Lifestyle Risk Factors Predict Healthcare Costs in an Aging Cohort

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Background: While the U.S. elderly population uses a disproportionate amount of healthcare resources, there is limited knowledge from prospective studies regarding the impact of lifestyle-related factors on costs in this group. The association was examined between smoking, drinking, exercise, body mass index (BMI), and changes in these risk factors, and healthcare costs after 4 years among 68- to 95-year-olds.

Methods: A total of 1323 participants completed annual surveys providing information on lifestyle factors (1986–1994) and health utilization (1994–1998). Healthcare costs in nine categories were ascertained from validated utilization. The relationships between risk factors and costs were examined in 2004 using linear regression models.

Results: Fewer cigarette pack-years and lower BMI were the most significant predictors of lower total costs in 1998 ($p < 0.001$), controlling for baseline sociodemographic factors, costs, and conditions. Associations with smoking were strongest for hospitalizations, diagnostic tests, and physician and nursing-home visits. Those who reduced smoking by one pack per day experienced cost savings of $1160 ($p < 0.05$). The costs for normal weight compared to minimally obese seniors were approximately $1548 lower, with diagnostic testing, physician visits, and medications accounting for much of this difference. Daily walking, measured at baseline, also predicted lower costs for hospitalizations and diagnostic testing.

Conclusions: Seniors who were leaner, smoked fewer cigarettes over a lifetime, reduced their smoking, or walked farther had significant subsequent cost savings compared to those with less-healthy lifestyle-related habits.

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Introduction

In an era of rising healthcare costs, it has been suggested that national expenditures may be reduced by promoting healthy lifestyles that decrease the incidence of disease and disability and, thus, the need for medical services.[1] A significant proportion of annual healthcare expenditures in the United States has been attributed to smoking (8%),[2] excessive drinking (2% to 3%),[3] obesity (1% to 9%),[4–7] and physical inactivity (2%).[8] However, studies of population-attributable risk rely on questionable assumptions about the proportion of morbidity and mortality due to each risk factor.[4–8]

Cross-sectional, cohort, and worksite studies have demonstrated associations between costs and smoking, obesity, or inactivity.[9–23] However, few have prospectively linked individuals' risk factors to subsequent healthcare costs and components thereof, particularly in the elderly who use a disproportionate amount of resources, and for whom the impact of risk factor change on costs is unknown. The per capita cost in U.S. seniors (aged ≥65 years) is three to five times greater than that in younger persons. The total cost burden will continue to grow given that population projections show a doubling in 30 years, not only of all Medicare eligible, but also of those aged ≥80 years.[24]

In light of these facts, the impact of modifiable lifestyle factors on costs was examined in seniors who were followed prospectively in a study of health outcomes. It was hypothesized that baseline levels and antecedent changes in five important health attributes (smoking, drinking, body mass index [BMI], regular walking, and other exercise) would predict healthcare costs after 4 years. This study uniquely describes: (1) the associations between lifestyle factors at baseline and subsequent costs, adjusting for baseline sociodemographic factors, comorbid conditions, and costs; (2) the effects of antecedent changes in lifestyle (i.e., risk factor modification) on subsequent costs; and

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(3) the impact of these factors on nine cost components.

Methods

A longitudinal study of risk factors for physical disability among 2843 >60-year-olds who were participating in a larger study of chronic disease among college alumni was initiated in 1986.[25] Respondents were living in 49 U.S. states, 77% men, and 99% white, similar to the original student cohort of the 1930s and 1940s. Information from the larger survey showed small but statistically significant differences ($p < 0.05$) between nonrespondents and respondents at entry. Nonrespondents were 2 years older (63 vs 61), more often smokers (15% vs 11%), and had higher rates of self-reported heart disease (14% vs 11%), cancer (9% vs 7%), and osteoarthritis (24% vs 20%).

Participants returned annual self-administered surveys describing sociodemographic factors, health habits, risk factors, medical history, and quality of life. Between 1995 and 1999, questions on the frequency of specific types of healthcare utilization in the prior year also were included. This paper describes 1323 participants who were followed through that time. By 1999, 29% of the cohort had died and about 2% per year had withdrawn for other reasons. Withdrawals did not have greater prevalence of chronic diseases at entry than ongoing participants, but were slightly older, heavier, and less active. Further details have been previously published.[26,27]

The year 1994 defined the baseline survey in which information on utilization, lifestyle, sociodemographic factors, and health conditions were collected. Antecedent changes in lifestyle factors were ascertained between 1986 and 1994. Participants were last queried in detail about healthcare utilization in 1998, the follow-up year for this study.

Healthcare costs were estimated in 1994 and 1998 for nine categories of resource use including hospitalizations, emergency department visits, diagnostic tests, outpatient surgeries, doctor visits, in-home care, visits to nontraditional practitioners, nursing home/rehabilitative care, and prescription and over-the-counter medications. A study was conducted comparing participant to provider reported utilization to validate self-report.[28] Agreement for physician, hospital, nursing home, emergency department visits, and high-cost outpatient procedures, including chemotherapy and radiation therapy, was excellent (weighted kappas=0.80 to 1.00). Agreement also was very good for other outpatient procedures, x-rays, and prescription medications (weighted kappas=0.50 to 0.70).

To derive costs, annual utilization was multiplied by published unit prices for each type of resource.[29] Units of utilization included the number of hospital stays (by diagnosis related group [DRG]), diagnostic tests, physician visits, outpatient surgeries, nontraditional therapy visits (by type), emergency department and home health visits, rehabilitative and nursing home days, and courses of medication treatment (by type). Prices were drawn from the *DRG Guidebook*[30] with Resource-Based Relative Value Scale (RBRVS) software,[31] the *Physician Fee and Coding Guide*,[32] and *Drug Topics Red Book*.[33] Average costs for nontraditional therapy, including acupuncture, acupressure, homeopathy, massage, herbal therapy, and other, were not available nationally, but were estimated from a wide sample of providers in northern California. Total healthcare costs represented the sum across the nine component categories.

The lifestyle-related, potentially modifiable risk factors of interest were cigarette smoking (pack-years); alcohol use (drinks per week of beer, wine, liquor); walking during normal activities (miles per day); moderate to vigorous exercise (hours per week energy expenditure >4 METs [metabolic equivalents]), and body mass index (BMI; weight in kilograms/height in meters squared). Eight-year changes (1994–1986) were estimated for number of cigarettes/day, miles walked/day, exercise hours/week, body weight, and drinks/week.

Sociodemographic factors included age, gender, marital status, education, income, working for pay, and medical insurance other than Medicare. These factors were chosen based on previous associations with demand for and use of health services.[34,35]

Race/ethnicity was not included here because only 1% of the cohort was nonwhite. Health conditions were coded into categories based on broad ICD-9 classifications: cancer, hypertension, coronary, cerebrovascular and other cardiovascular, neurologic, gastrointestinal, musculoskeletal, pulmonary, endocrine, and genitourinary disease; depression; vision problems; hearing problems; and fractures. Total 1994 costs were derived and used as adjustors to capture unobserved influences on later costs, including unmeasured diseases and tendencies to use medical care, important in the assessment of causal relationships.[35,36]

Linear regression in SAS, version 6.12 (SAS Institute Inc., Cary NC, 1996) was used to estimate the independent effects of lifestyle factors and their changes on 1998 costs.[37,38] The natural log of costs (adding $1 to eliminate zeros) was used to normalize the data for analysis. Means were substituted for missing values of predictors, and dummy variables (1=missing, 0=not) were entered into models to minimize possible bias. Two-part models often are used to analyze costs, estimating parameters for occurrence of costs (0=no, 1=yes) and costs greater than zero. However, the standard (single equation) model was chosen for these analyses, because (1) <1% of respondents generated zero costs, and (2) objectives were to identify predictors of costs (not to understand underlying cost structure) and to compare the impact and consistency of factors across cost categories.[37]

To gain a better understanding of the impact of lifestyle factors on costs, analyses proceeded in a staged fashion. The first model (Regression I) included 1994 sociodemographic and lifestyle factors; the second model (Regression II) added 8-year changes in lifestyle factors; and the final model (Regression III) also included 1994 conditions and total costs. Baseline values of lifestyle factors were likely correlated with their changes and baseline conditions and costs probably represented intermediate variables in the causal pathway. If the latter were true, adjustments for conditions and costs (Regression III) would lead to underestimation of effects of lifestyle factors. However, if diseases resulted in lifestyle change, omitting conditions (Regressions I and II) could overestimate the effects of change on costs.

Three models (Regressions I, II, III) were created for total costs. Only those factors that were associated with total costs at $p < 0.10$ were further examined within the nine specific categories using the same modeling approach. This strategy

Table 1. 1998 healthcare costs by resource category, men and women aged 68 to 95 years

Cost category	Sample size	Percent costs >0	Mean costs ≥0	Standard deviation	Maximum
Total costs, 1998	1323	99.6	$4732	$5552	$68,130
1. Outpatient diagnostic tests	1323	89.6	$1342	$2704	$41,271
2. Hospital stays	1323	16.4	$1263	$3511	$34,153
3. Prescription and nonprescription medications	1321	93.5	$943	$968	$7,381
4. Physician visits	1322	97.7	$724	$780	$11,101
5. Outpatient surgeries	1323	22.8	$241	$560	$3,979
6. Emergency department visits	1323	9.8	$79	$323	$7,584
7. Home healthcare visits	1317	4.6	$66	$462	$7,290
8. Nursing home and rehabilitation stays	1323	2.1	$54	$430	$6,272
9. Nontraditional therapy visits	1323	4.6	$22	$170	$3,160

identified the types of resources that accounted for the relationships obtained in the total cost models, while minimizing problems that could arise from multiple comparisons and correlations among the ten cost outcomes. Associations were assessed using two-tailed tests of significance. The percent difference in costs associated with specified differences in each factor was calculated to show the cost saving potential of healthier lifestyles or risk factor modification. The formula used follows:

$$[\exp(b_x \cdot d_x) - 1] \cdot 100$$

where b equals the regression coefficient for factor x, and d equals the evaluated difference in x.[38]

Results

Average and maximum total costs per person in 1998 were $4732 and $68,130, respectively (Table 1). The distribution was skewed, with 50% showing costs <$2831, including 0.4% with zero costs. Costs were highest for diagnostic tests and hospital stays, although only 16% reported hospitalizations in 1998. Nursing home stays were infrequent and of limited duration, with a maximum cost of $6272.

Participants were aged 68 to 95 years at baseline, and all were Medicare beneficiaries, 95% also having supplemental insurance (Table 2). While 3% of the group smoked cigarettes in 1994, 53% were former smokers. Alcohol consumption also was low. Although average exercise levels appeared adequate in this cohort, 35% reported no moderate to vigorous activity. Being overweight (BMI >25) was common (45%), and 7% were classified as obese (BMI ≥30). On average, participants reduced smoking by 1.3 cigarettes/day, alcohol by 1.7 drinks/week, and weight by 0.5 pounds from 1986 to 1994. The most frequently reported baseline condition was hypertension, followed by vision, musculoskeletal, and genitourinary problems.

Results of multivariable analysis examining baseline factors and changes as predictors of total costs are presented in Table 3. In Regression I, including demographic variables and risk factors in 1994, being married ($p<0.05$), less income ($p<0.01$), working for pay ($p<0.01$), less pack-years ($p<0.001$), more walking ($p<0.05$), and lower BMI ($p<0.001$) were significantly associated with lower total costs in 1998. However, differences in costs related to marital status (19% lower if married), work status (22% lower if working for pay), and amount of walking (7% lower per mile walked) were explained, in large part, by baseline disease prevalence and were no longer significant after appropriate adjustment (Regression III).

Change in daily cigarette consumption between 1986 and 1994 also was a significant predictor of total 1998 costs ($p<0.05$, Regression II) before adjustment for baseline diseases, conditions, and costs, and was of borderline significance ($p=0.06$) after controlling for these covariates (Regression III). A decrease of 20 cigarettes per day predicted a 24.5% reduction in annual costs. While previous weight loss predicted higher total costs (22.8% higher with 20-pound loss, $p<0.05$, Regression II), this finding was predominantly explained by the association of weight loss to greater disease and cost burdens (Regression III). Costs also increased with weight gain, but not significantly after adjustment for subsequently higher baseline BMI (data not shown). Costs were lowest in those whose weight remained fairly constant.

Baseline conditions at least marginally associated with higher total costs in 1998 included hypertension (33% higher) and coronary (17% higher), neurologic (40% higher), musculoskeletal (17% higher), and genitourinary (19% higher) diseases. Baseline (log) costs were strongly associated with 1998 (log) costs ($p<0.001$).

Total costs associated with differences in significant lifestyle factors and costs attributable to categories of utilization are presented in Table 4. Smoking 20 pack-years less at baseline was associated with 10.4% lower costs (Regression II), or a savings of $493 (95% confidence interval [CI]=$719–$254) for the average participant. Pack-years had the greatest economic impact on hospital stays (20 pack-years less=19.2% lower costs), followed by diagnostic tests, and smaller effects on nursing home, physician, and nontraditional therapy visits. Decreasing cigarette consumption by one pack per day between 1986 and 1994 was associated

Table 2. Baseline (1994) characteristics of the study population, men and women aged 68 to 95

Characteristics	Frequency (%) (total n=1323)	Mean (SD)	Minimum	Maximum
Demographics, 1994				
Age (years)		74.5 (3.3)	68	95
Female	294 (22.2)			
Married	1090 (82.4)			
Education level (years of school completed)		17.5 (1.8)	13	20
Household income		$74,837 ($34,556)	$5000	$120,000
Working for pay	199 (15.0)			
Other insurance, in addition to Medicare	1251 (94.6)			
Risk factors, 1994				
Pack-years smoked		18.5 (27.4)	0	219
Number of drinks per week		5.3 (6.7)	0	60
Number of miles walked per day		1.4 (1.1)	0	12
Moderate/vigorous exercise hours per week		2.5 (3.0)	0	25
Body mass index (kg/m^2)		25.0 (3.3)	16	40
Change in risk factors, 1994–1986				
Change in number of cigarettes per day		−1.3 (5.5)	−60	10
Change in number of drinks per week		−1.7 (6.0)	−42	24
Change in miles walked per day		0.2 (1.2)	−11	11
Change in exercise hours per week		−0.02 (3.8)	−30	17
Change in weight (pounds)		−0.5 (8.9)	−35	37
Diseases, conditions, and costs, 1994				
Cancer	180 (13.6)			
Coronary heart disease	180 (13.6)			
Hypertension	605 (45.7)			
Other cardiovascular disease	95 (7.2)			
Neurologic disease	50 (3.8)			
Depression	19 (1.4)			
Gastrointestinal disease	135 (10.2)			
Musculoskeletal disease	301 (22.8)			
Pulmonary disease	58 (4.4)			
Endocrine disease	105 (7.9)			
Genitourinary disease	247 (18.7)			
Significant vision problems	309 (23.4)			
Significant hearing problems	94 (7.1)			
Fractures	45 (3.4)			
Total costs (1994)		$2632 ($3245)	$0	$34,751

SD, standard deviation

with 24.5% lower costs (Regression II) on average or −$1160 (CI=−$1994–−$72). Smoking reduction appeared mainly to reduce costs for hospital stays, although modest effects also were evident for home care, nursing home, and nontraditional therapy.

Miles walked per day at baseline were marginally associated with total costs (p <0.10, Regression II). Walking 1 mile more corresponded to $314 lower costs (CI=−$634–$31), 14% less for diagnostic tests (p <0.05), and 17% less for hospitalizations (p =0.07).

A baseline difference in BMI of negative three units, equal to about −20 pounds on average, was associated with 13.8% lower costs (Regression II) or −$653 (CI=−$908–−$382). Given these results, the cost savings for normal weight (BMI=22 to 24) compared to minimally obese seniors (BMI=30–32), an eight-unit difference, could be estimated at 32.7% annually or $1538 (CI=$2050–$951). BMI was most strongly associated with diagnostic and medication costs, and to a lesser degree, with physician and nontraditional therapy costs. Weight loss between 1986 and 1994 was not significantly related to later costs after adjustments for appropriate confounders at baseline (Regression III), suggesting that those who lost the most weight had poorer health and already higher expenditures.[39]

Discussion

Whether behavioral risk factors and changes in factors influence healthcare costs in a large elderly cohort was investigated, and it was found that lifetime smoking and BMI were strong predictors 4 years later. Hospital stays comprised the largest component of additional costs from smoking, but diagnostic tests were the largest contributors to costs from obesity. Annual cost savings of normal weight compared to minimally obese participants were estimated at 32.7% or $1548, on average. Those who decreased their cigarette consumption between 1986 and 1994 by a pack per day incurred $1160 lower costs.

Table 3. Predictors of total healthcare costs in 1998 using multivariable linear regression

Characteristics	Regression model: coefficient (95% CI)[a]		
	Regression I: demographics, risk factors	**Regression II: demographics, risk factors, changes in risk factors**	**Regression III: demographics, risk factors, changes in risk factors, diseases, prior costs**
Demographics, 1994			
Age (years)	−0.001 (±0.021)	−0.005 (±0.021)	−0.012 (±0.019)
Gender (female=1)	0.075 (±0.170)	0.114 (±0.172)	0.083 (±0.164)
Marital status (married=1)	**−0.204** (±0.187)**	**−0.209** (±0.186)**	−0.119 (±0.172)
Education (years of schooling)	**0.034* (±0.038)**	0.031 (±0.038)	0.017 (±0.035)
Income ($)	**0.0000031*** (±0.0000019)**	**0.0000035**** (±0.0000019)**	**0.0000025** (±0.0000019)**
Working for pay (yes=1)	**−0.247*** (±0.187)**	**−0.243** (±0.187)**	−0.064 (±0.173)
Other insurance, in addition to Medicare (yes=1)	0.153 (±0.287)	0.147 (±0.287)	0.118 (±0.264)
Risk factors, 1994			
Pack-years smoked	**0.004**** (±0.002)**	**0.006**** (±0.003)**	**0.004*** (±0.003)**
Drinks per week	−0.003 (±0.010)	−0.002 (±0.010)	0.001 (±0.010)
Miles walked per day	**−0.074** (±0.062)**	**−0.069* (±0.075)**	−0.054 (±0.069)
Exercise hours per week	0.004 (±0.023)	0.0008 (±0.027)	0.004 (±0.025)
Body mass index (kg/m^2)	**0.040**** (±0.020)**	**0.050**** (±0.021)**	**0.025** (±0.020)**
Change in risk factors, 1994–1986			
Change in number of cigarettes per day		**0.014** (±0.013)**	**0.012* (±0.012)**
Change in number of drinks per week		−0.005 (±0.011)	−0.0009 (±0.010)
Change in miles walked per day		−0.016 (±0.067)	−0.012 (±0.062)
Change in exercise hours per week		0.006 (±0.020)	0.012 (±0.018)
Change in weight (pounds)		**−0.010** (±0.008)**	−0.003 (±0.007)
Diseases, conditions and costs, 1994			
Cancer (yes=1)			−0.119 (±0.178)
Coronary heart disease			**0.155* (±0.184)**
Hypertension			**0.287**** (±0.128)**
Other cardiovascular disease			−0.077 (±0.236)
Neurologic disease			**0.337** (±0.314)**
Depression			0.152 (±0.509)
Gastrointestinal disease			−0.102 (±0.205)
Musculoskeletal disease			**0.156** (±0.150)**
Pulmonary disease			**0.194 (±0.296)**
Endocrine disease			0.150 (±0.227)
Genitourinary disease			**0.177** (±0.161)**
Significant vision problems			0.103 (±0.147)
Significant hearing problems			0.175 (±0.238)
Fractures			0.060 (±0.330)
Natural log total costs, 1994			**0.275**** (±0.049)**

[a]Linear regression was used to predict *ln* (1998 costs + 1). The percent difference in healthcare costs associated with specified differences in each characteristic can be calculated using the formula $(\exp(b_x \cdot d_x)-1) \cdot 100$, where b equals the regression coefficient for factor x, and d equals the specified difference in factor x to be evaluated.

*p <0.10; **p <0.05; ***p <0.01; ****p <0.001 (all bolded).

CI, confidence interval.

Some prospective studies of seniors have found associations between prior smoking and healthcare costs over the short term,[15,21] or hospital admissions over a 10-year period.[20] In a large Japanese study, prior smoking was associated with higher costs over 30 months; greatest excesses were evident among males and 60- to 69-year-olds, particularly for inpatient care.[21] However, the present study illustrates the impact of lifetime smoking on costs for several components of care, including hospital and nursing home stays, physician and nontraditional therapy visits, and diagnostic tests. More importantly, this study shows that seniors who curtailed smoking significantly reduced their risk of total, hospitalization, and nursing home costs 4 years later.

In contrast, BMI was strongly related to costs for outpatient services including diagnostic tests, medications, and physician visits. While there are few comparable prospective data in seniors, the most extensive study to date showed that BMI measured at an average age of 47 was significantly associated with total and hospital-related Medicare expenditures in late life.[23] However, no costs specifically for outpatient services were evaluated. In a study of younger health plan

Table 4. Predictors of 1998 healthcare costs: differences in costs associated with differences in significant lifestyle factors by resource category[a]

	Percent difference in cost (actual dollar difference from the mean cost; 95% CI)[b]									
Lifestyle factors (difference in lifestyle factor)	**Total costs**	**Diagnostic tests**	**Hospital stays**	**Medications**	**Physician visits**	**Outpatient surgery**	**ER**	**Home care visits**	**Nursing home and rehab care**	**Nontraditional therapy visits**
Pack-years (−20 pack-years)										
Regression I	**−8.0 (−$380; −$584–−$167)****	**−8.7****	**−13.0****		**−5.1****				**−4.6****	**−4.6***
II	**−10.4 (−$493; −$719–−$254)****	**−10.6****	**−19.2*****		**−6.6****				**−7.7*****	**−6.5****
III	**−7.0 (−$331; −$552–−$99)*****	NS	**−16.8****		NS				**−8.3******	NS
Drinks per week (−7 drinks)	No statistically significant findings									
Miles walked per day (+1 mile)										
Regression I	**−7.2 (−$339; −$605–−$57)****		**−17.2****							
II	**−6.6 (−$314; −$634–+$31)***	**−14.0****	**−17.0***							
III		**−12.4***	**−17.1***							
Exercise hours per week (+3.5 hours)	No statistically significant findings									
BMI (−3.0 units, about 20 lbs)										
Regression I	**−11.3 (−$533; −$778–−$272)******	**−21.2******		**−12.2*****	**−9.3*****					
II	**−13.8 (−$653; −$908–−$382)******	**−22.3******		**−16.8******	**−10.2*****					
III	**−7.3 (−$344; −$603–−$70)*****	**−15.3*****		NS	NS					**−6.4****
Change in cigarettes (−20/day)										
Regression II	**−24.5 (−$1160; −$1994–−$72)****		**−54.6****					**−25.7***	**−27.4****	**−20.3***
III	**−21.0 (−$993; −$1811–+$55)***		**−53.0****					**−26.7***	**−25.6****	**−20.9***
Change in drinks (−7/week)	No statistically significant findings									
Change in miles walked (+1/day)	No statistically significant findings									
Change in exercise (+3.5 hours/week)	No statistically significant findings									

(*continued on next page*)

Table 4. (continued)

Lifestyle factors (difference in lifestyle factor)	Percent difference in cost (actual dollar difference from the mean cost; 95% CI)[b] Total costs	Diagnostic tests	Hospital stays	Medications	Physician visits	Outpatient surgery	ER	Home care visits	Nursing home and rehab care	Nontraditional therapy visits
Change in weight (−20 lbs)										
Regression II	**22.8 ($1077;$222–$2068)****		**49.9***	**38.2****						
III	Not statistically significant		NS	NS						

CI, confidence interval; NS, not statistically significant.

[a]Based on results of multivariable regression analyses including adjustments for covariates shown in Table 3. Only results for 1994 lifestyle factors that significantly predicted 1998 total costs at the $p<0.10$ level are presented. Regression I includes 1994 demographics and risk factors; Regression II also includes 8-year changes in risk factors; and Regression III also includes 1994 diseases and total costs. The formula for calculating the percent difference in cost is $(\exp(b_x \cdot d_x) - 1) \cdot 100$, where b = the regression coefficient for lifestyle factor x taken to five decimal places, and d = the difference in lifestyle factor x to be evaluated. Dollar amounts noted in parentheses represent the difference in cost (from the mean, or $4732) associated with the difference in lifestyle factor as calculated by $(\exp(b_x \cdot d_x) - 1) \cdot \$4732$. The 95% CIs around costs were calculated assuming a constant mean of $4732.

[b]The CI for costs is not symmetric around the mean due to the nonlinear nature of the percent difference in cost formula described in footnote a.*$p<0.10$;**$p<0.05$;***$p<0.01$;****$p<0.001$ (all bolded).

members, costs after 9 years rose with higher levels of BMI; this relationship was stronger for inpatient services and prescription drugs than for outpatient care.[18] Other investigators found that BMI was associated with total health plan charges over 18 months, but no data were presented for seniors or cost components.[9] Associations of BMI with medical costs or charges in other studies of seniors have been essentially cross-sectional with inadequate control for confounding factors.[15,17]

Greater distances walked at baseline were associated, at least marginally, with lower costs for hospitalization and diagnostic testing. Other studies of physical activity in seniors have not adequately teased out the impact of disease conditions on activity and have shown mixed results regarding cost outcomes.[15,17] A study of walking in older adults found associations comparable to ours where ≥2 hours per week were associated with lower risk of hospitalization after adjusting for health status.[22]

Although not the primary focus of this paper, factors such as working for pay and supplemental insurance have policy implications relevant to Medicare. Employment, particularly in seniors, is an indicator of high functional status and low disease burden. In this study, working for pay was no longer significantly associated with costs after adjustment for comorbidity, consistent with the "healthy worker effect."[40] Due to the moral hazard problem,[41] having insurance other than Medicare was expected to be positively correlated with costs. The observed association was positive but not significant, probably because of the relationship between insurance and higher income, a factor strongly associated with greater total costs in all analyses.

While racial/ethnic and socioeconomic homogeneity of this cohort limits generalizability of findings to the U.S. population as a whole, homogeneity also may provide built-in stratification for ethnic and socioeconomic differences that confound studies of more diverse groups. It has been argued that people of higher socioeconomic status achieve the best health, and therefore have limited potential for additional improvement.[42–44] If so, it would follow that these results are conservative, and that lifestyle-related factors may have a comparatively greater impact on costs in populations with more ethnic and socioeconomic heterogeneity. Lifestyle factors also may have different effects by gender, but female representation (22%) was insufficient to detect these interaction effects.

This study is limited by the collected data. For example, family health history, psychiatric history (other than depression), and healthcare attitudes were not ascertained, yet each of these factors has been linked to costs.[45–47] Psychiatric comorbidity is associated with smoking, and is likely to independently increase healthcare costs. By omitting this covariate, the effect of cumulative pack-years on costs may have been overestimated in final regressions. Estimates of the

effects of smoking changes seem less susceptible to variable omission, but bias cannot be excluded.

Although self-reported healthcare utilization was potentially prone to bias, validation studies suggest that these data are reasonably reliable without obvious sources of systematic error. Participant responses were sufficiently consistent to preserve the well-established association between prior and future costs. Consistent findings also were evident using the 2-year sum of costs (1997 and 1998) as the outcome. Furthermore, costs alternatively ascertained through Medicare would be unavailable for many participants, given the large number who had unrecorded Social Security numbers or received coverage through an HMO. Such data also would not include costs for medications or nontraditional therapy.

As in all longitudinal studies, nonresponse and attrition have taken a cumulative toll. People with dementia or cared for in the final phases of terminal illness as well as those in long-term nursing confinement were unlikely to have provided ongoing data. Initial nonrespondents had more chronic diseases and risk factors, and withdrawals had more risk factors, than persons who continued to be followed. Decedents and withdrawals after 1994 also had significantly greater 1994 health costs and lifetime pack-years ($p < 0.001$); thus, nonresponse and attrition may have downwardly biased our estimates of the effects of lifestyle factors on costs.

It remains unclear whether the lower annual costs observed among people who decreased their smoking would translate into lower lifetime costs. Barendregt et al.[48] argue that because smokers die prematurely, they generate lower lifetime costs than nonsmokers. However, the "compression of morbidity" hypothesis[26,27,44] and other data[49] suggest that smoking lengthens the duration and severity of morbidity before death, and therefore may increase lifetime costs. Similar questions could be raised regarding the impact of obesity on lifetime costs.

Evidence is provided that elderly nonsmokers and normal weight individuals generate significantly lower healthcare costs in subsequent years than smokers and overweight individuals, and that walking for exercise also may decrease costly hospitalizations. More importantly, reducing cigarette consumption appears to reduce healthcare costs over a brief time horizon of only 4 years. While strides have been made in the public health arena to get smokers to quit, U.S. data show that physical inactivity is common, and that the problem of overweight and obesity continues to grow.[50–53] These findings are consistent with the notion that targeted risk factor reduction may make important contributions to decreasing healthcare utilization and costs in aging populations.

What This Study Adds . . .

Longitudinal research in employed populations suggests that encouraging healthy behaviors may reduce soaring medical costs, but few studies exist in seniors who are responsible for the greatest share of costs.

Study results in 68- to 95-year-olds showed that those who never smoked, stopped smoking, maintained desirable weights, or walked daily had the lowest total healthcare costs after follow-up.

Health behaviors also predicted lower costs in specific categories including hospitalizations, diagnostics, physician visits, and medications.

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