Cardiovascular Health and Healthcare Utilization and Expenditures Among Medicare Beneficiaries: The REasons for Geographic And Racial Differences in Stroke (REGARDS) Study

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***Background*—**Better cardiovascular health is associated with lower cardiovascular disease risk.

***Methods and Results*—**We determined the association between cardiovascular health and healthcare utilization and expenditures in the REasons for Geographic And Racial Differences in Stroke (REGARDS) study. We included 6262 participants ≥65 years with Medicare fee-for-service coverage for the year after their baseline study visit in 2003-2007. Cardiovascular health at baseline was assessed using the American Heart Association's Life's Simple 7 (LS7) metric, which includes 7 factors: cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose. Healthcare utilization and expenditures were ascertained using Medicare claims in the year following baseline. Overall, 17.2%, 31.1%, 29.0%, 16.4% and 6.4% of participants had 0 to 1, 2, 3, 4, and 5 to 7 ideal LS7 factors, respectively. The multivariable-adjusted relative risk (95% confidence interval [CI]) for having any inpatient and outpatient encounters comparing participants with 5 to 7 versus 0 to 1 ideal LS7 factors were 0.55 (0.39, 0.76) and 1.00 (0.98, 1.02), respectively. Among participants with 0 to 1 and 5 to 7 ideal LS7 factors, mean inpatient expenditures were $3995 and $1250, respectively, mean outpatient expenditures were $5166 and $2853, respectively, and mean total expenditures were $9147 and $4111, respectively. After multivariable adjustment, the mean (95% CI) cost difference comparing participants with 5 to 7 versus 0 to 1 ideal LS7 factors was −$2551 (−$3667, −$1435) for inpatient, −$2410 (−$3089, −$1731) for outpatient, and −$5016 (−$6577, −$3454) for total expenditures.

***Conclusions*—**Better cardiovascular health is associated with lower risk for inpatient encounters and lower inpatient and outpatient healthcare expenditures. **(*J Am Heart Assoc*. 2017;6:e005106. DOI: 10.1161/JAHA.116.005106.)**

Key Words: cost • health services research • Life's Simple 7 • Medicare • prevention • risk factor

Despite several decades of decline, cardiovascular disease (CVD) remains the leading cause of death and disability in the United States.[1] The American Heart Association's (AHA) 2020 Strategic Goals include improving the cardiovascular health of the US population by 20% while reducing deaths from CVD and stroke by 20%.[2] To assess progress in reaching this goal, the AHA developed the Life's Simple 7 (LS7) metric. LS7 is a composite measure of cardiovascular health based on cigarette smoking, physical activity, diet, body mass index (BMI), blood pressure (BP), cholesterol, and glucose.[2]

Most of the growth in healthcare spending over the past 2 decades has been linked to modifiable risk factors including several components of LS7.[3,4] CVD is a major contributor to healthcare utilization and expenditures, particularly among older adults.[5,6] The medical expenditures associated with CVD in the United States were estimated to be $320 billion in 2011 and are projected to increase almost 3-fold by 2030.[1] Given these projections, it is important to identify modifiable risk factors that contribute to healthcare utilization and expenditures. We hypothesized that a better cardiovascular health profile would be associated with lower rates of health service utilization and healthcare expenditures. To test this hypothesis, we analyzed the association between LS7 and healthcare utilization and expenditures using data from

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Accompanying Tables S1 through S8 are available at http://jaha.ahajournals.org/content/6/2/e005106/DC1/embed/inline-supplementary-material-1.pdf

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REasons for Geographic And Racial Differences in Stroke (REGARDS) study participants with Medicare coverage.

Methods

Study Participants and Data Collection

The REGARDS study enrolled a population-based sample of community-dwelling US adults to examine reasons for higher risk for stroke mortality among blacks compared with whites and residents of the southeastern United States compared with the rest of the contiguous United States.[7] Overall, 30 239 black and white adults were enrolled between January 2003 and October 2007. By design, REGARDS oversampled blacks and residents from the Southeastern United States, commonly referred to as the stroke belt. REGARDS study participants' data were linked to Medicare claims using social security number with matches confirmed using sex and date of birth.[8]

We restricted the current analysis to REGARDS study participants ≥65 years of age at the time of their baseline in-home study visit who did not have electrocardiogram evidence of a previous myocardial infarction (MI) and did not self-report a previous stroke, MI, or coronary revascularization procedure. The analyses were further restricted to participants who were alive with continuous Medicare fee-for-service coverage including Parts A (inpatient acute care) and B (outpatient) for at least 1 year after their baseline REGARDS study visit. Medicare is a federally administered program in the United States that provides health insurance for adults 65 years of age or older and those under 65 years who are permanently disabled or have end-stage renal disease (ESRD).[9] We restricted the analyses to participants 65 years of age or older because Medicare-eligible adults under 65 years of age differ from the general population by socioeconomic status, medical comorbidities, and types and amounts of healthcare services utilized.[10] Complete claims data are not available for beneficiaries enrolled in Medicare Advantage plans (Medicare Part C). Therefore, we excluded participants with Medicare Part C coverage at any time during the year following their baseline study visit. After these criteria were applied, 6262 participants were included in the analyses (Figure). All participants provided written informed consent, and the REGARDS study was approved by institutional review boards of all participating centers and included permission to link data with Medicare claims.

REGARDS study data were collected at baseline through a computer-assisted telephone interview (CATI), an in-home examination, and self-administered questionnaires. The CATI was conducted by trained staff and used to obtain information on demographics (age, race, sex), socioeconomic factors (household income, education, and marital status), and medical history. After the telephone interview, trained health professionals conducted an in-home study visit that included a physical examination, medication inventory, the collection of blood and urine samples, and an electrocardiogram. Self-administered questionnaires were left with the participants to complete and return by mail.

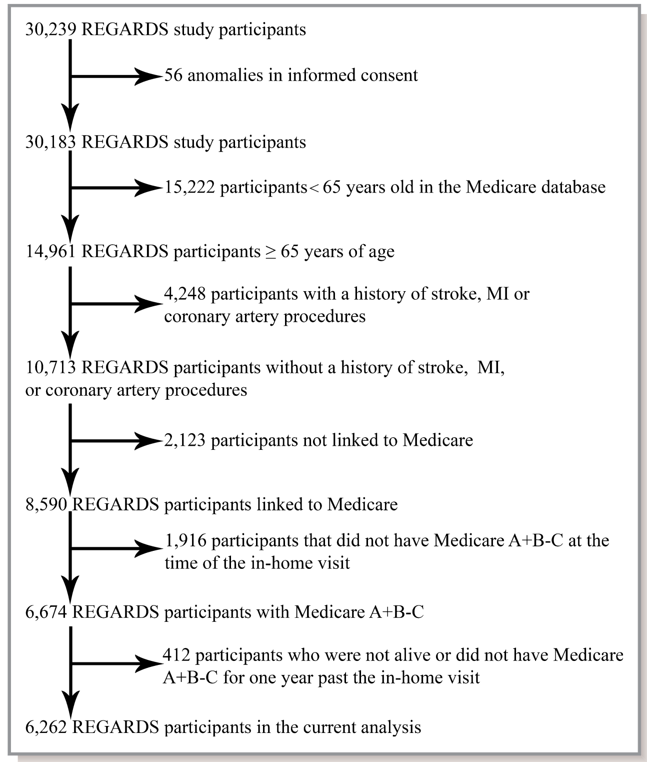

Figure. Flowchart showing the inclusion and exclusion criteria for the current analysis of Life's Simple 7 and healthcare utilization and expenditures among REGARDS study participants. BMI indicates body mass index; BP, blood pressure; MI, myocardial infarction; REGARDS, REasons for Geographic And Racial Differences in Stroke. See Xie et al[8] for additional details on the linkage of REGARDS study participant data with Medicare claims.

Life's Simple 7

Cardiovascular health at baseline was assessed using the American Heart Association's Life's Simple 7 (LS7) metric, which includes 7 factors: cigarette smoking, physical activity, diet, BMI, BP, cholesterol, and glucose. Current and former smoking status and time since smoking cessation for former smokers were assessed during the CATI. Physical activity was assessed through a single question administered during the CATI "How many times per week do you engage in intense physical activity, enough to work up a sweat?" with response options of none, 1 to 3 times per week, and 4 or more times per week. Using a self-administered Block 98 Food Frequency Questionnaire,[11] each participant recorded food intake in the year prior to his in-home visit. Dietary analysis was conducted

Table 1. Definitions of Life's Simple 7 Poor, Intermediate, and Ideal Health Factors for Adults

Metric	Definition		
	Poor Health	Intermediate Health	Ideal Health
Smoking	Yes	Former ≤12 months	Never or quit >12 months
BMI	≥30 kg/m^2	25 to 29.9 kg/m^2	<25 kg/m^2
Physical activity*	None	1 to 149 min/week moderate intensity or 1 to 74 min/week vigorous intensity or 1 to 149 min/week moderate+vigorous intensity	≥150 min/week moderate intensity or ≥75 min/week vigorous intensity or ≥150 min/week moderate+vigorous intensity
Healthy diet score†	0 to 1 Components	2 to 3 Components	4 to 5 Components
Total cholesterol	≥240 mg/dL	200 to 239 mg/dL or treated to the goal of <200 mg/dL	<200 mg/dL
Blood pressure	SBP ≥140 or DBP ≥90 mm Hg	SBP 120 to 139 or DBP 80 to 89 mm Hg or treated to the goal of a SBP <120 mm Hg and a DBP <80 mm Hg	SBP <120 mm Hg and DBP <80 mm Hg
Fasting glucose	≥126 mg/dL	100 to 125 mg/dL or treated to the goal of <100 mg/dL	<100 mg/dL

BMI indicates body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure.
*Modified for the REasons for Geographic And Racial Differences in Stroke (REGARDS) Study. Participants in REGARDS were asked "How many times per week do you engage in intense physical activity, enough to work up a sweat?" We defined ideal physical activity as a frequency of 4 or more times per week, intermediate as 1 to 3 times per week, and poor as none.
†Modified for REGARDS. Responses to the Block Food Frequency Questionnaire were used for the "healthy diet score" that is based on how many components of the 5 diet goals are met. Fruits and vegetables ≥4.5 cups/day; fish 3.5 ounces ≥2 servings/week; sodium <1500 mg/day; sweets/sugar-sweetened beverages ≤450 kcal/week; whole grains (1.1 g of fiber in 10 g of carbohydrates), 1-oz equivalent servings ≥3 servings/day.

by *NutritionQuest*. Using data from the Block 98 Food Frequency Questionnaire, we defined the diet score for the LS7 based on fish, fruit, and vegetable consumption and sodium, sugar, and fiber/carbohydrate ratio intake. BMI was calculated using height and weight measured with calibrated equipment during the in-home study visit. The average systolic and diastolic BP, based on 2 measurements taken during the in-home study visit, was used for all analyses. Total cholesterol and serum glucose were measured by colorimetric reflectance spectrophotometry using blood samples collected during the in-home study visit. The use of antihypertensive, glucose-lowering, and lipid-lowering medication was determined by self-report during the CATI. Table 1 provides the definitions of poor, intermediate, and ideal status for each of the LS7 factors.

Medicare Service Utilization and Expenditures

For the primary analysis, we used Medicare claims data for 1 year after each participant's REGARDS in-home study visit. Acute inpatient encounters and expenditures (ie, hospital expenses) were identified using claims in Medicare inpatient files. We used claims in the Medicare outpatient and carrier files to identify outpatient encounters and expenditures. CVD-related encounters (ie, inpatient and outpatient) and expenditures were defined as claims with the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) primary diagnosis codes 390 to 459 and 745 to 747.[1] We did not include skilled nursing facilities, home health, and hospice care expenditures, as these data have not been obtained for all REGARDS study participants. Also, we did not analyze medication expenditures because most REGARDS study participants did not have Medicare Part D prescription drug coverage at baseline, as this program did not start until 2006.

Statistical Analyses

We calculated the total number of ideal LS7 factors for each participant. Because only a small number of participants had 0 (N=77), 6 (N=48), or 7 (N=0) ideal LS7 factors, we grouped participants with 0 or 1 and, separately, 5, 6, or 7 ideal LS7 factors. Baseline characteristics were calculated by number of ideal LS7 factors. Trends in baseline characteristics across number of ideal LS7 factors were analyzed using logistic regression for binary variables and linear regression for continuous variables.

We calculated the percentage of participants with inpatient and outpatient encounters in the year following their baseline in-home visit by number of ideal LS7 factors. Calculations were performed separately for all-cause and CVD-related encounters. Poisson regression models with robust standard errors were used to estimate the relative risk (RR) and 95% CI for having any inpatient and outpatient encounters, and CVD-related inpatient and outpatient encounters, in the year following baseline associated with 2, 3, 4, and 5 to 7 versus 0 to 1 ideal LS7 factors.[12] In addition to the unadjusted model, we constructed a model including adjustment for age, race, sex, education, income, and marital status. RRs were estimated for the overall population and in analyses stratified by race and, separately, by sex. *P*-trends for any inpatient and outpatient encounters were calculated by modeling the number of ideal LS7 factors as an ordinal variable.

We calculated the mean all-cause and CVD-related inpatient, outpatient, and total (ie, inpatient plus outpatient) healthcare expenditures and 95% CI in the year following baseline among REGARDS study participants with 0 to 1, 2, 3, 4, and 5 to 7 ideal LS7 factors. Two-part regression models were used to estimate the mean cost difference for all-cause and CVD-related inpatient, outpatient, and total healthcare expenditures among participants with 2, 3, 4, and 5 to 7 versus 0 to 1 ideal LS7 factors. Specifically, part 1 incorporated a logistic regression determining the participant's probability of inpatient, outpatient, or both inpatient and outpatient expenditures; and in part 2, we ran a generalized linear model with a Γ distribution and log link to account for the skewed distribution of the expenditure data.[13,14] In addition to the unadjusted model, we conducted a model including multivariable adjustment for age, race, sex, education, income, and marital status. Mean cost differences were calculated for the overall population and stratified by race and, separately, by sex. *P*-trends for mean cost differences were calculated by modeling the number of ideal LS7 factors as an ordinal variable. In a sensitivity analysis, annualized all-cause and CVD-related inpatient, outpatient, and total healthcare expenditures were calculated using all available claims from baseline through participants' death, loss of Medicare fee-for-service coverage, or December 31, 2013, whichever occurred first. Next, we estimated the reduction in inpatient, outpatient, and total expenditures if all fee-for-service Medicare beneficiaries ≥65 years of age had 5 to 7 ideal LS7 factors. First, we calculated inpatient and outpatient expenditures attributable to participants having 0 to 1, 2, 3, and 4 versus 5 to 7 ideal LS7 factors in the REGARDS study. For example, inpatient expenditures attributable to participants having 0 to 1 versus 5 to 7 ideal LS7 factors was calculated as the mean inpatient cost among participants with 0 to 1 ideal LS7 factors minus the mean inpatient cost among participants with 5 to 7 ideal LS7 factors, multiplied by the number of participants with 0 to 1 ideal LS7 factors. Second, we divided expenditures attributable to participants having 0 to 1, 2, 3, and 4 versus 5 to 7 ideal LS7 factors by the sum of all expenditures to calculate the attributable inpatient and outpatient cost percentage. Third, we calculated inpatient, outpatient, and total expenditures in 2014 for all Medicare beneficiaries ≥65 years of age without a history of CVD who had fee-for-service coverage for the entire calendar year using a 5% random sample. These costs were multiplied by 20 to estimate costs for 100% versus 5% of Medicare beneficiaries. Fourth, we multiplied 2014 Medicare inpatient and outpatient expenditures by the attributable inpatient and outpatient cost percentage from REGARDS to estimate the potential reduction in these expenditures if all fee-for-service beneficiaries ≥65 years of age without a history of CVD had 5 to 7 ideal LS7 factors. Potential reductions in Medicare inpatient and outpatient expenditures were summed to estimate the potential reduction in total Medicare expenditures in 2014. Bootstrapping was used to calculate 95% CIs. To account for inflation, all healthcare expenditures were adjusted to third quarter 2015 US dollars (USD) using price indices for the gross domestic product.[15]

All analyses were conducted using multiple imputation in order to include REGARDS participants with missing data on income (N=874), education (N=3), and LS7 factors, including BMI (N=33), physical activity (N=114), diet (N=1403), total cholesterol (N=236), blood pressure (N=15), and fasting glucose (N=1075). Multiple imputation was conducted using chained equations to obtain 15 imputed data sets for each outcome of interest, separately.[16,17] All analyses were performed in Stata 13 (Stata Corp, College Station, TX) using a 2-sided level of significance of $\alpha<0.05$.

Results

Participant Characteristics

Overall, 17.2%, 31.1%, 29.0%, 16.4%, and 6.4% of participants had 0 to 1, 2, 3, 4, and 5 to 7 ideal LS7 factors, respectively. Participants with more ideal LS7 factors were older and less likely to be women, black, have an annual income less than $20 000, less than a high school education, and be unmarried (Table 2).

Health Service Utilization

Participants with more ideal LS7 factors were less likely to have all-cause and CVD-related inpatient encounters, and CVD-related outpatient encounters in the year following their in-home study visit (Table 3). The vast majority (>95%) of participants had an all-cause outpatient encounter regardless of the number of ideal LS7 factors. After multivariable adjustment, having more ideal LS7 factors was associated with a lower risk for having all-cause and CVD-related inpatient encounters and CVD-related outpatient encounters. There was no association between the number of ideal LS7 factors and having an all-cause outpatient encounter after multivariable adjustment. Results were similar for whites and blacks and men and women analyzed separately (Table S1). For example, the RR (95% CI) for an inpatient encounter associated with 5 to 7 versus 0 to 1 LS7 factors was 0.58

Table 2. Characteristics of REGARDS Participants ≥65 Years of Age Included in the Current Analysis by Number of Ideal Life's Simple 7 Factors

Characteristics of Participants With Dietary Data	Number of Ideal Life's Simple 7 Factors* 0 to 1 N=1079 (17.2%)	2 N=1947 (31.1%)	3 N=1814 (29.0%)	4 N=1024 (16.4%)	5 to 7 N=398 (6.4%)	*P* Trend†
Age, y (SE)	71.8 (0.17)	72.0 (0.13)	72.6 (0.14)	73.0 (0.20)	72.6 (0.30)	<0.001
Women	64.2%	57.8%	52.3%	51.9%	47.7%	<0.001
Black race	44.9%	36.2%	29.2%	20.9%	12.8%	<0.001
Annual income <$20 000	31.7%	22.6%	20.8%	18.0%	14.0%	<0.001
Less than a high school education	21.2%	15.2%	10.6%	8.9%	5.3%	<0.001
Unmarried	50.7%	44.4%	42.7%	38.4%	39.3%	<0.001

Values are expressed as percentage or mean (SE). The absolute number of participants in each category of Life's Simple 7 factors was calculated as the average across multiple imputations and rounded to the closest integer number. REGARDS indicates REasons for Geographic And Racial Differences in Stroke; SE, standard error.
*Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose, and ideal levels are defined in Table 1.
†*P*-trends on baseline characteristics across the number of ideal Life's Simple 7 factors were calculated using logistic regression for binary variables and linear regression for continuous variables.

(0.41, 0.83) for whites, 0.32 (0.08, 1.36) for blacks, 0.53 (0.32, 0.86) for men, and 0.57 (0.36, 0.91) for women.

Healthcare Expenditures

Participants with more ideal LS7 factors had lower mean all-cause inpatient, outpatient, and total expenditures in the year following baseline (Table 4). These associations remained present after multivariable adjustment. CVD-related inpatient, outpatient, and total expenditures were lower among participants with more ideal LS7 factors in unadjusted and multivariable-adjusted analyses (Table 5). Having more LS7 factors was associated with lower overall and CVD inpatient and outpatient expenditures among blacks and whites and

Table 3. Relative Risks and 95% Confidence Intervals for All-Cause and Cardiovascular Disease–Related Inpatient and Outpatient Encounters Over 1 Year of Follow-Up by Number of Ideal Life's Simple 7 Factors

	Number of Ideal Life's Simple 7 Factors* 0 to 1 (N=1079)	2 (N=1947)	3 (N=1814)	4 (N=1024)	5 to 7 (N=398)	*P* Trend
All-cause encounters						
Inpatient, N (%)	197 (18.3%)	308 (15.8%)	234 (12.9%)	132 (12.9%)	41 (10.3%)	—
Unadjusted, RR (95% CI)	1.00 (Ref)	0.86 (0.71, 1.03)	0.70 (0.58, 0.83)	0.69 (0.56, 0.86)	0.55 (0.40, 0.77)	<0.001
Adjusted, RR (95% CI)	1.00 (Ref)	0.86 (0.72, 1.03)	0.69 (0.57, 0.82)	0.67 (0.54, 0.83)	0.55 (0.39, 0.76)	<0.001
Outpatient, N (%)	1045 (96.8%)	1876 (96.4%)	1760 (97.0%)	982 (95.9%)	390 (97.8%)	—
Unadjusted, RR (95% CI)	1.00 (Ref)	1.00 (0.98, 1.01)	1.00 (0.99, 1.02)	0.99 (0.97, 1.01)	1.01 (0.99, 1.03)	0.871
Adjusted, RR (95% CI)	1.00 (Ref)	0.99 (0.98, 1.01)	1.00 (0.98, 1.01)	0.98 (0.96, 1.00)	1.00 (0.98, 1.02)	0.407
CVD-related encounters†						
Inpatient, N (%)	56 (5.2%)	96 (4.9%)	74 (4.1%)	46 (4.5%)	6 (1.6%)	—
Unadjusted, RR (95% CI)	1.00 (Ref)	0.94 (0.67, 1.32)	0.78 (0.55, 1.11)	0.85 (0.57, 1.26)	0.29 (0.12, 0.70)	0.007
Adjusted, RR (95% CI)	1.00 (Ref)	0.96 (0.68, 1.35)	0.79 (0.55, 1.13)	0.85 (0.57, 1.28)	0.31 (0.13, 0.73)	0.010
Outpatient, N (%)	791 (73.3%)	1314 (67.5%)	1164 (64.2%)	592 (57.8%)	167 (41.9%)	—
Unadjusted, RR (95% CI)	1.00 (Ref)	0.92 (0.87, 0.97)	0.87 (0.83, 0.92)	0.79 (0.73, 0.84)	0.57 (0.50, 0.65)	<0.001
Adjusted, RR (95% CI)	1.00 (Ref)	0.93 (0.89, 0.98)	0.90 (0.85, 0.94)	0.81 (0.75, 0.87)	0.60 (0.53, 0.68)	<0.001

Raw values were calculated for the unadjusted model; the estimated adjusted values were based on inclusion of age, race, sex, education, income, and marital status. The absolute number of participants and the number of participants with inpatient and outpatient encounters in each category of Life's Simple 7 factors was calculated as the average across multiple imputations and rounded to the closest integer number. CI indicates confidence interval; CVD, cardiovascular disease; RR, relative risk.
*Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose and ideal levels are defined in Table 1.
†CVD-related healthcare encounters were defined as claims with the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) primary diagnosis codes 390 to 459 and 745 to 747.

Table 4. Mean Cost and Cost Differences for All-Cause Expenditures Over 1 Year of Follow-Up by Number of Ideal Life's Simple 7 Factors

Expenditures	Number of Ideal Life's Simple 7 Factors*					*P* Trend
	0 to 1 (N=1079)	2 (N=1947)	3 (N=1814)	4 (N=1024)	5 to 7 (N=398)	
Inpatient, N (%)	197 (18.3%)	308 (15.8%)	234 (12.9%)	132 (12.9%)	41 (10.3%)	—
Mean cost (95% CI)	$3995 ($2944, $5047)	$2799 ($2237, $3361)	$2402 ($1805, $2998)	$2140 ($1623, $2656)	$1250 ($760, $1740)	—
Unadjusted mean cost difference (95% CI)	$0 (Ref)	−$1197 (−$2302, −$91)	−$1594 (−$2702, −$486)	−$1856 (−$3001, −$711)	−$2745 (−$3894, −$1596)	<0.001
Adjusted mean cost difference (95% CI)	$0 (Ref)	−$1119 (−$2152, −$87)	−$1471 (−$2518, −$424)	−$1730 (−$2840, −$621)	−$2551 (−$3667, −$1435)	<0.001
Outpatient, N (%)	1045 (96.8%)	1876 (96.4%)	1760 (97.0%)	982 (95.9%)	390 (97.8%)	—
Mean cost (95% CI)	$5166 ($4626, $5706)	$4310 ($3972, $4648)	$3737 ($3479, $3996)	$3652 ($3313, $3990)	$2853 ($2423, $3282)	—
Unadjusted mean cost difference (95% CI)	$0 (Ref)	−$856 (−$1449, −$264)	−$1428 (−$1998, −$859)	−$1514 (−$2137, −$891)	−$2313 (−$2982, −$1645)	<0.001
Adjusted mean cost difference (95% CI)	$0 (Ref)	−$891 (−$1495, −$287)	−$1479 (−$2060, −$898)	−$1639 (−$2276, −$1002)	−$2410 (−$3089, −$1731)	<0.001
Total, N (%)	1045 (96.8%)	1876 (96.4%)	1760 (97.0%)	982 (95.9%)	390 (97.8%)	—
Mean cost (95% CI)	$9147 ($7752, $10 542)	$7117 ($6338, $7896)	$6149 ($5402, $6897)	$5771 ($5031, $6511)	$4111 ($3328, $4894)	—
Unadjusted mean cost difference (95% CI)	$0 (Ref)	−$2030 (−$3527, −$533)	−$2998 (−$4463, −$1532)	−$3376 (−$4896, −$1856)	−$5036 (−$6599, −$3474)	<0.001
Adjusted mean cost difference (95% CI)	$0 (Ref)	−$2002 (−$3483, −$520)	−$2919 (−$4384, −$1454)	−$3504 (−$5028, −$1980)	−$5016 (−$6577, −$3454)	<0.001

Expenditures were adjusted to third quarter 2015 US dollars using price indices for the GDP. Adjusted mean cost differences include adjustment for age, race, sex, education, income, and marital status. The absolute number of participants and the number of participants with inpatient, outpatient, and total encounters in each category of Life's Simple 7 factors was calculated as the average across multiple imputations and rounded to the closest integer number. CI indicates confidence interval; GDP, gross domestic product; SE, standard error. Separate imputations were conducted for inpatient, outpatient and total expenditures. Therefore, inpatient and outpatient expenditures do not sum exactly to the total expenditures.

*Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose, and ideal levels are listed in Table 1.

Table 5. Mean Cost and Cost Differences for Cardiovascular Disease Expenditures Over 1 Year of Follow-Up by Number of Ideal Life's Simple 7 Factors

Expenditures	Number of Ideal Life's Simple 7 Factors*					*P* Trend
	0 to 1 (N=1079)	2 (N=1947)	3 (N=1814)	4 (N=1024)	5 to 7 (N=398)	
Inpatient, N (%)	56 (5.2%)	96 (4.9%)	74 (4.1%)	46 (4.5%)	6 (1.6%)	—
Mean cost (95% CI)	$988 ($640, $1337)	$890 ($632, $1148)	$688 ($467, $910)	$627 ($393, $861)	$174 ($6, $343)	—
Unadjusted mean cost difference (95% CI)	$0 (Ref)	−$98 (−$539, $342)	−$300 (−$717, $117)	−$362 (−$798, $75)	−$814 (−$1220, −$409)	0.003
Adjusted mean cost difference (95% CI)	$0 (Ref)	−$140 (−$583, $303)	−$349 (−$776, $79)	−$397 (−$848, $53)	−$827 (−$1253, −$400)	0.002
Outpatient, N (%)	791 (73.3%)	1314 (67.5%)	1164 (64.2%)	592 (57.8%)	167 (41.9%)	—
Mean cost (95% CI)	$617 ($516, $718)	$509 ($447, $570)	$482 ($415, $549)	$398 ($332, $464)	$249 ($163, $335)	—
Unadjusted mean cost difference (95% CI)	$0 (Ref)	−$108 (−$226, $10)	−$135 (−$251, −$19)	−$219 (−$342, −$96)	−$368 (−$497, −$239)	<0.001
Adjusted mean cost difference (95% CI)	$0 (Ref)	−$116 (−$241, $9)	−$145 (−$267, −$22)	−$238 (−$368, −$107)	−$368 (−$506, −$229)	<0.001
Total,† N (%)	791 (73.3%)	1314 (67.5%)	1164 (64.2%)	592 (57.8%)	167 (41.9%)	—
Mean cost (95% CI)	$1602 ($1184, $2020)	$1403 ($1102, $1703)	$1168 ($908, $1429)	$1024 ($741, $1307)	$423 ($210, $636)	—
Unadjusted mean cost difference (95% CI)	$0 (Ref)	−$199 (−$714, $316)	−$433 (−$922, $55)	−$578 (−$1103, −$53)	−$1179 (−$1664, −$694)	<0.001
Adjusted mean cost difference (95% CI)	$0 (Ref)	−$298 (−$847, $251)	−$553 (−$1081, −$25)	−$709 (−$1271, −$147)	−$1234 (−$1771, −$697)	<0.001

Expenditures were adjusted to third quarter 2015 US dollars using price indices for the GDP. Adjusted mean cost differences include adjustment for age, race, sex, education, income, and marital status. The absolute number participants and the number of participants with inpatient, outpatient, and total encounters in each category of Life's Simple 7 factors was calculated as the average across multiple imputations and rounded to the closest integer number. CI indicates confidence interval; GDP, gross domestic product. Separate imputations were conducted for inpatient, outpatient and total expenditures. Therefore, inpatient and outpatient expenditures do not sum exactly to the total expenditures.
*Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose, and ideal levels are listed in Table 1.
†All participants included for calculation of total healthcare expenditures had an outpatient encounter.

men and women (Tables S2 and S3). For example, when participants with 5 to 7 are compared to those with 0 to 1 LS7 factors, adjusted mean cost differences (95% CI) for inpatient expenditures were −\$2067 (−\$3135, −\$999) for whites and −\$4114 (−\$6382, −\$1846) for blacks, −\$2014 (−\$3590, −\$438) for men and −\$2666 (−\$4189, −\$1143) for women.

Sensitivity Analysis

On the basis of all available Medicare claims after baseline (median follow-up 6.9 years; maximum follow-up 9.9 years), having more ideal LS7 factors was associated with lower all-cause and CVD-related inpatient, outpatient, and total healthcare expenditures (Tables S4 and S5). Having more ideal LS7 factors was associated with lower all-cause and CVD-related inpatient, outpatient, and total healthcare expenditures among blacks and whites and men and women (Tables S6 and S7).

Potential Cost Reduction Associated With Population-Wide Achievement of 5 to 7 LS7 Factors

Inpatient, outpatient, and total expenditures for Medicare beneficiaries ≥65 years old without CVD and with fee-for-service coverage in 2014 Medicare were 35.9, 73.9, and 109.8 billion USD, respectively (Table S8). The percentage of these expenditures attributable to not having 5 to 7 ideal LS7 factors for inpatient, outpatient, and total annual expenditures was 53.4%, 29.7%, and 37.5%, respectively. The potential annualized cost reductions were 19.2, 22.0, and 41.2 billion USD for inpatient, outpatient, and total expenditures, respectively, if all Medicare beneficiaries had 5 to 7 LS7 factors.

Discussion

In the current study of older, community-dwelling US adults, having a higher number of ideal LS7 factors was associated with lower risk for all-cause and CVD-related inpatient encounters. Having more ideal LS7 factors was not associated with all-cause outpatient encounters but was associated with lower risk for CVD-related outpatient encounters. Additionally, participants with more ideal LS7 factors had lower all-cause and CVD-related inpatient, outpatient, and total healthcare expenditures. Better cardiovascular health defined by the LS7 score was associated with lower risk for all-cause and CVD-related inpatient encounters, CVD-related outpatient encounters, and lower all-cause and CVD-related expenditures. Extension of estimates from the REGARDS study to all Medicare beneficiaries with fee-for-service coverage and no previous history of CVD demonstrated that having fewer than 5 to 7 ideal LS7 factors accounted for more than half of inpatient costs and ~30% of outpatient costs. Furthermore, we estimated that the achievement of ideal levels for 5 to 7 LS7 factors for the entire Medicare population could result in a total potential annualized cost reduction of 41.2 billion USD. The potential cost reduction associated with achieving 5 to 7 ideal LS7 factors is likely to be much greater, as we only considered inpatient and outpatient expenditures and restricted this analysis to beneficiaries with Medicare fee-for-service for the entire 2014 calendar year.

Cardiovascular health extends the concept of CVD beyond clinically evident disease and provides a framework for primordial prevention, including population-level and high-risk prevention approaches. Prior studies highlight the importance of cardiovascular health for disease prevention.[18,19] For example, in the Atherosclerosis Risk in Communities study, there was a graded association with lower risk for incident CVD among participants with progressively more ideal LS7 factors. The hazard ratio for incident CVD comparing participants with 5 and 6 versus 0 ideal LS7 factors was 0.18 (95% CI 0.14-0.23) and 0.11 (95% CI 0.07-0.17), respectively.[20] Better cardiovascular health assessed by LS7 has also been associated with lower risks for several other outcomes including mortality,[21-23] ESRD,[24] stroke,[25] cognitive impairment,[26] diabetes,[27] heart failure,[18] and cancer.[28] The current study extends these prior findings and demonstrates lower healthcare utilization and expenditures associated with having more ideal LS7 factors in a population free of CVD.

LS7 is being used by the AHA to track the cardiovascular health of the US population. When LS7 was introduced, the AHA statistics committee estimated a low prevalence of ideal factors including 73% for smoking, 45% for physical activity, less than 1% for diet, 33% for BMI, 42% for BP, 45% for total cholesterol, and 58% for glucose.[29] Additionally, in 2005-2006, only 18% of US adults had 6 or 7 ideal LS7 factors.[1] Prior studies have estimated that 70% of CVD can be averted through the prevention of risk factors, including those that comprise LS7.[23] Given the low prevalence of many LS7 factors, there is a tremendous opportunity to reduce not only CVD but also healthcare utilization and expenditures through population-wide improvements aimed at improving cardiovascular health.

The association of individual CVD risk factors with healthcare expenditures has been evaluated in prior studies.[30-36] Having low CVD risk in middle age was associated with Medicare expenditures later in life among 279 men and 298 women in the Chicago Heart Association Detection Project.[36] Both men and women with low CVD risk (defined by systolic BP/diastolic BP <120/80 mm Hg, serum cholesterol <200 mg/dL, not currently smoking, no electrocardiographic abnormalities, no history of diabetes, and no history of MI) had lower all-cause and CVD expenditures compared with their counterparts with higher CVD risk. In the Framingham

Heart Study the association of cigarette smoking, systolic BP, and serum cholesterol with Medicare expenditures was examined among 1053 participants who attended the Exam 17 cycle in 1984-1985. A graded association was present between having more CVD risk factors and higher Medicare expenditures in the 2 years following the examination. These studies were conducted using risk factor data collected in the 1960s and 1980s with cost data available from the 1980s and 1990s.

A few studies have examined cardiovascular health profiles and healthcare costs and resource utilization.[37,38] In the Cooper Center Longitudinal Study, investigators evaluated the association between midlife cardiovascular health and later-life health care costs. In that single-center cohort, which consisted predominantly of well-educated whites, having more ideal cardiovascular health components in middle age was associated with lower non-CVD and CVD healthcare costs in later life.[38] Valero-Elizondo and colleagues used the 2012 Medical Expenditure Panel Survey to examine cardiovascular risk profiles and associated healthcare expenditures and resource utilization.[37] In that cohort of US adults with a mean age of 58.5 years, they found that a favorable cardiovascular risk profile was associated with lower healthcare expenditures and utilization.

The current analysis was restricted to older adults, a population that accounts for a disproportionate amount of healthcare resources.[39] With the population over 65 years of age in the United States projected to double over the next 25 years,[40] there is an emphasis on meeting population health goals and reducing the economic impact of healthcare expenditures, particularly in the Medicare program. An array of strategies have emerged to control the growth of healthcare costs and improve quality, including public reporting, pay for performance, accountable care organizations, bundled payments, and value-based insurance design.[41,42]

Alongside these strategies, the data from the current study highlight potential economic benefits of improving cardiovascular health among older adults. Participants in the current study had similar insurance and access to health services. This demonstrates that even when access to health services is present, there are large differences in healthcare expenditures that appear to be related to behavioral and behavior-related factors such as those that compose LS7. This finding is similar to that of Chetty and colleagues, who examined the association between income and life expectancy in the United States. They found that major explanations of differences in mortality by income were lifestyle behaviors, not health care access or environmental factors.[43] Moreover, randomized controlled trials have demonstrated the benefits of multifaceted interventions (eg, smoking cessation, diet, and exercise) on improvements in risk factors and CVD risk.[44,45] Given the substantially higher healthcare utilization and costs among participants with worse cardiovascular health, the benefits of these interventions may extend to reduced healthcare utilization and costs. These results have broader implications for stakeholders to focus on population behaviors for improving health and reducing costs rather than changes in access to health services and insurance plan design.

The current study has several strengths. The REGARDS study enrolled a large sample of white and black adults from across the United States and included broad data collection allowing the assessment of cardiovascular health. Additionally, the linkage with Medicare claims allowed for the analysis of data on healthcare utilization and expenditures.[8] However, the current analysis has several known and potential limitations. The current analysis was restricted to adults ≥65 years of age who live in community settings and not nursing homes. Although REGARDS participants ≥65 years have been shown to be representative of older community-dwelling Medicare beneficiaries, the results of the current study may have limited generalizability to younger adults and nursing home residents.[8] Data on diet were missing for a substantial percentage of study participants. Also, there is the possible misclassification of participants as LS7 factors were assessed on a single occasion. It is possible that better cardiovascular health is associated with other health behaviors not measured in the REGARDS study, and causal inferences should be made with caution.

In conclusion, more favorable cardiovascular health was associated with lower overall and CVD-related inpatient encounters and CVD-related outpatient encounters in this large national sample of black and white older adults. Additionally, better cardiovascular health was associated with lower inpatient, outpatient, and total healthcare expenditures. Improving cardiovascular health has the potential to reduce healthcare utilization and expenditures among US adults.

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None.

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Supplemental Table 1. Adjusted relative risks for all-cause and cardiovascular disease-related inpatient and outpatient encounters over one year of follow-up by number of ideal Life's Simple 7 factors, stratified by race and by sex.

	Number of ideal Life's Simple 7 factors†					
	0-1	2	3	4	5-7	p-trend
All-cause Encounters						
Inpatient						
Blacks, RR (95% CI)	1.00 (ref)	0.91 (0.68, 1.21)	0.61 (0.43, 0.87)	0.65 (0.42, 1.01)	0.32 (0.08, 1.36)	0.001
Whites, RR (95% CI)	1.00 (ref)	0.84 (0.67, 1.05)	0.72 (0.58, 0.91)	0.68 (0.53, 0.88)	0.58 (0.41, 0.83)	<0.001
Men, RR (95% CI)	1.00 (ref)	0.97 (0.72, 1.31)	0.69 (0.51, 0.93)	0.69 (0.49, 0.96)	0.53 (0.32, 0.86)	<0.001
Women, RR (95% CI)	1.00 (ref)	0.79 (0.62, 1.00)	0.70 (0.55, 0.89)	0.67 (0.49, 0.90)	0.57 (0.36, 0.91)	0.001
Outpatient						
Blacks, RR (95% CI)	1.00 (ref)	0.98 (0.95, 1.00)	0.99 (0.96, 1.01)	0.95 (0.91, 1.00)	0.98 (0.90, 1.06)	0.077
Whites, RR (95% CI)	1.00 (ref)	1.01 (0.99, 1.02)	1.01 (0.99, 1.03)	1.00 (0.98, 1.02)	1.02 (1.00, 1.04)	0.394
Men, RR (95% CI)	1.00 (ref)	0.99 (0.96, 1.03)	1.00 (0.97, 1.03)	0.98 (0.94, 1.02)	1.00 (0.97, 1.04)	0.691
Women, RR (95% CI)	1.00 (ref)	0.99 (0.98, 1.01)	1.00 (0.99, 1.01)	0.99 (0.97, 1.00)	1.00 (0.99, 1.02)	0.628
CVD-Related Encounters††						
Inpatient						
Blacks, RR (95% CI)	1.00 (ref)	0.94 (0.58, 1.54)	0.66 (0.37, 1.20)	0.76 (0.37, 1.56) ‡		0.210
Whites, RR (95% CI)	1.00 (ref)	1.02 (0.63, 1.65)	0.89 (0.56, 1.43)	0.73 (0.45, 1.19) ‡		0.093

Men, RR (95% CI)	1.00 (ref)	1.53 (0.85, 2.78)	1.16 (0.62, 2.14)	1.18 (0.61, 2.30)	0.19 (0.03, 1.10)	0.041
Women, RR (95% CI)	1.00 (ref)	0.75 (0.48, 1.16)	0.66 (0.42, 1.06)	0.76 (0.44, 1.30)	0.47 (0.16, 1.33)	0.100
Outpatient						
Blacks, RR (95% CI)	1.00 (ref)	0.96 (0.90, 1.03)	0.92 (0.86, 1.00)	0.85 (0.76, 0.96)	0.76 (0.58, 0.98)	<0.001
Whites, RR (95% CI)	1.00 (ref)	0.91 (0.85, 0.98)	0.88 (0.82, 0.94)	0.79 (0.72, 0.86)	0.57 (0.49, 0.65)	<0.001
Men, RR (95% CI)	1.00 (ref)	0.88 (0.80, 0.97)	0.88 (0.81, 0.97)	0.80 (0.72, 0.89)	0.63 (0.53, 0.75)	<0.001
Women, RR (95% CI)	1.00 (ref)	0.97 (0.91, 1.03)	0.90 (0.85, 0.96)	0.82 (0.75, 0.89)	0.56 (0.47, 0.68)	<0.001

† Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose and ideal levels are defined in Table 1.

†† CVD-related healthcare encounters were defined as claims with the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) primary diagnosis codes 390 to 459 and 745 to 747.

‡ There were few black participants with 5-7 ideal Life's Simple 7 factors included in the analysis (n=51), and there were no hospitalizations in this group over one year of follow-up. Therefore, participants with 4 and 5-7 ideal Life's Simple 7 factors were combined for analyses of cardiovascular disease inpatient encounters by race.

CI: confidence interval; CVD: cardiovascular disease; RR: relative risk

All models include adjustment for age, education, income, and marital status. Models stratified by race also adjust for sex. Models stratified by sex also adjust for race.

Supplemental Table 2. Adjusted mean cost differences for all-cause expenditures over one year of follow-up by number of ideal Life's Simple 7 factors, stratified by race and by sex

	Number of ideal Life's Simple 7 factors†					
Expenditures	**0-1**	**2**	**3**	**4**	**5-7**	**p-trend**
Inpatient						
Adjusted mean cost difference (95% CI), stratified by race and by sex						
Blacks	$0 (ref)	-$1,201 (-$3,442, $1,040)	-$2,112 (-$4,456, $232)	-$2,246 (-$4,839, $347)	-4,114 (-6,382, -1,846)	0.020
Whites	$0 (ref)	-$894 (-$1,914, $127)	-$1,121 (-$2,123, -$120)	-$1,472 (-$2,525, -$419)	-$2,067 (-$3,135, -$999)	<0.001
Men	$0 (ref)	-$310 (-$1,850, $1,230)	-$652 (-$2,157, $854)	-$1,121 (-$2,717, $476)	-$2,014 (-$3,590, -$438)	0.023
Women	$0 (ref)	-$1,434 (-$2,730, -$137)	-$1,856 (-$3,196, -$515)	-$1,978 (-$3,389, -$568)	-$2,666 (-$4,189, -$1,143)	0.001
Outpatient						
Adjusted mean cost difference (95% CI), stratified by race and by sex						
Blacks	$0 (ref)	-$689 (-$1,732, $353)	-$1,533 (-$2,553, -$514)	-$1,921 (-$3,083, -$760)	-$2,470 (-$4,055, -$886)	<0.001
Whites	$0 (ref)	-$1,029 (-$1,822, -$236)	-$1,490 (-$2,231, -$749)	-$1,597 (-$2,395, -$799)	-$2,444 (-$3,252, -$1,636)	<0.001
Men	$0 (ref)	-$1,134 (-$2,114, -$155)	-$1,510 (-$2,439, -$581)	-$1,703 (-$2,698, -$707)	-$2,501 (-$3,544, -$1,459)	<0.001
Women	$0 (ref)	-$793 (-$1,578, -$9)	-$1,527 (-$2,287, -$767)	-$1,710 (-$2,537, -$883)	-$2,485 (-$3,399, -$1,571)	<0.001
Total						
Adjusted mean cost difference (95% CI), stratified by race and by sex						

Blacks	$0 (ref)	-$1,829 (-$4,744, $1,086)	-$3,547 (-$6,589, -$506)	-$4,162 (-$7,364, -$959)	-$6,536 (-$9,964, -$3,108)	0.001
Whites	$0 (ref)	-$1,979 (-$3,625, -$333)	-$2,591 (-$4,156, -$1,025)	-$3,214 (-$4,854, -$1,573)	-$4,621 (-$6,258, -$2,984)	<0.001
Men	$0 (ref)	-$1,503 (-$3,849, $843)	-$2,047 (-$4,318, $224)	-$2,888 (-$5,241, -$536)	-$4,577 (-$6,978, -$2,176)	<0.001
Women	$0 (ref)	-$2,237 (-$4,104, -$369)	-$3,411 (-$5,285, -$1,538)	-$3,869 (-$5,836, -$1,902)	-$5,253 (-$7,308, -$3,199)	<0.001

† Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose and ideal levels are listed in Table 1.

CI: confidence interval; GDP: gross domestic product.

Expenditures were adjusted to 3rd quarter 2015 US dollars using price indices for the GDP.

Numbers in the table represent adjusted mean cost difference (95% confidence intervals)

All models adjust for age, education, income, and marital status. Models stratified by race also adjust for sex. Models stratified by sex also adjust for race.

Separate imputations were conducted for inpatient, outpatient and total expenditures. Therefore, inpatient and outpatient expenditures do not sum exactly to the total expenditures.

Supplemental Table 3. Adjusted mean cost differences for cardiovascular disease expenditures over one year of follow-up by number of ideal Life's Simple 7 factors, stratified by race and by sex

	Number of ideal Life's Simple 7 factors†					
Expenditures	**0-1**	**2**	**3**	**4**	**5-7**	**p-trend**
Inpatient						
Adjusted mean cost difference (95% CI), stratified by race and by sex						
Blacks	$0 (ref)	-$144 (-$966, $678)	-$535 (-$1,345, $275)	-$432 (-$1,372, $509) ††		0.201
Whites	$0 (ref)	-$125 (-$661, $411)	-$271 (-$786, $245)	-$507 (-$1,005, -$9) ††		0.012
Men	$0 (ref)	$371 (-$370, $1,113)	$177 (-$515, $868)	-$94 (-$782, $594)	-$675 (-$1,294, -$57)	0.080
Women	$0 (ref)	-$339 (-$832, $154)	-$553 (-$1,021, -$84)	-$451 (-$977, $75)	-$744 (-$1,283, -$205)	0.015
Outpatient						
Adjusted mean cost difference (95% CI), stratified by race and by sex						
Blacks	$0 (ref)	-$238 (-$415, -$60)	-$294 (-$479, -$110)	-$303 (-$525, -$82)	-$492 (-$757, -$227)	<0.001
Whites	$0 (ref)	-$16 (-$176, $144)	-$35 (-$181, $112)	-$156 (-$307, -$5)	-$279 (-$435, -$123)	0.001
Men	$0 (ref)	$56 (-$119, $231)	-$46 (-$212, $119)	-$100 (-$280, $81)	-$287 (-$459, -$115)	0.004
Women	$0 (ref)	-$200 (-$360, -$41)	-$174 (-$337, -$11)	-$297 (-$465, -$130)	-$373 (-$581, -$165)	<0.001
Total						
Adjusted mean cost difference (95% CI), stratified by race and by sex						

Blacks	$0 (ref)	-$488 (-$1,544, $568)	-$952 (-$1,994, $89)	-$680 (-$1,992, $632)	-$1,613 (-$2,889, -$337)	0.060
Whites	$0 (ref)	-$160 (-$783, $464)	-$328 (-$913, $258)	-$618 (-$1,221, -$14)	-$1,042 (-$1,614, -$470)	0.001
Men	$0 (ref)	$519 (-$333, $1,372)	$156 (-$571, $882)	-$218 (-$987, $552)	-$921 (-$1,573, -$269)	0.030
Women	$0 (ref)	-$611 (-$1,249, $26)	-$783 (-$1,416, -$149)	-$804 (-$1,486, -$123)	-$1,160 (-$1,904, -$415)	0.002

† Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose and ideal levels are listed in Table 1.

†† There were few black participants with 5-7 ideal Life's Simple 7 factors included in the analysis (N=51). No hospitalizations occurred among blacks with 5-7 ideal Life's Simple 7 factors over one year of follow-up. Therefore, participants with 4 and 5-7 ideal Life's Simple 7 factors were combined for analyses of cardiovascular disease inpatient expenditures by race.

CI: confidence interval; GDP: gross domestic product.

Expenditures were adjusted to 3rd quarter 2015 US dollars using price indices for the GDP.

Numbers in the table represent adjusted mean cost difference (95% confidence intervals)

All models adjust for age, education, income, and marital status. Models stratified by race also adjust for sex. Models stratified by sex also adjust for race.

Separate imputations were conducted for inpatient, outpatient and total expenditures. Therefore, inpatient and outpatient expenditures do not sum exactly to the total expenditures.

Supplemental Table 4. Mean annualized cost and annualized cost differences for all-cause expenditures over the entire follow-up by number of ideal Life's Simple 7 factors.

	Number of ideal Life's Simple 7 factors†					
Expenditures	**0-1 (N=1,079)**	**2 (N=1,947)**	**3 (N=1,814)**	**4 (N=1,024)**	**5-7 (N=398)**	**p-trend**
Inpatient, N (%)	634 (58.8%)	1,103 (56.7%)	969 (53.4%)	532 (51.9%)	198 (46.6%)	-
Mean cost (95% CI)	$5,506 ($4,665, $6,347)	$4,092 ($3,611, $4,573)	$3,603 ($3,163, $4,042)	$3,156 ($2,714, $3,598)	$3,281 ($1,990, $4,572)	-
Unadjusted mean cost difference (95% CI)	$0 (ref)	-$1,414 (-$2,385, -$443)	-$1,904 (-$2,861, -$946)	-$2,350 (-$3,341, -$1,359)	-$2,226 (-$3,438, -$1,013)	<0.001
Adjusted mean cost difference (95% CI)	$0 (ref)	-$1,431 (-$2,315, -$547)	-$1,877 (-$2,759, -$994)	-$2,333 (-$3,252, -$1,413)	-$2,251 (-$3,370, -$1,132)	<0.001
Outpatient, N (%)	1,070 (99.1%)	1,933 (99.3%)	1,798 (99.1%)	1,012 (98.9%)	397 (99.5%)	-
Mean cost (95% CI)	$6,216 ($5,640, $6,791)	$5,125 ($4,780, $5,471)	$4,493 ($4,245, $4,741)	$4,639 ($4,268, $5,009)	$4,392 ($3,779, $5,004)	-
Unadjusted mean cost difference (95% CI)	$0 (ref)	-$1,090 (-$1,727, -$454)	-$1,723 (-$2,306, -$1,140)	-$1,577 (-$2,227, -$927)	-$1,824 (-$2,596, -$1,052)	<0.001
Adjusted mean cost difference (95% CI)	$0 (ref)	-$1,117 (-$1,773, -$461)	-$1,812 (-$2,415, -$1,209)	-$1,710 (-$2,385, -$1,035)	-$1,900 (-$2,697, -$1,102)	<0.001
Total, N (%)	1,071 (99.2%)	1,933 (99.3%)	1,798 (99.1%)	1,012 (98.9%)	397 (99.5%)	-
Mean cost (95% CI)	$11,731 ($10,463, $13,000)	$9,232 ($8,520, $9,944)	$8,067 ($7,460, $8,673)	$7,805 ($7,093, $8,517)	$7,677 ($6,038, $9,315)	-
Unadjusted mean cost difference (95% CI)	$0 (ref)	-$2,499 (-$3,920, -$1,078)	-$3,664 (-$5,023, -$2,306)	-$3,926 (-$5,360, -$2,493)	-$4,054 (-$5,761, -$2,348)	<0.001
Adjusted mean cost difference (95% CI)	$0 (ref)	-$2,506 (-$3,913, -$1,099)	-$3,769 (-$5,114, -$2,424)	-$4,081 (-$5,510, -$2,652)	-$4,020 (-$5,724, -$2,315)	<0.001

† Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose and ideal levels are listed in Table 1.

CI: confidence interval; GDP: gross domestic product; SE: standard error.

Expenditures were adjusted to 3rd quarter 2015 US dollars using price indices for the GDP.

Analyses in this table were conducted using all available claims between baseline and the participants' death date, loss of Medicare fee-for-service coverage or December 31, 2013, whichever occurs first (median follow-up: 6.9 years, maximum follow-up: 9.9 years). Costs reported are per 1 year of follow-up.

Adjusted mean cost differences include adjustment for age, race, sex, education, income, and marital status. Models stratified by race adjust for age, sex, education, income, and marital status. Models stratified by sex adjust for age, race, education, income, and marital status.

The absolute number participants and the number of participants with inpatient, outpatient and total encounters in each category of Life's Simple 7 factors was calculated as the average across multiple imputations and rounded to the closest integer number. Separate imputations were conducted for inpatient, outpatient and total expenditures. Therefore, inpatient and outpatient expenditures do not sum exactly to the total expenditures.

Supplemental Table 5. Mean annualized cost and cost differences for cardiovascular disease expenditures over the entire follow-up by number of ideal Life's Simple 7 factors

	Number of ideal Life's Simple 7 factors†					
Expenditures	**0-1 (N=1,079)**	**2 (N=1,947)**	**3 (N=1,814)**	**4 (N=1,024)**	**5-7 (N=398)**	**p-trend**
Inpatient, N (%)	285 (26.4%)	471 (24.2%)	401 (22.1%)	224 (21.9%)	69 (16.8%)	-
Mean cost (95% CI)	$1,376 ($1,078, $1,674)	$1,036 ($866, $1,206)	$915 ($743, $1,088)	$860 ($676, $1,045)	$503 ($295, $712)	-
Unadjusted mean cost difference (95% CI)	$0 (ref)	-$340 (-$682, $2)	-$461 (-$793, -$128)	-$516 (-$866, -$166)	-$873 (-$1,235, -$510)	<0.001
Adjusted mean cost difference (95% CI)	$0 (ref)	-$361 (-$702, -$20)	-$511 (-$848, -$173)	-$591 (-$942, -$239)	-$889 (-$1,259, -$519)	<0.001
Outpatient, N (%)	1,012 (93.7%)	1,787 (91.8%)	1,638 (90.3%)	890 (87.0%)	323 (81.1%)	-
Mean cost (95% CI)	$769 ($681, $856)	$645 ($593, $696)	$600 ($552, $648)	$538 ($483, $592)	$417 ($334, $500)	-
Unadjusted mean cost difference (95% CI)	$0 (ref)	-$124 (-$228, -$20)	-$169 (-$263, -$75)	-$231 (-$334, -$127)	-$352 (-$462, -$242)	<0.001
Adjusted mean cost difference (95% CI)	$0 (ref)	-$131 (-$237, -$24)	-$199 (-$295, -$102)	-$263 (-$370, -$156)	-$363 (-$477, -$249)	<0.001
Total, N (%)	1,013 (93.8%)	1,788 (91.8%)	1,638 (90.3%)	890 (87.0%)	323 (81.1%)	-
Mean cost (95% CI)	$2,137 ($1,783, $2,492)	$1,687 ($1,481, $1,893)	$1,513 ($1,304, $1,722)	$1,398 ($1,173, $1,623)	$920 ($665, $1,174)	-
Unadjusted mean cost difference (95% CI)	$0 (ref)	-$451 (-$871, -$30)	-$624 (-$1,030, -$219)	-$739 (-$1,164, -$314)	-$1,218 (-$1,657, -$779)	<0.001
Adjusted mean cost difference (95% CI)	$0 (ref)	-$516 (-$950, -$83)	-$808 (-$1,225, -$392)	-$946 (-$1,384, -$509)	-$1,261 (-$1,726, -$796)	<0.001

† Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose and ideal levels are listed in Table 1.

CI: confidence interval; GDP: gross domestic product; SE: standard error.

Expenditures were adjusted to 3rd quarter 2015 US dollars using price indices for the GDP.

Analyses in this table were conducted using all available claims between baseline and the participants' death date, loss of Medicare fee-for-service coverage or December 31, 2013, whichever occurs first (median follow-up: 6.9 years, maximum follow-up: 9.9 years). Costs reported are per 1 year of follow-up.

Adjusted mean cost differences include adjustment for age, race, sex, education, income, and marital status. Models stratified by race adjust for age, sex, education, income, and marital status. Models stratified by sex adjust for age, race, education, income, and marital status.

The absolute number participants and the number of participants with inpatient, outpatient and total encounters in each category of Life's Simple 7 factors was calculated as the average across multiple imputations and rounded to the closest integer number. Separate imputations were conducted for inpatient, outpatient and total expenditures. Therefore, inpatient and outpatient expenditures do not sum exactly to the total expenditures.

Supplemental Table 6. Mean annualized cost differences for all-cause expenditures over the entire follow-up by number of ideal Life's Simple 7 factors, stratified by race and by sex

	Number of ideal Life's Simple 7 factors†					
Expenditures	**0-1**	**2**	**3**	**4**	**5-7**	**p-trend**
Inpatient						
Adjusted mean cost difference (95% CI), stratified by race and by sex						
Blacks	$0 (ref)	-$1,198 (-$2,981, $585)	-$2,516 (-$4,294, -$738)	-$3,015 (-$5,023, -$1,006)	-$3,151 (-$6,032, -$271)	0.001
Whites	$0 (ref)	-$1,517 (-$2,488, -$547)	-$1,677 (-$2,651, -$704)	-$2,119 (-$3,112, -$1,127)	-$2,057 (-$3,216, -$898)	<0.001
Men	$0 (ref)	-$1,110 (-$2,611, $391)	-$1,332 (-$2,824, $161)	-$1,605 (-$3,159, -$50)	-$1,145 (-$3,164, $873)	0.088
Women	$0 (ref)	-$1,523 (-$2,544, -$501)	-$2,106 (-$3,114, -$1,097)	-$2,691 (-$3,746, -$1,636)	-$3,193 (-$4,332, -$2,054)	<0.001
Outpatient						
Adjusted mean cost difference (95% CI), stratified by race and by sex						
Blacks	$0 (ref)	-$1,213 (-$2,344, -$81)	-$2,085 (-$3,143, -$1,027)	-$2,515 (-$3,657, -$1,374) ††		<0.001
Whites	$0 (ref)	-$1,012 (-$1,854, -$170)	-$1,619 (-$2,385, -$854)	-$1,467 (-$2,242, -$692) ††		<0.001
Men	$0 (ref)	-$1,328 (-$2,379, -$276)	-$1,662 (-$2,642, -$682)	-$1,514 (-$2,558, -$470) ††		0.004
Women	$0 (ref)	-$1,028 (-$1,837, -$218)	-$1,974 (-$2,734, -$1,214)	-$2,046 (-$2,834, -$1,258) ††		<0.001
Total						
Adjusted mean cost difference (95% CI), stratified by race and by sex						

Blacks	$0 (ref)	-$2,356 (-$4,973, $261)	-$4,653 (-$7,187, -$2,119)	-$5,486 (-$8,275, -$2,697) ††	<0.001
Whites	$0 (ref)	-$2,566 (-$4,197, -$935)	-$3,405 (-$4,982, -$1,829)	-$3,640 (-$5,193, -$2,087) ††	<0.001
Men	$0 (ref)	-$2,406 (-$4,743, -$68)	-$3,010 (-$5,291, -$729)	-$2,862 (-$5,179, -$544) ††	0.015
Women	$0 (ref)	-$2,528 (-$4,203, -$852)	-$4,237 (-$5,828, -$2,647)	-$4,951 (-$6,544, -$3,357) ††	<0.001

† Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose and ideal levels are listed in Table 1.

†† All whites and women with 5-7 ideal Life's Simple 7 factors had all-cause outpatient encounters when analyses were conducted using all available Medicare claims after baseline. Participants with 5-7 ideal Life's Simple 7 factors were combined with those who had 4 ideal Life's Simple 7 factors for analyses of all-cause outpatient and total expenditures by race and by sex to be included in two-part regression models.

CI: confidence interval; GDP: gross domestic product; SE: standard error.

Expenditures were adjusted to 3rd quarter 2015 US dollars using price indices for the GDP.

Analyses in this table were conducted using all available claims between baseline and the participants' death date, loss of Medicare fee-for-service coverage or December 31, 2013, whichever occurs first (median follow-up: 6.9 years, maximum follow-up: 9.9 years). Costs reported are per 1 year of follow-up.

Adjusted mean cost differences include adjustment for age, race, sex, education, income, and marital status. Models stratified by race adjust for age, sex, education, income, and marital status. Models stratified by sex adjust for age, race, education, income, and marital status.

Separate imputations were conducted for inpatient, outpatient and total expenditures. Therefore, inpatient and outpatient expenditures do not sum exactly to the total expenditures.

Supplemental Table 7. Mean annualized cost differences for cardiovascular disease expenditures over the entire follow-up period available by number of ideal Life's Simple 7 factors, stratified by race and by sex

	Number of ideal Life's Simple 7 factors†					
Expenditures	**0-1**	**2**	**3**	**4**	**5-7**	**p-trend**
Inpatient						
Adjusted mean cost difference (95% CI), stratified by race and by sex						
Blacks	\$0 (ref)	-\$548 (-\$1,283, \$187)	-\$978 (-\$1,668, -\$289)	-\$884 (-\$1,687, -\$82)	-\$1,353 (-\$2,221, -\$485)	0.002
Whites	\$0 (ref)	-\$237 (-\$604, \$131)	-\$279 (-\$646, \$88)	-\$421 (-\$792, -\$49)	-\$693 (-\$1,077, -\$310)	0.001
Men	\$0 (ref)	\$37 (-\$484, \$558)	-\$122 (-\$626, \$382)	-\$132 (-\$678, \$413)	-\$688 (-\$1,224, -\$151)	0.058
Women	\$0 (ref)	-\$521 (-\$914, -\$129)	-\$635 (-\$1,031, -\$240)	-\$787 (-\$1,183, -\$391)	-\$854 (-\$1,326, -\$382)	<0.001
Outpatient						
Adjusted mean cost difference (95% CI), stratified by race and by sex						
Blacks	\$0 (ref)	-\$163 (-\$350, \$24)	-\$285 (-\$462, -\$108)	-\$350 (-\$542, -\$158)	-\$553 (-\$779, -\$326)	<0.001
Whites	\$0 (ref)	-\$98 (-\$221, \$26)	-\$136 (-\$249, -\$23)	-\$206 (-\$325, -\$87)	-\$291 (-\$420, -\$162)	<0.001
Men	\$0 (ref)	-\$57 (-\$231, \$117)	-\$130 (-\$285, \$26)	-\$177 (-\$347, -\$8)	-\$369 (-\$544, -\$195)	<0.001
Women	\$0 (ref)	-\$159 (-\$280, -\$38)	-\$212 (-\$328, -\$95)	-\$294 (-\$418, -\$169)	-\$313 (-\$465, -\$162)	<0.001
Total						
Adjusted mean cost difference (95% CI), stratified by race and by sex						

Blacks	$0 (ref)	-$636 (-$1,474, $203)	-$1,245 (-$2,022, -$469)	-$1,187 (-$2,096, -$278)	-$1,863 (-$2,852, -$875)	<0.001
Whites	$0 (ref)	-$399 (-$892, $93)	-$542 (-$1,018, -$66)	-$763 (-$1,248, -$278)	-$1,018 (-$1,524, -$511)	<0.001
Men	$0 (ref)	$22 (-$649, $694)	-$233 (-$870, $403)	-$321 (-$1,017, $375)	-$1,038 (-$1,715, -$362)	0.011
Women	$0 (ref)	-$671 (-$1,151, -$192)	-$917 (-$1,383, -$451)	-$1,118 (-$1,593, -$643)	-$1,107 (-$1,681, -$533)	<0.001

[†] Life's Simple 7 factors include cigarette smoking, physical activity, diet, body mass index, blood pressure, cholesterol, and glucose and ideal levels are listed in Table 1.

CI: confidence interval; GDP: gross domestic product; SE: standard error.

Expenditures were adjusted to 3rd quarter 2015 US dollars using price indices for the GDP.

Analyses in this table were conducted using all available claims between baseline and the participants' death date, loss of Medicare fee-for-service coverage or December 31, 2013, whichever occurs first (median follow-up: 6.9 years, maximum follow-up: 9.9 years). Costs reported are per 1 year of follow-up.

Adjusted mean cost differences include adjustment for age, race, sex, education, income, and marital status. Models stratified by race adjust for age, sex, education, income, and marital status. Models stratified by sex adjust for age, race, education, income, and marital status.

Separate imputations were conducted for inpatient, outpatient and total expenditures. Therefore, inpatient and outpatient expenditures do not sum exactly to the total expenditures.

Supplemental Table 8. Potential reduction in Medicare expenditures associated with the entire population achieving 5 to 7 ideal factors of the Life's Simple 7.

Expenditure type	Total Medicare expenditures in 2014 (in billions of USD)	Percent of expenditures†	Potential cost reduction (in billions of USD)†
Inpatient	35.9	53.4% (34.5%, 68.6%)	19.2 (12.4, 24.6)
Outpatient	73.9	29.7% (18.5%, 38.0%)	22.0 (13.7, 28.1)
Total	109.8	37.5% (25.6%, 46.9%)	41.2 (28.1, 51.5)

†Percentage of total expenditures and potential cost reduction attributable to not having 5 to 7 ideal factors of the Life's Simple 7.
Numbers in the table are restricted to Medicare beneficiaries ≥ 65 years of age with Medicare fee-for-service for the full 2014 calendar year and without a history of cardiovascular disease (defined using all available Medicare inpatient, outpatient and carrier claims prior to January 1, 2014).

History of cardiovascular disease includes:

- Myocardial infarction (defined by ≥1 inpatient claim with an international classification of diseases, ninth revision [ICD-9] discharge diagnosis code of 410.xx in any position),
- Coronary revascularization (defined by ≥1 inpatient, outpatient or carrier claim with an ICD-9 procedure code of 00.66, 36.0, 36.01-36.07, 36.09-36.19, or 36.2, an ICD-9 diagnosis code of V45.81 or V45.82, or a Current Procedure Terminology [CPT] code of 92980-92982, 92984, 92995, 92996, 33510-33519, 33521-33523, 33530, 33533-33536) in any position,
- Other ischemic heart disease (≥1 inpatient claim with an ICD-9 diagnosis code of 411.xx, 412, 413.xx, or 414.xx in any position, or ≥1 outpatient or carrier claim with an ICD-9 diagnosis code of 411.xx, 412, 413.xx, or 414.xx in any position linked to an ambulatory physician evaluation and management code), and
- Stroke (defined by ≥1 inpatient claim with an ICD-9 diagnosis code of 430.xx, 431.xx, 433.x1, 434.x1 or 436 in any position, or ≥1 outpatient or carrier claim with and ICD-9 diagnosis code of 430.xx, 431.xx, 433.x1, 434.x1 or 436 in any position linked to an ambulatory physician evaluation and management code).