smoking history ascertained at NHEFS 1982–1984. A high level of agreement has been found between NHANES I baseline smoking responses and baseline smoking as determined in the NHEFS (24). For persons who were missing smoking information at both NHANES I and NHEFS (n = 603 for these analyses), smoking status was imputed using the method developed by Kleinman and colleagues (25).

Variables included as adjustment variables in our analyses were age, race (white or other), years of education, income (as a percentage of the federal poverty level), employment (employed or not employed outside the home during the previous 3 months), living arrangement (alone, with spouse, with someone other than a spouse), number of chronic conditions (pulmonary disease, heart disease, hypertension, stroke, gastrointestinal disease, diabetes, kidney disease, malignant tumor, fracture) (26), and dietary quality (consumption of less than two-thirds RDA for five or more of eight nutrients was categorized as poor dietary quality (27)).

Statistical Analyses

We examined the association of baseline health behaviors with subsequent survival to NHEFS 1982–1984 using Cox proportional hazard models (28), fitted by the PHGLM procedure in SAS (29). Separate models were fitted for each of the six age–sex groups. Plots of the log minus log survivor function by each health behavior for each age–sex group were consistent with the proportional hazards assumption.

Estimates of the relative hazards corresponding to each behavioral variable were computed for each age–sex group from models including age (as a continuous variable within the age group), race, education, income, employment, living arrangement, dietary quality, and chronic conditions.

TABLE 1

Sample Sizes at NHANES I and Number of Deaths to NHEFS 1982–1984 by Age and Sex

	45–54 Years		55–64 Years		65–74 Years	
	Sample size	Deaths	Sample size	Deaths	Sample size	Deaths
Men	732	102	589	144	1591	774
Women	797	55	652	80	1748	538

The NHANES I sampling design, which included differential sampling rates by age, sex, and income, was incorporated into our analyses. The sample distributions of the health behaviors were calculated using the NHANES I sample weights (Table 2 and 3). Additionally, all proportional hazards models were fitted separately by sex- and design-compatible age groups and included adjustments for income and race. Our proportional hazards analyses used standard error estimates based on independence of survival times within clusters since previous analyses of NHANES I survival data showed little dependence of survival times within clusters and found design effects for Cox regression coefficients near 1 (30).

RESULTS

Figure 1 shows the Kaplan–Meier survival curves by sex for the three age groups (45–54 years, 55–64 years, 65–74 years) we analyzed. As expected, the survival experience for this sample reflects the survival experience generally observed for U.S. adults; men have shorter survival times than women in all three age groups and the mortality risk increases with age.

Tables 2 and 3 present the distribution of health behaviors in the sample. A larger percentage of men were current smokers than women and the percentage of smokers decreased with age. A greater proportion of men than women drank two or more drinks per day, and the proportion drinking more than two drinks per day decreased with age. Adults 65–74 years old were less likely to report nonrecreational physical activity than in the two younger age groups. In general, a greater percentage of women had low body mass (BMI <22) and high body mass (BMI >30) than men. The proportions of persons with low BMI increased slightly with age for men, but decreased for women. There was no clear difference in the proportion with high BMI by age group.

Tables 4 and 5 present the relative hazards of death for the health behavior measures. For men, the most consistent predictor of shorter survival time across age groups was nonrecreational physical activity. Men who were physically inactive were more likely to die sooner than were those who were very physically active. Current smoking, low BMI, and consuming two or more drinks per day increased the risk of death in some but not all age groups of men. Smoking, drinking, nonrecreational physical activity, and low BMI were all associated with shorter survival time for the oldest group of men.

Among women there was little consistency in the association of health behaviors with survival across age groups. Smoking and BMI were associated with survival for women age 45–54 years. Nonrecreational physical activity and low body mass index were associated with shorter survival time among the oldest group of women.

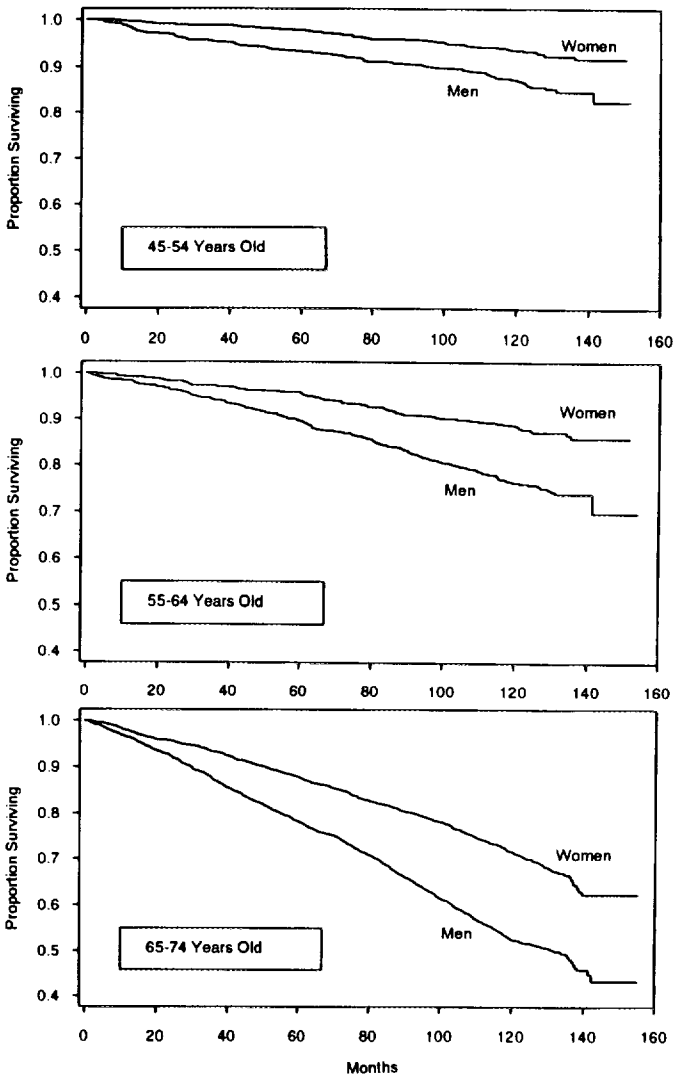

FIG. 1. Kaplan–Meier survival curves from NHANES I to NHEFS 1982–1984 by age and sex.

DISCUSSION

In this study, we examined whether health behaviors that previous research has suggested are predictive of survival among middle-aged adults are also predictors of survival among older adults and whether there were gender differences in the associations of health behaviors with survival. Although we observed gender differences in the distribution of smoking, drinking, recreational physical activity, and BMI, we did not observe consistent gender differences in the strength of the association of health behaviors with survival. For men and women age 65–74 both nonrecreational physical activity and low BMI were associated with increased mortality risk, suggesting that risk factor intervention has the potential for increasing survival for both older men and women. Among men we observed that more health behaviors were as-

TABLE 2
Distribution of Health Behaviors for Men by Age: NHANES I

	45–54 years (n = 732) %	55–64 Years (n = 589) %	65–74 Years (n = 1591) %
Smoking			
Current smoker	47.1	40.1	29.7
Former smoker	32.3	32.9	34.5
Never smoked	20.6	27.0	35.8
Drinking			
No drinks/day	45.2	48.0	42.3
1 drink/day	23.9	30.2	42.5
2 drinks/day	14.5	12.1	8.5
>2 drinks/day	16.4	9.7	6.7
Nonrecreational physical activity			
Inactive	10.3	9.8	13.6
Moderate active	43.5	39.0	52.6
Very active	46.2	51.2	33.8
Recreational physical activity			
Little or none	42.7	39.8	42.9
Moderate	35.0	39.4	37.7
Much	22.3	20.8	19.4
Body mass index			
BMI <22	13.8	16.4	18.4
BMI 22–30	73.4	69.7	70.7
BMI >30	12.8	13.9	10.9

Note. Percentages are weighted population estimates.

TABLE 3
Distribution of Health Behaviors for Women by Age: NHANES I

	45–54 Years (n = 797) %	55–64 Years (n = 652) %	65–74 Years (n = 1,748) %
Smoking			
Current smoker	34.7	31.5	14.7
Former smoker	11.7	9.1	8.1
Never smoked	53.6	59.4	77.2
Drinking			
No drinks/day	45.4	37.7	28.4
1 drink/day	45.0	55.0	67.3
2 drinks/day	6.1	4.4	2.7
>2 drinks/day	3.5	2.9	1.6
Nonrecreational physical activity			
Inactive	10.0	9.4	14.3
Moderately active	44.6	46.6	55.9
Very active	45.4	44.0	29.8
Recreational physical activity			
Little or none	54.6	51.1	57.3
Moderate	31.2	36.9	31.3
Much	14.2	12.0	11.4
Body mass index			
BMI <22	25.8	22.2	18.2
BMI 22–30	56.2	53.9	60.3
BMI >30	18.0	23.9	21.5

Note. Percentages are weighted population estimates.

sociated with survival for those 65–74 years old compared to middle-aged men 45–54 years. These results add to the growing evidence for the association of health behaviors with survival among older adults (3–20).

A number of recent studies provide evidence that physical activity protects against adverse health effects among older adults (3, 7–14), including physical fitness (9), combined recreational and nonrecreational activity (7, 8, 10–14), and recreational activity (3, 11). Few studies have examined whether there are gender differences in the association of physical activity with mortality, but those that have (9, 11) observed an association for both men and women, as we did. Our findings, as well as those of others, also suggest a role for moderate activity increasing survival (9, 10) among older adults.

We found an association of nonrecreational physical activity with survival but not for recreational physical activity. As has already been noted (31), these two questions reflect two important different aspects of daily activity. In our analysis, less than 15% of persons reported being quite physically inactive in their usual day aside from recreation. However, close to 40% reported little or no recreational exercise. Thus in 1971–1975 when the NHANES I survey data were collected, it appears that a large percentage of adults were not physically active in their recreation activities, and most of the physical activity was apparently due to nonrecreational activity. The relative unimportance of recreational activity may explain the lack of an association of this measure with mortality. A previous analysis of the association of these two measures of physical activity in NHANES I with subsequent cancer morbidity and mortality at NHEFS 1982–1984, generally found an association of nonrecreational activity with cancer, but not for recreational activity (32). These researchers reported correlations of nonrecreational activity with indicators of energy intake and expenditure and with employment status (32). Thus, although the categories of exercise may be subjectively interpreted, there is support for the validity of this self-reported measure.

Although we did not observe an association of recreational physical activity with survival, other studies have reported such an association (3, 4, 9). Given the variation in definitions and measurement of physical activity/exercise/physical fitness that have been used in studies of physical activity, it is difficult to compare the results between studies. Clearly further research needs to be done to establish the reliability and validity of physical activity measures and to determine

TABLE 4

Relative Hazards of Death (NHEFS 1982–1984) and Associated 95% Confidence Intervals from Multivariate Proportional Hazards Models for Health Behaviors at NHANES I for Men by Age

	45–54 years		55–64 years		65–74 years	
	RH	95% CI	RH	95% CI	RH	95% CI
Smoking						
Current/never	2.1	(1.1, 3.8)	1.2	(0.7, 1.9)	1.5	(1.2, 1.8)
Former/never	1.0	(0.5, 2.0)	1.2	(0.7, 2.0)	1.1	(0.9, 1.3)
Drinks/day						
1/0	0.8	(0.5, 1.4)	0.9	(0.6, 1.4)	1.3	(1.1, 1.6)
2/0	0.7	(0.3, 1.6)	0.8	(0.4, 1.6)	1.2	(0.9, 1.6)
>2/0	1.2	(0.7, 2.1)	1.7	(1.0, 2.8)	1.4	(1.0, 1.9)
Nonrecreational physical activity						
Inactive/very active	1.8	(0.9, 3.4)	2.0	(1.1, 3.6)	2.2	(1.7, 2.8)
Moderately active/very active	1.3	(0.8, 2.2)	1.0	(0.6, 1.6)	1.3	(1.1, 1.6)
Recreational physical activity						
Little or none/much	1.3	(0.7, 2.4)	1.3	(0.8, 2.2)	1.1	(0.9, 1.4)
Moderate/much	1.1	(0.6, 2.2)	0.8	(0.4, 1.4)	1.0	(0.8, 1.3)
Body mass index						
BMI <22/22–30	0.9	(0.5, 1.6)	2.1	(1.4, 3.3)	1.3	(1.1, 1.6)
BMI >30/22–30	1.4	(0.8, 2.4)	1.2	(0.7, 2.1)	1.1	(0.9, 1.4)

Note. All analyses controlled for each other variable in the table in addition to age, race, education, income employment status, living arrangement, dietary quality, and chronic conditions. RH, relative hazard; CI, confidence interval.

which aspects of physical activity are associated with survival.

Previous studies of the association between weight and mortality among adults suggest a curvilinear association with extreme values of weight associated with higher risk of mortality (3, 16, 33) and that this curvilinear association is also observed in older adults (3, 4, 15, 16). Previous analyses of body weight and mortality for white adults 55–74 years in the NHANES I survey (5) found a stronger association of low body weight with mortality than for high body weight among older adults. Our findings are similar. Additionally, weight loss among older adults in the Alameda County study has been observed to be asso-

TABLE 5

Relative Hazards of Death (NHEFS 1982–1984) and Associated 95% Confidence Intervals from Multivariate Proportional Hazards Models for Health Behaviors at NHANES I for Women by Age

	45–54 years		55–64 years		65–74 years	
	RH	95% CI	RH	95% CI	RH	95% CI
Smoking						
Current/never	2.0	(1.1, 3.6)	1.2	(0.7, 2.1)	1.2	(0.9, 1.5)
Former/never	0.7	(0.2, 2.5)	2.3	(1.2, 4.5)	1.2	(0.9, 1.7)
Drinks/day:						
1/0	0.7	(0.4, 1.3)	0.8	(0.5, 1.3)	1.1	(0.9, 1.3)
1–2/0	0.6	(0.1, 2.6)	1.1	(0.3, 3.9)	1.1	(0.6, 2.2)
2+/0	2.3	(0.4, 6.1)	0.9	(0.2, 4.1)	1.1	(0.5, 2.5)
Nonrecreational physical activity						
Inactive/very active	1.3	(0.5, 3.3)	1.7	(0.8, 3.7)	2.1	(1.5, 2.8)
Moderately active/very active	1.2	(0.6, 2.2)	1.3	(0.7, 2.1)	1.2	(1.0, 1.6)
Recreational physical activity						
Little or none/much	0.9	(0.4, 2.4)	2.2	(0.8, 6.6)	1.0	(0.7, 1.4)
Moderate/much	0.8	(0.3, 2.3)	1.7	(0.6, 5.2)	0.8	(0.5, 1.1)
Body mass index						
BMI <22/22–30	2.6	(1.3, 5.1)	1.5	(0.8, 2.7)	1.5	(1.2, 1.8)
BMI >30/22–30	2.0	(1.0, 4.0)	1.6	(0.9, 2.7)	0.9	(0.7, 1.1)

Note. All analyses controlled for each other variable in the table in addition to age, race, education, income employment status, living arrangement, dietary quality, and chronic conditions. RH, relative hazard; CI, confidence interval.

ciated with an increased risk of death (4), suggesting the need to investigate further the extent to which low body weight is associated with shorter survival time independent of underlying life threatening morbidity that may be associated with low body weight.

Although we adjusted for chronic conditions and dietary quality in our analyses, it is possible that these baseline measures were not sensitive enough to adjust for their confounding effects on the associations of physical activity and body mass index with mortality. Although our measure of chronic conditions was associated with survival in all of our age and sex groups (relative hazards for two or more chronic conditions compared with none ranged from 1.6 to 2.6), we were concerned that the associations of mortality with nonrecreational activity and with BMI might be due to imminent death among those who were inactive or very thin due to serious illness. Therefore, we reanalyzed the data excluding those persons who died during the first 2 years of follow-up. This exclusion did not change the magnitudes of either association in any of the age–sex strata (data not shown).

We found a stronger association of smoking with survival time for men and women 45–54 years than for those 65–74 years, which was also observed in the Alameda County Study (3). However, given the higher mortality rate among older adults, even though the association between smoking and survival time may be weaker than among middle-aged adults, the overall impact of smoking may be greater among older adults (18).

There was a weak association of drinking with mortality for older men and no suggestion of a U-shape relationship of drinking with mortality for older adults. For adults age 45–64 years there was some suggestion of a U-shaped relationship of alcohol consumption with survival; however, the 95% confidence intervals for the relative hazards all included 1.

The range of drinks per day in our sample was narrow, with relatively few persons reporting more than two drinks per day, particularly among women. Thus, we were limited in our ability to analyze the impact of heavy drinking on mortality. It is important for future studies to examine cause-specific mortality, since the relationship of alcohol consumption and overall mortality is the result of the different effects of alcohol consumption on specific causes of death (an increased risk of death for diseases of the liver, accidents, stroke, and cancer and a potential decreased risk for coronary heart disease among moderate drinkers) (34, 35) and the relative prevalence of alcohol-related conditions at specific ages for men and women.

Interim changes in the health behaviors between NHANES I and NHEFS 1982–1984 may have obscured associations of the health behaviors with survival. However, to invalidate our comparisons between age groups, there would need to be an age-related change in health behaviors. Since, the survival curves for the health behaviors within age and sex groups conformed to the proportional hazards assumption throughout the follow-up period, it is unlikely our results are biased due to changes in health behaviors.

Health and survival of older adults is affected by a wide range of variables in dynamic and complex pathways and interactions. In order to deepen our understanding of these relationships and process, it is important for future studies to carry out multiple assessments over time and at frequent intervals.

There are a number of methodological issues to consider in interpreting the results from our study and other studies of risk factors for mortality in older adults. A number of these issues have been discussed in detail by Kaplan and colleagues (36). Different patterns of risk factor association with mortality in older adults observed by different studies may be due in part to differences in the age range included, the length of follow-up, the distribution of diseases in the populations studied, and the choice of type and timing of risk factor measurement. For example, risk factor levels obtained at older ages may not reflect characteristic values over the preceding years. Therefore, the timing of the risk factor assessment, and whether average, cumulative, or risk factor change measures are used in a specific study may have an impact on the findings. Changes in the strength of an association between a specific risk factor and mortality with age have been frequently observed, with the most frequent observation being a decline in risk factor–mortality associations with increasing age. There are a number of possible explanations to consider in interpreting this pattern. The first is the "survivor" explanation (36). If a risk factor is associated with a fatal disease outcome, then over time, with increasing age, there will be a selective removal of the susceptibles from the exposed group, leaving a group that becomes more and more like the unexposed group with respect to level of risk (36). In addition, when mortality rates are high in older age groups, then the ability of the risk factor level to rise further is constrained. Additionally it is possible that the impact of the risk factor on mortality changes with age.

CONCLUSION

Our findings do not provide information on the benefits that can be expected from initiating changes in health behaviors during later years of life. Prospective intervention studies are needed to address the impact of such changes for older adults. Recent studies provide direct evidence that there may be important potential for preventive activities among older persons not only for mortality (4, 37) but also for incidence of coronary heart disease (6) and case fatality (38). As others have noted (2, 4), observed associations of health behaviors

with mortality cannot be interpreted to conclude that an intervention among older adults to alter behavioral risk factors will have the desired results. Further research is needed regarding the efficacy of various health prevention and health promotion efforts among older adults (2).

In conclusion, these results based on national health data suggest that health behaviors are associated with survival in older U.S. adults as well as middle-aged U.S. adults, although the specific behavioral risk factors may vary by age and gender.

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