Original Contribution

Life's Simple 7 and Risk of Incident Stroke

The Reasons for Geographic and Racial Differences in Stroke Study

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Background and Purpose—The American Heart Association developed Life's Simple 7 (LS7) as a metric defining cardiovascular health. We investigated the association between LS7 and incident stroke in black and white Americans.

Methods—The Reasons for Geographic And Racial Differences in Stroke (REGARDS) is a national population-based cohort of 30 239 blacks and whites, aged ≥45 years, sampled from the US population from 2003 to 2007. Data were collected by telephone, self-administered questionnaires, and an in-home examination. Incident strokes were identified through biannual participant contact followed by adjudication of medical records. Levels of the LS7 components (blood pressure, cholesterol, glucose, body mass index, smoking, physical activity, and diet) were each coded as poor (0 point), intermediate (1 point), or ideal (2 points) health. An overall LS7 score was categorized as inadequate (0–4), average (5–9), or optimum (10–14) cardiovascular health.

Results—Among 22 914 subjects with LS7 data and no previous cardiovascular disease, there were 432 incident strokes over 4.9 years of follow-up. After adjusting for demographics, socioeconomic status, and region of residence, each better health category of the LS7 score was associated with a 25% lower risk of stroke (hazard ratios, 0.75; 95% confidence interval, 0.63–0.90). The association was similar for blacks and whites (interaction *P* value=0.55). A 1-point higher LS7 score was associated with an 8% lower risk of stroke (hazard ratios, 0.92; 95% confidence interval, 0.88–0.95).

Conclusions—In both blacks and whites, better cardiovascular health, on the basis of the LS7 score, is associated with lower risk of stroke, and a small difference in scores was an important stroke determinant. **(*Stroke*. 2013;44:XX-XX.)**

Key Words: racial differences ■ risk factors ■ stroke

Stroke is the fourth leading cause of death in the United States and the leading cause of adult disability with direct and indirect costs exceeding $50 billion annually.[1] Previous studies demonstrated that most cardiovascular disease (CVD) events, including stroke, are preventable by optimizing a few key indicators of cardiovascular health.[2,3] In 2010, the American Heart Association/American Stroke Association (AHA/ASA) proposed a population metric to define and track the nation's cardiovascular health through time.[4] This metric was released as a score called Life's Simple 7 (LS7). The LS7 metric emphasizes primordial prevention and includes 7 modifiable components, including 3 health factors (glucose, cholesterol, and blood pressure) and 4 health behaviors (body mass index, physical activity, diet, and cigarette smoking), categorizing each of these 7 factors into ideal, intermediate, and poor levels. Incorporation of modifiable risk factors in the LS7 metric was intentional to promote translation into prevention programs, particularly lifestyle change, a potent weapon in the battle against CVD.[5]

Recent evidence suggested that the presence of more ideal cardiovascular health factors from the LS7 metric is associated with lower CVD and all-cause mortality.[6–8] There are limited data available pertaining to stroke.[9] More broadly, there are scarce data on the use of a composite measure of biological and behavioral risk factors in predicting stroke. Using data from the Reasons for Geographic and Racial Differences in Stroke (REGARDS) study, we determined the association between LS7 and incident stroke and examined differences by race.

Methods

Study Participants and Data Collection

The REGARDS study is a population-based cohort study of stroke incidence and cognitive function among US adults, aged ≥45 years,

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oversampling blacks, and residents of the southeastern stroke belt region.[10] Potential participants were identified from commercially available lists of US residents and recruited through a mailing followed by telephone calls. Overall, 30 239 participants were enrolled between 2003 and 2007. Sociodemographic and clinical data were collected with standardized methods at baseline through a telephone interview, an in-home examination, and self-administered questionnaires. We included participants with data on blood pressure, cholesterol, glucose, body mass index, smoking, diet, and physical activity (LS7 components). We excluded participants with a self-reported history of stroke, peripheral vascular disease, or coronary heart disease. The Food Frequency Questionnaire documented dietary intake patterns for the 1 year preceding the in-home visit.[11] The REGARDS study protocol was approved by the institutional review boards at the collaborating centers, and all participants provided informed consent.

Life's Simple 7

Components of the LS7 metric include cigarette smoking, body mass index, blood pressure, cholesterol, blood glucose, physical activity, and diet. Physical activity and diet classification were modified from the original LS7 definitions (Appendix in the online-only Data Supplement). Diet information was missing for 6086 (27%) and was imputed. Each LS7 component was given a point score of 0, 1, or 2 to represent poor, intermediate, or ideal health, respectively.[12] An overall LS7 score ranging from 0 to 14 was calculated as the sum of the LS7 component scores. This score was classified as inadequate (0–4), average (5–9), or optimum (10–14) cardiovascular health.

Study Outcome

Participants or their proxies were contacted every 6 months by telephone. Details on stroke adjudication have been published.[13] Stroke events were defined according to the World Health Organization definition.[14] Events not meeting the World Health Organization definition but characterized by symptoms lasting <24 hours, with neuroimaging consistent with acute ischemia or hemorrhage were also classified as stroke events. Time to a stroke event was recorded as the number of days between the baseline examination and the date of stroke event. Participants who did not develop a stroke were censored on their date of death or last follow-up contact, whichever occurred first.

Statistical Analyses

Baseline characteristics were calculated and compared according to race and LS7 categories using χ^2 statistics. The distribution of LS7 components and number of ideal health factors were compared by race and sex. For each LS7 component, stroke incidence rates and adjusted hazard ratios (HRs) for stroke were calculated separately for blacks and whites. Cox proportional hazards models were used, adjusting for age, race, sex, region of residence (stroke belt or other), alcohol use, income, and education. HRs of stroke across overall LS7 categories (optimum or average versus inadequate) were calculated. LS7 score was also examined as a continuous variable, considering the HR per a 1-point higher overall LS7 score. HRs for stroke were also calculated for increasing number of ideal health factors with the reference group being those with no ideal factors. All analyses were conducted using SAS version 9.2 (SAS Institute, Cary, NC).

Results

There were 22 914 participants with data on LS7 and no previous CVD. Mean age was 65 years, 42% were black, and 58% women. Sociodemographic factors for LS7 categories by race are presented in Table 1. Male sex, low income, less education, and current alcohol use were associated with poorer cardiovascular health in both blacks and whites. The distribution of LS7 categories differed significantly between blacks and whites. Whites had a higher proportion of people in the optimum cardiovascular health category (19%) as compared with blacks (7%), irrespective of age, sex, income, education, and geographic region. The distribution of ideal status varied widely across LS7 factors (Figure 1), ranging from 84% of participants having ideal status for smoking, to 0% of participants having an ideal diet.

The mean (SD) overall LS7 score was 7.2 (±2.2) points. Adjusting for age and sex, the mean (±SD) overall LS7 score was lower for blacks (6.5±2.0) than whites (7.6±2.1). Blacks had fewer ideal factors compared with whites. Only 3% of blacks and 8% of whites had ≥5 ideal factors (Figure in the online-only Data Supplement).

During 4.9 years of follow-up, there were 432 incident strokes (232 in whites and 200 in blacks). For many LS7 components, stroke incidence was lowest in those with ideal status and highest in those with poor levels (Table 2). For example, for blood pressure incidence rates per 10 000 person-years for poor, intermediate, and ideal status were 3.2, 1.8, and 1.1, respectively, for blacks and 2.4, 1.9, and 0.8, respectively, for whites. The adjusted HRs for some LS7 components (total cholesterol, blood pressure, blood glucose, and smoking) showed a graded relationship with stroke, particularly among whites (Table 2).

Worsening overall LS7 score categories of cardiovascular health were inversely associated with incident stroke in a graded fashion (Figure 2). Stroke incidence rates were 2.4 per 10 000 person-years among those with inadequate health and 1.3 per 10 000 person-years with optimum health. After multivariable adjustment, with LS7 score category modeled as an ordinal variable, each better health category was associated with a 25% lower risk of incident stroke (HR, 0.75; 95% confidence interval [CI], 0.63–0.90). Compared with the inadequate health category, those with average (HR, 0.72; 95% CI, 0.55–0.96) or optimum (HR, 0.52; 95% CI, 0.35–0.76) health had lower stroke risk. Although the association of LS7 category and stroke was not statistically significant among blacks (Table 3), the crude and adjusted HRs were similar for blacks and whites (*P* value for interaction=0.55).

For the total LS7 score on a continuous scale from 0 (all 7 poor) to 14 (all 7 ideal), a 1-point higher LS7 score was associated with an 8% lower risk of stroke (HR, 0.92; 95% CI, 0.88–0.95) and this was similar in blacks and whites (Table 3). The association of LS7, or its individual components, with stroke risk did not differ after exclusion of those with hemorrhagic stroke (n=81; HR for ischemic stroke per 1-point higher score=0.90; 95% CI, 0.86–0.95). Finally, an increasing number of ideal factors was inversely associated with risk of stroke in both blacks and whites. Even those with only 1 ideal factor compared with those with 0 ideal factors had a lower stroke risk (HR, 0.70; 95% CI, 0.42–1.19).Those with 6 versus 0 ideal factors had a multivariable adjusted HR of 0.34 (95% CI, 0.08–1.52; Table 4). In sensitivity analysis, results were similar when participants with imputed diet scores were excluded or were all assumed to have a poor diet or an intermediate diet.[15]

Discussion

The stroke epidemic can be curtailed with a multidisciplinary strategy that identifies and manages stroke risk factors.[16] The AHA developed the LS7 metric as part of its strategic impact goal to improve the cardiovascular health of all Americans by

Table 1. Baseline Characteristics of 22 914 REGARDS Study Participants by Race and Life's Simple 7 Health Categories

	Percent in Each Cardiovascular Health Category							
	Blacks (N=9553)				Whites (N=13 361)			
Characteristic	Optimum (n=692)	Average (n=7302)	Inadequate (n=1559)	*P* Value	Optimum (n=2589)	Average (n=9756)	Inadequate (n=1016)	*P* Value
Age, y								
≤65	7.4	75.7	16.9	0.13	20.5	71.2	8.3	<0.001
>65	7.0	77.4	15.5		18.1	75.1	6.8	
Sex								
Men	8.6	78.4	12.9	<0.001	18.5	74.9	6.6	<0.001
Women	6.5	75.3	18.2		20.1	71.4	8.4	
Income								
>$20 000k	8.1	77.2	14.7	<0.001	20.2	72.9	6.8	<0.001
≤$20 000k	4.6	74.1	21.3		12.4	73.5	14.1	
Education, grade								
>12th	7.9	77.1	14.9	<0.001	20.1	72.7	7.2	<0.001
≤12th	4.1	73.2	22.7		8.3	78.8	13.1	
Geographic region								
Stroke belt	7.3	76.1	16.6	0.18	19.6	72.7	7.7	0.24
Non-stroke belt	7.0	78.1	14.9		18.5	74.2	7.3	
Alcohol consumption								
Current	7.8	75.9	16.2	0.008	21.3	72.0	6.7	<0.001
Former	6.9	75.5	17.6		14.9	74.8	10.2	

REGARDS indicates Reasons for Geographic and Racial Differences in Stroke study.

20%, by 2020. Our study shows that the LS7 metric is a useful tool to describe the risk of incident stroke and has the potential to help refine population interventions to reduce stroke incidence rates in the US population. Using a simple point system to represent the LS7 metric, an incremental increase in the overall LS7 score (inadequate to average to optimum) was associated with a 25% lower risk of incident stroke. However, there were important differences in population levels of LS7, as blacks had lower levels of cardiovascular health factors than whites. These findings suggest that comprehensive population-based interventions targeting risk factors included in the LS7 will be critical to support the attainment of the AHA's 2020 impact goal for cardiovascular health, reduce the incidence and prevalence of stroke, and eliminate disparities.

The prevalence of ideal cardiovascular health is extremely low in the United States as measured in national studies and other cohorts, including REGARDS.[6,17] The distribution of ideal factors in REGARDS was similar to the National

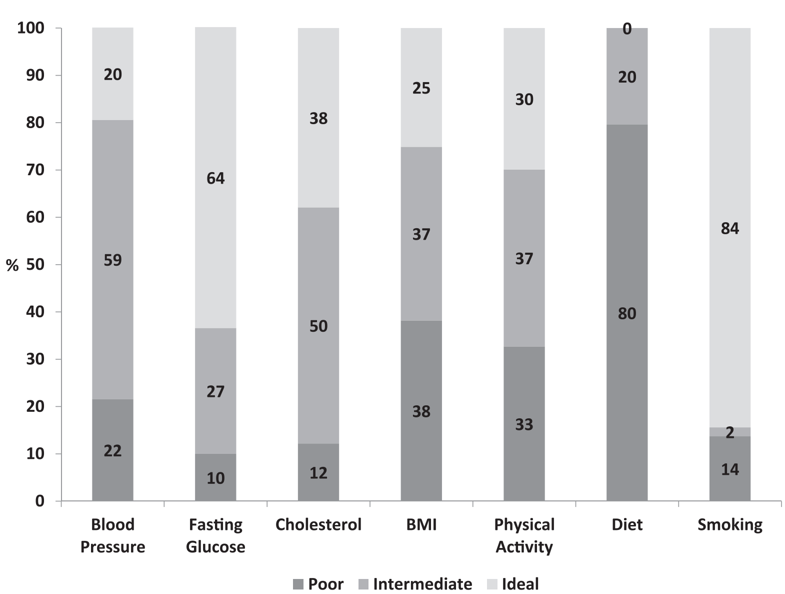

Figure 1. Distribution of Life's Simple 7 components among Reasons for Geographic and Racial Differences in Stroke participants. BMI indicates body mass index.

Table 2. Incidence Rates and Adjusted Hazard Ratio of Stroke for Life's Simple 7 Components Among REGARDS Participants by Race

	Overall		Blacks		Whites	
	IR†	HR* (95% CI)	IR	HR* (95% CI)	IR*	HR* (95% CI)
Total cholesterol (n=22 106)						
Ideal	1.9	0.8 (0.6, 1.1)	2.3	0.7 (0.4, 1.0)	1.6	0.7 (0.5, 1.2)
Intermediate	1.8	0.8 (0.6, 1.0)	1.8	0.8 (0.5, 1.3)	1.8	0.8 (0.6, 1.3)
Poor	2.1	Ref	2.5	Ref	1.8	Ref
Blood pressure (n=22 864)						
Ideal	0.9	0.4 (0.3,0.6)	1.1	0.4 (0.2, 0.7)	0.8	0.5 (0.3, 0.8)
Intermediate	1.8	0.7 (0.6, 0.9)	1.8	0.6 (0.4, 0.8)	1.9	0.9 (0.6, 1.3)
Poor	2.8	Ref	3.2	Ref	2.4	Ref
Blood glucose (n=22 551)						
Ideal	1.6	0.6 (0.5, 0.9)	1.7	0.7 (0.4, 1.1)	1.5	0.6 (0.4, 1.0)
Intermediate	2.3	0.9 (0.6, 1.2)	2.5	1.0 (0.6, 1.6)	2.2	0.8 (0.5, 1.4)
Poor	2.5	Ref	2.4	Ref	2.6	Ref
Physical activity (n=22 585)						
Ideal	1.8	0.9 (0.7, 1.1)	1.8	0.8 (0.6,1.2)	1.8	0.9 (0.6, 1.3)
Intermediate	1.8	0.9 (0.6, 1.1)	2.0	0.9 (0.7, 1.3)	1.6	0.9 (0.6, 1.2)
Poor	2.0	Ref	2.2	Ref	1.9	Ref
Healthy diet score (n=16 829)						
Ideal**			…		…	
Intermediate	1.8	1.0 (0.7, 1.3)	2.2	1.1 (0.7,1.8)	1.5	0.9 (0.6, 1.3)
Poor	1.9	Ref	2.0	Ref	1.7	Ref
Smoking (n=22 914)						
Ideal	2.2	0.6 (0.5, 0.8)	2.9	0.3 (0.1, 1.2)	1.6	0.5 (0.4, 0.7)
Intermediate	2.3	0.5 (0.2, 1.1)	1.9	0.7 (0.5, 1.0)	2.5	0.7 (0.3, 1.8)
Poor	2.4	Ref	2.3	Ref	2.4	Ref
Body mass index (n=22 771)						
Ideal	2.1	1.0 (0.8, 1.3)	2.2	1.1 (0.7,1.6)	1.9	1.0 (0.7, 1.4)
Intermediate	1.9	1.1 (0.9, 1.4)	2.1	1.1 (0.8,1.6)	1.7	1.1 (0.8, 1.6)
Poor	2.0	Ref	2.3	Ref	1.9	Ref

CI indicates confidence interval; HR, hazard ratio; IR, incidence rate; and REGARDS, Reasons for Geographic and Racial Differences in Stroke study.
*Adjusted for age, race, sex, income, education, alcohol use, and geographic region. Race stratified models not adjusted for race.
**Category had no data.
†Incidence rate per 10 000 person-years.

Health and Nutrition Examination Surveys (NHANES) and Atherosclerosis Risk in Communities Study (ARIC) studies.[7,18] Our study from a more contemporary cohort demonstrates that blacks have lower levels of ideal factors compared with whites and also presents analysis of stroke. The association of LS7 and stroke was not statistically different in blacks than whites. This finding needs confirmation from other studies or further follow-up in REGARDS. National statistics and REGARDS findings demonstrated higher stroke incidence and stroke mortality rates for blacks compared with whites, possibly because of the higher prevalence of hypertension, obesity, and diabetes mellitus among blacks, although the higher risk factor levels only explain ≈50% of the excess risk.[13,19,20] Understanding the basis for these differences will be important to design and effectively implement stroke prevention programs among blacks.

The Northern Manhattan Study (NOMAS) previously reported that increasing numbers of ideal health factors for LS7 was associated with reduced stroke risk.[9] Our findings expand on these by considering the full range of poor to intermediate to ideal LS7 score. Moreover, we showed that a 1-point increase in overall LS7 score, which corresponds to improvement of 1 component of the LS7 score by 1 level (eg, from poor to intermediate or from intermediate to ideal) was associated with an 8% lower risk of stroke. Thus, unlike NOMAS, our findings support the hypothesis that small shifts in the population distribution of risk factors can have a dramatic impact on reducing the disease burden in populations.[21] Although there were differences in associations of each component of LS7 with stroke risk, the overall metric is conceptualized as a broad public health metric for CVD prevention, and we demonstrate the use of this metric specifically for stroke risk.

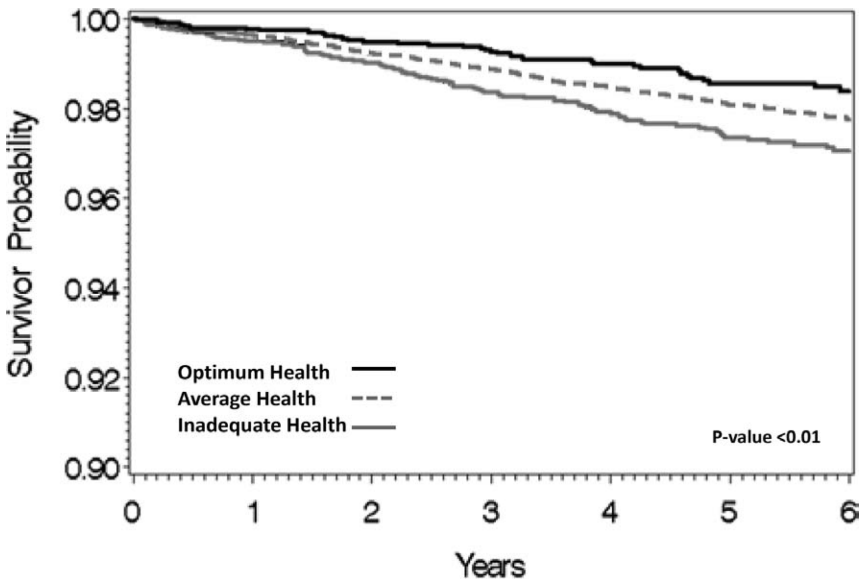

Figure 2. Survival free from stroke by cardiovascular health categories.

Improvements in a single health behavior could result in a reduction of CVD and also improvements of other cardiovascular health factors (eg, obesity, cholesterol). Indeed, these components are interrelated and do not operate in silos. Previous studies also support the potential of using population-based strategies targeting multiple risk factors simultaneously to achieve reductions in stroke and CVD rates in communities.[2,22]

Our study has several strengths, including the large national sample, with oversampling of blacks to allow examination of racial differences. Data collection used standardized questionnaires and measured, not self-reported risk factor levels. There was rigorous ascertainment of stroke outcomes, including adjudication of stroke events, by neurologists. There are also some limitations to our study. Health factors and behaviors were measured only once. Thus, we cannot assess whether changes in LS7 score affect stroke incidence, and we expect some misclassification. The cooperation rate for participation in REGARDS was 49%. Although this is similar to other large national cohorts, this may limit generalizability of the findings. We also used a modified definition for physical activity and diet for computation of the LS7 score.

In conclusion, in this large population-based sample of US adults, aged ≥45 years, favorable levels of cardiovascular health factors, as defined by the LS7 score, were associated with a substantially reduced risk of stroke. On the basis of our findings, differences in LS7 score corresponding to an improvement by 1 level of 1 component of the LS7 metric may result in substantial reductions in stroke risk. This provides confidence that meeting the AHA goals for LS7 may lead to reduction in stroke incidence. Future studies are needed to determine the actual risk reduction benefit that can be achieved through an intervention approach to improve health behaviors and risk factors in the LS7 metric.

Sources of Funding

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Table 3. Incidence Rate and Adjusted Hazard Ratio (95% CI) of Incident Stroke for Categories of Overall Life's Simple 7 Score by Race

	Overall (N=22914)		Blacks (n=9553)		Whites (n=13361)	
	IR†	HR* (95% CI)	IR	HR* (95% CI)	IR	HR* (95% CI)
Cardiovascular health categories						
Optimum	1.3	0.52 (0.35, 0.76)	1.6	0.63 (0.33, 1.22)	1.2	0.49 (0.29, 0.89)
Average	1.9	0.73 (0.55, 0.96)	1.9	0.76 (0.53, 1.10)	1.7	0.71 (0.46, 1.10)
Inadequate	2.4	1.0	2.4	1.0	2.2	1.0
P for trend		<0.001		0.22		0.04
Cardiovascular health score per 1 unit increase		0.92 (0.88, 0.95)		0.93 (0.87, 0.98)		0.91 (0.86, 0.96)

CI indicates confidence interval; HR, hazard ratio; and IR, incidence rates.

*Adjusted for age, race, sex, income, alcohol use, education, and geographic region. Race stratified models not adjusted for race.

†Incidence rate per 10000 person-years.

Table 4. Adjusted Hazard Ratios for Incident Stroke Associated With Number of Ideal Life's Simple 7 Components

	Overall		Blacks		Whites	
No. of Ideal Components	No. of Strokes	HR* (95% CI)	No. of Strokes	HR* (95% CI)	No. of Strokes	HR* (95% CI)
0 (n=576)	16	Ref	8	Ref	8	Ref
1 (n=4465)	99	0.70 (0.42, 1.19)	56	0.86 (0.41, 1.81)	43	0.51 (0.24, 1.20)
2 (n=7249)	155	0.67 (0.40, 1.13)	74	0.81 (0.39, 1.69)	81	0.49 (0.24, 1.02)
3 (n=6105)	104	0.53 (0.31, 0.90)	43	0.66 (0.31, 1.41)	61	0.38 (0.18, 0.80)
4 (n=3187)	40	0.40 (0.23, 0.73)	15	0.58 (0.25, 1.38)	25	0.27 (0.12, 0.60)
5 (n=1117)	16	0.50 (0.25, 1.0)	3	0.51 (0.14, 1.96)	13	0.38 (0.16, 0.92)
6 (n=216)	2	0.34 (0.08, 1.52)	1	0.50 (0.56, 1.07)	1	0.15 (0.02, 1.19)

CI indicates confidence interval; HR, hazard ratio.

*Adjusted for age, race, sex, socioeconomic, alcohol use, education, and geographic region. Race stratified models not adjusted for race.

Prevention. A full list of participating REGARDS investigators and institutions can be found at http://www.regardsstudy.org.

Disclosures

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Life's Simple 7 and Risk of Incident Stroke: The Reasons for Geographic and Racial Differences in Stroke Study

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SUPPLEMENTAL MATERIAL

APPENDIX TABLE

Health Metric	Levels	Score	Definition
Total cholesterol	Ideal	2	<200 mg/dl, without lipid lowering medication
	Intermediate	1	200-239 mg/dl or treated to <200 mg/dl
	Poor	0	≥240 mg/dl
Blood pressure	Ideal	2	<120/<80 mm Hg, without antihypertensive medication
	Intermediate	1	SBP 120–139 or DBP 80–89 mm Hg or treated with antihypertensive to <120/<80 mm Hg
	Poor	0	SBP ≥140 or DBP ≥90 mm Hg
Blood glucose	Ideal	2	<100 mg/dl, without antidiabetes medication
	Intermediate	1	100–125 mg/dl or treated with antidiabetes to <100 mg/dl
	Poor	0	≥126 mg/dl
Physical activity*	Ideal	2	4 or more times per week of intense physical activity
	Intermediate	1	1-3 times per week of intense physical activity
	Poor	0	No physical activity

Healthy diet score†	Ideal	2	4–5 components
	Intermediate	1	2–3 components
	Poor	0	0–1 components
Smoking	Ideal	2	Never or quit >12 months
	Intermediate	1	Former, quit ≤12 months
	Poor	0	Current
Body mass index	Ideal	2	<25 kg/m^2
	Intermediate	1	25–29.99 kg/m^2
	Poor	0	≥30 kg/m^2

* modified for REGARDS. 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 1-3 times per week, and poor as none.

†modified for REGARDS. Responses to the Block FFQ 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 (1.1g of fiber in 10 gms of carbohydrates), 1-oz equivalent servings ≥ 3 services/day.

Figure: Distribution of the number of ideal health factors in the REGARDS cohort by race and gender