2017

Life's Simple 7 and Incident Heart Failure: The Multi-Ethnic Study of Atherosclerosis

Oluseye Ogunmoroti
Baptist Health Medical Group, oluseyeo@baptisthealth.net

Emir Veledar
Baptist Health South Florida, emirv@baptisthealth.net

Khurram Nasir
Baptist Health Medical Group, khurramn@baptisthealth.net

Citation
J Am Heart Assoc (2017) 6(6): pii: e005180

ORIGINAL RESEARCH

Life's Simple 7 and Incident Heart Failure: The Multi-Ethnic Study of Atherosclerosis

Oluseye Ogunmoroti, MD, MPH; Ebenezer Oni, MD, MPH; Erin D. Michos, MD, MHS; Erica S. Spatz, MD, MHS; Norrina B. Allen, PhD; Jamal S. Rana, MD, PhD; Salim S Virani, MD, PhD; Ron Blankstein, MD; Konstantinos N. Aronis, MD; Roger S. Blumenthal, MD; Emir Veledar, PhD; Moyses Szklo, MD, DrPH; Michael J. Blaha, MD, MPH; Khurram Nasir, MD, MPH

***Background*—**The American Heart Association introduced the Life's Simple 7 (LS7) metrics to assess and promote cardiovascular health. We sought to examine the association between the LS7 metrics and incident heart failure (HF) in a multiethnic cohort.

***Methods and Results*—**We analyzed data from 6506 participants of the Multi-Ethnic Study of Atherosclerosis free of cardiovascular disease at baseline. The LS7 metrics (smoking, physical activity, body mass index, diet, blood pressure, total cholesterol, and blood glucose) were graded on a scale of 0 to 2, with 2 indicating "ideal" status, 1 "intermediate" status, and 0 "poor" status. Points were summed, thus the LS7 score ranged from 0 to 14. Cox proportional hazard ratios and incidence rates of HF per 1000 person-years were calculated. During a median follow-up of 12.2 years, 262 (4%) participants developed HF. Incidence of HF decreased as the number of ideal LS7 metrics increased; 5.9 per 1000 person-years for participants with 0 to 1 ideal metrics and 0.6 per 1000 person-years for those with 6 to 7 ideal metrics. Compared with inadequate scores (0–8 points), hazard ratios for HF were 0.57 (0.43–0.76) and 0.31 (0.19–0.49) for average (9–10 points) and optimal (11–14 points) scores, respectively. A similar pattern was observed when the results were stratified by 4 racial/ethnic groups: white, Chinese American, black, and Hispanic.

***Conclusions*—**A lower risk of HF with more favorable LS7 status regardless of race/ethnicity suggests that efforts to achieve ideal cardiovascular health may reduce the burden of HF, a major source of morbidity and mortality. **(*J Am Heart Assoc*. 2017;6: e005180. DOI: 10.1161/JAHA.116.005180.)**

Key Words: cardiovascular disease prevention • epidemiology • heart failure • ideal cardiovascular health metrics • Life's Simple 7 • risk factor

Heart failure (HF) prevention is a top public health priority.[1] Approximately 23 million people have HF worldwide,[2] a number that is expected to rise because of the aging population and increasing prevalence of risk factors.[3,4] In the United States, an estimated 5.7 million people have HF, with a total annual cost of $30.7 billion.[5] Incidence and

From the Center for Healthcare Advancement and Outcomes (O.O., E.V., K.N.) and Miami Cardiac & Vascular Institute (K.N.), Baptist Health South Florida, Miami, FL; Department of Epidemiology, Robert Stempel College of Public Health and Social Work (O.O., K.N.), Department of Biostatistics, Robert Stempel College of Public Health and Social Work (E.V.), and Department of Medicine, Herbert Wertheim College of Medicine (K.N.), Florida International University, Miami, FL; Brooklyn Hospital Center, Brooklyn, NY (E.O.); Ciccarone Center for the Prevention of Heart Disease, Johns Hopkins University, Baltimore, MD (E.D.M., R.S.B., M.J.B., K.N.); Division of Cardiology, Department of Medicine, Johns Hopkins Hospital, Johns Hopkins University School of Medicine, Baltimore, MD (K.N.A.); Center for Outcomes Research and Evaluation, Yale New Haven Hospital, New Haven, CT (E.S.S.); Section of Cardiovascular Medicine, Yale University, New Haven, CT (E.S.S.); Department of Preventive Medicine, Feinberg School of Medicine, Northwestern University, Chicago, IL (N.B.A.); Division of Cardiology and Division of Research, Kaiser Permanente Northern California, Oakland, CA (J.S.R.); Department of Medicine, University of California, San Francisco, CA (J.S.R.); Michael E. DeBakey Veterans Affairs Medical Center, Houston, TX (S.S.V.); Baylor College of Medicine, Houston, TX (S.S.V.); Departments of Medicine and Radiology, Brigham and Women's Hospital, Boston, MA (R.B.); Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD (M.S.).

Accompanying Tables S1 through S6 and Figure S1 are available at http://jaha.ahajournals.org/content/6/6/e005180/DC1/embed/inline-supplementary-material-1.pdf

The abstract of this work was presented as a moderated poster at the American Heart Association's EPI|Lifestyle Scientific Sessions, March 1–4, 2016, in Phoenix, AZ.

Correspondence to: Khurram Nasir, MD, MPH, Center for Healthcare Advancement and Outcomes, Baptist Health South Florida. 1500 San Remo Ave, Suite 340, Coral Gables, FL 33146. E-mail: khurramn@baptisthealth.net

Received December 2, 2016; accepted April 24, 2017.

Clinical Perspective

What is New?

- This study examined the association between the American Heart Association's Life's Simple 7 and incident heart failure in a multiethnic cohort, with Chinese American and Hispanic participants included in the analyses unlike previous studies that examined a similar association in only white or black participants.
- Our findings show that irrespective of race/ethnicity, greater numbers of the Life's Simple 7 metrics at ideal levels and average as well as optimal Life's Simple 7 scores were associated with a lower risk of heart failure.

What are the Clinical Implications?

- Heart failure is responsible for a significant reduction in quality of life and higher mortality rates with a life expectancy of 5 years for ≈50% of patients.
- An estimated 870 000 new cases are documented in the United States annually, and if the current trend continues, it is projected that by 2030 over 8 million people, aged 18 years or older, will have the disease.
- The morbidity, mortality, and socioeconomic burden associated with heart failure can be reduced by encouraging the public to improve their cardiovascular health by adopting healthy lifestyles and achieving greater numbers of ideal Life's Simple 7 metrics.

substantial economic burden of HF can be decreased by intensifying efforts to reduce modifiable risk factors, such as tobacco use, sedentary lifestyle, obesity, hypertension, hypercholesterolemia, and diabetes mellitus.[1,6]

The American Heart Association introduced the concept of "ideal cardiovascular health (CVH)" with a focus on risk factor prevention to reduce the burden of cardiovascular diseases (CVDs).[7] Ideal CVH is defined as meeting the ideal levels for 7 health behaviors and factors called Life's Simple 7 (LS7) metrics.[7] These 7 metrics are known traditional risk factors for CVD and they include smoking, physical activity, body mass index (BMI), diet, total cholesterol, blood pressure, and blood glucose.[8–10] Although research has shown that ideal CVH is associated with a lower incidence of CVDs,[11–17] few studies have examined the association between the LS7 metrics and the incidence of HF in an ethnically diverse population.[18,19]

The aim of this study is to analyze data from the MESA (Multi-Ethnic Study of Atherosclerosis), a prospective cohort study, to determine the association between the LS7 metrics and incident HF, based on the hypothesis that favorable LS7 status will confer a lower risk for HF across all 4 racial/ethnic groups independent of other sociodemographic factors such as age, sex, education, income, and health insurance.

Methods

Study Population

The details of the MESA have been previously described by Bild et al.[20] In summary, 6814 study participants were recruited between July 2000 and September 2002 from 6 field centers in the United States (Baltimore, MD; Chicago, IL; Forsyth County, NC; Los Angeles, CA; New York City, NY; and St Paul, MN). They included men and women aged between 45 and 84 years, who were free from clinical CVD (including HF) at baseline. Approximately 38% were white, 28% black, 23% Hispanic, and 11% Chinese American. Participants gave informed consent and the institutional review boards of the 6 centers approved the study protocol. Standardized questionnaires were administered to collect information on the use of medications and socioeconomic characteristics, such as education, income, and health insurance.

Baseline Measurement of LS7 Metrics

Baseline levels of LS7 metrics (smoking, physical activity, BMI, diet, total cholesterol, blood pressure, and blood glucose) were measured between 2000 and 2002. Participants were classified as current smokers, former smokers (if they quit within the last 12 months) or never smokers (if they have never smoked or quit more than 12 months ago). BMI (kg/m^2) was calculated from weight and height measurements. Physical activity was assessed using the MESA Typical Week Physical Activity Survey adapted from the Cross-Cultural Activity Participation Study.[21] The questionnaire contains 28 detailed questions on time and frequency of activities during a typical week in the previous month. Participants provided responses to questions, such as household chores, lawn/yard/garden/farm, care of children/adults, transportation, walking (not at work), dancing and sport activities, conditioning activities, leisure activities, and occupational and volunteer activities. Minutes spent during activities like walking, conditioning, and leisure (eg, exercises) were also included. The total minutes of moderate and vigorous exercise were estimated from the questionnaire.

A validated 120-item food frequency questionnaire was administered to collect information on the dietary habits of study participants. It was modified from the Insulin Resistance Atherosclerosis Study instrument.[22,23] A healthy diet consisted of adequate quantities of 5 items defined by the American Heart Association (fruits and vegetables, fish, whole grains, sodium <1500 mg per day, and sugar-sweetened beverages ≤450 kcal [36 oz] per week).[7]Study participants had their blood pressure assessed from 3 readings taken after they had rested for 5 minutes. The average of the last 2 readings was recorded for analysis. Total cholesterol and blood glucose levels were obtained from fasting blood samples.

Follow-up and Incident HF Definition

Median follow-up time was 12.2 years (interquartile range, 11.6–12.7) resulting in 71 718 person-years of observation. After the baseline examination, study participants were followed up every 9 to 12 months by telephone to obtain information on interim hospital admissions, cardiovascular outpatient diagnoses, and deaths. Self-reported diagnoses were verified from death certificates, medical records for all hospitalizations, and outpatient diagnoses. Hospital records were abstracted by trained personnel and transmitted to the coordinating center. Two physicians (cardiologists or cardiovascular physician epidemiologists) reviewed the records for independent end point classification and disagreements were adjudicated by both. If disagreements were not resolved the full morbidity and mortality classification committee made the final decision. The end point for our study was a combination of probable and definite HF as defined by previously published research from MESA.[24–27] Both required HF symptoms and/or signs such as shortness of breath or edema. Probable HF was defined as a diagnosis of HF made by a physician and medical treatment for HF. For definite HF, 1 or more additional objective criteria were required, such as pulmonary edema/congestion by chest X-ray, dilated ventricle or poor left ventricular function by echocardiography or ventriculography, or evidence of left ventricular diastolic dysfunction. For our analysis, we combined incident definite and probable HF as 1 outcome without stratification into preserved or reduced ejection fraction HF.

Statistical Analysis

Baseline characteristics of study participants were compared by race/ethnicity. Categorical variables were reported as proportions and continuous variables as means with standard deviation (SD). We categorized the LS7 metrics into ideal, intermediate, and poor with modifications as previously reported in MESA (Table S1).[7,28] We created the LS7 score from points assigned to each category of the metrics; poor=0 point, intermediate=1 point, and ideal=2 points. The points were summed for a total LS7 score ranging from 0 to 14.[29] As previously described, we considered 0 to 8, 9 to 10, and 11 to 14 points as inadequate, average, and optimal scores, respectively.[28] The HF incidence rate per 1000 person-years was calculated for each ideal metric and LS7 score category stratified by race/ethnicity. Hazard ratios (HRs) and 95% confidence intervals (CIs) for incident HF were then calculated using 0 to 1 ideal metric as reference for the number of ideal metrics and using the inadequate score as reference for the LS7 score, with stratification by race/ethnicity. *P* values for trend were calculated using the log-rank test. We also calculated the HRs and 95% CIs for incident HF for the intermediate and ideal categories for individual LS7 metrics (using the poor category as reference) stratified by race/ethnicity. Covariates adjusted for included age, sex, race/ethnicity, education, income, and health insurance. We tested for interaction, using the Wald test, between the measures of cardiovascular health (LS7 score and number of ideal metrics) and race/ethnicity by inserting the interaction terms in our models. Kaplan–Meier curves were constructed for HF free survival. A sensitivity analysis was performed where participants with any nonfatal coronary heart disease event at or before the time of incident HF diagnosis were excluded from the study sample. A 2-sided *P* value <0.05 was considered as statistically significant. All statistical analyses were performed in STATA (version 12.1; StataCorp LP, College Station, TX).

Results

Baseline Characteristics

Baseline characteristics of study participants varied across race/ethnicity as shown in Table 1. Final sample size for our study was 6506 after exclusion of study participants with incomplete data on the LS7 metrics, education, and income (n=308). Mean age (SD) by categories of the LS7 score are as follows: Optimal, 60 (10.5); Average, 62 (10.5); and Inadequate, 63 (9.8). BMI, systolic and diastolic blood pressure levels were highest among black participants. Along with Hispanic participants, black participants also had the lowest proportion with 6 to 7 ideal metrics and optimal LS7 scores. Hispanic participants had the lowest proportion with at least a bachelor's degree and income >$40 000. Overall, only 0.1% of participants were in ideal CVH (ideal levels for all 7 metrics).

Incidence of HF

A total of 262 cases (4%) of incident HF were reported during a median follow-up of 12.2 years with an incidence rate of 3.7 per 1000 person-years. Blacks had the highest incidence rate (4.1 per 1000 person-years; Table 1). Participants who developed HF were older (*P*<0.0001) and more likely to be men (*P*<0.0001). They also had higher baseline levels of systolic blood pressure (139 versus 126 mm Hg; *P*<0.0001) and fasting glucose (110 versus 97 mg/dL; *P*<0.0001; Table S2). Incidence of HF was 5.9 per 1000 person-years among participants with 0 to 1 ideal LS7 metrics. Incidence rate decreased to 0.6 per 1000 person-years for participants with 6 to 7 ideal metrics (Table 2). Participants with optimal LS7 scores had a lower incidence rate of HF compared with those with average and inadequate scores (Figure 1). A Kaplan–Meier curve for HF free survival by the categories of the LS7 score for all 4 racial/ethnic groups combined is illustrated in Figure 2 while Figure S1 shows the Kaplan–Meier curves for each race/ethnicity.

Table 1. Baseline Characteristics of Study Participants: MESA (2000–2002)

	Total (N=6506)	White (n=2539)	Chinese American (n=795)	Black (n=1716)	Hispanic (n=1456)
Age	62.0 (10.2)	62.4 (10.2)	62.3 (10.3)	61.7 (10.0)	61.2 (10.4)
Women	53%	52%	51%	56%	51%
Education ≥bachelor's degree	35.8%	50.3%	39.0%	34.8%	10.1%
Income >$40 000	49.4%	68.1%	34.8%	48.0%	26.4%
No health insurance	(9%)	2.6%	19.4%	6.2%	17.5%
Current smoking	12.9%	12%	6%	18%	13%
Body mass index, kg/m^2	28.3 (5.5)	27.7 (5.1)	24.0 (3.3)	30.2 (5.9)	29.4 (5.1)
Physical activity, min/w	402 (605)	435 (591)	296 (395)	446 (727)	348 (554)
Healthy diet score (0–5)	1.6 (0.9)	1.6 (0.9)	1.9 (0.8)	1.5 (0.9)	1.4 (0.9)
Total cholesterol, mg/dL	194 (36)	196 (35)	192 (32)	190 (37)	198 (37)
Systolic blood pressure, mm Hg	126 (21)	123 (20)	124 (22)	131 (21)	127 (22)
Diastolic blood pressure, mm Hg	72 (10)	70 (10)	72 (10)	75 (10)	72 (10)
Fasting glucose, mg/dL	97 (30)	91 (21)	99 (28)	100 (33)	104 (39)
Incident heart failure (per 1000 person-years)	3.7 (3.2–4.1)	3.8 (3.2–4.1)	2.1 (1.4–3.3)	4.1 (3.3–5.1)	3.7 (2.9–4.8)
Baseline categories of ideal Life's Simple 7 metrics					
0 to 2	26.3%	20.8%	16.2%	33.6%	33.8%
3 to 5	69.6%	73.3%	76.0%	64.9%	65.0%
6 to 7	4.2%	5.9%	7.8%	1.5%	2.3%
Baseline Life's Simple 7 score					
Inadequate (0–8)	47%	39%	27%	61%	58%
Average (9–10)	33%	36%	40%	28%	29%
Optimal (11–14)	20%	26%	33%	12%	13%

MESA indicates the Multi-Ethnic Study of Atherosclerosis.

Hazards for Developing HF

Table 3 shows adjusted HRs for incident HF by the number of ideal metrics and LS7 score. In the multivariable adjusted model with the 0 to 1 ideal metric serving as reference, HRs decreased as the number of ideal metrics increased. Participants with 2 and 6 to 7 ideal metrics had adjusted HRs of 0.93 (0.60–1.44) and 0.15 (0.04–0.65), respectively. Participants with average and optimal scores had a statistically significant lower risk of developing HF compared with those with inadequate scores (0.57 [0.43–0.76] and 0.31 [0.19–0.49], respectively). Additionally, we found no evidence of interaction between the measures of cardiovascular health (LS7 score and number of ideal metrics) and race/ethnicity.

Table 4 shows adjusted HRs for incident HF by the categories of each LS7 metrics. For the entire study population, the ideal categories of smoking, BMI, physical activity, blood pressure, and blood glucose were associated with a statistically significant lower risk of developing HF compared with the poor category after adjusting for age, sex, race/ethnicity, education, income, and health insurance. Although there was an increased risk of HF for participants in the ideal categories of diet and total cholesterol, the associations were not statistically significant. Across the racial/ethnic groups, we found a statistically significant lower risk of HF for the ideal versus poor categories of smoking in black; BMI in white; physical activity in Hispanic; blood pressure in white, black and Hispanic; and blood glucose in Chinese American, black, and Hispanic.

Sensitivity Analysis

In the sensitivity analysis, we excluded participants with incident nonfatal coronary heart disease (n=72). Overall, the associations remained the same as shown in Table S3. In addition, incidence rates and hazard ratios for HF decreased with greater numbers of ideal LS7 metrics and higher scores, regardless of age or sex (Tables S4 and S5).

Discussion

In this large, multiethnic population of adults free of clinically evident CVD at baseline, achieving a greater number of ideal

Table 2. Incidence Rates of HF Per 1000 Person-Years by Baseline Levels of Life's Simple 7 Metrics

	Total	White	Chinese American	Black	Hispanic
Incidence rates of heart failure by number of Ideal Life's Simple 7 Metrics					
0 to 1	5.9 (4.1–8.5)	3.3 (1.4–7.9)	4.0 (0.6–28.4)	7.8 (4.4–13.7)	6.9 (3.7–12.8)
2	5.6 (4.4–7.0)	7.5 (5.2–10.6)	2.6 (0.9–8.2)	5.2 (3.5–7.9)	4.7 (2.9–7.6)
3	4.1 (3.3–5.0)	4.0 (2.8–5.6)	3.0 (1.3–6.6)	4.2 (2.9–6.2)	4.5 (3.0–6.7)
4	2.9 (2.2–3.8)	3.7 (2.6–5.3)	2.5 (1.2–5.2)	2.5 (1.3–4.6)	1.9 (0.9–4.1)
5	1.6 (1.0–2.6)	1.8 (0.9–3.5)	1.0 (0.3–4.1)	2.2 (0.8–5.8)	1.2 (0.3–4.7)
6 to 7	0.6 (0.2–2.5)	1.1 (0.3–4.5)	0	0	0

LS7 metrics was associated with a lower incidence of HF. Study participants with average and optimal scores were less likely to develop HF compared with those with inadequate scores, though incidence and risk of HF were much lower for those with optimal scores. Across racial/ethnic groups, a similar trend was observed, but many of the associations were not statistically significant.

The findings of this study are consistent with the results of 2 recently published studies that examined the association between the LS7 metrics and incidence of HF among the offspring of the original cohort of the Framingham study and the ARIC (Atherosclerosis Risk in Communities) Study.[18,19] These studies, though not as ethnically diverse as ours, demonstrated that higher LS7 scores were associated with a lower risk of HF. In the Framingham study, LS7 scores of 8 to 9 and 10 to 14 were associated with a 45% and 66% lower risk of HF, respectively, compared with scores of 0 to 7. In the ARIC study, LS7 scores of 5 to 9 and 10 to 14 were associated with a 51% and 78% lower risk of HF, respectively, compared with scores of 0 to 4. In our study, LS7 scores of 9 to 10 (average) and 11 to 14 (optimal) were associated with a 43% and 69% risk of HF, respectively, compared with scores of 0 to 8 (inadequate). Moreover, achieving greater numbers of ideal LS7 metrics was associated with a lower risk of HF in the ARIC study,[19] which is similar to the findings of our study.

We showed that black participants had the highest incidence of HF followed by Hispanic, white, and Chinese American participants. Bahrami et al, using the same study population had previously reported comparable results and attributed the high incidence of HF found among black participants to the higher prevalences of hypertension and diabetes mellitus, in addition to lower socioeconomic status and higher dietary caloric intake.[25] In our study, black participants had the poorest CVH status followed by Hispanic

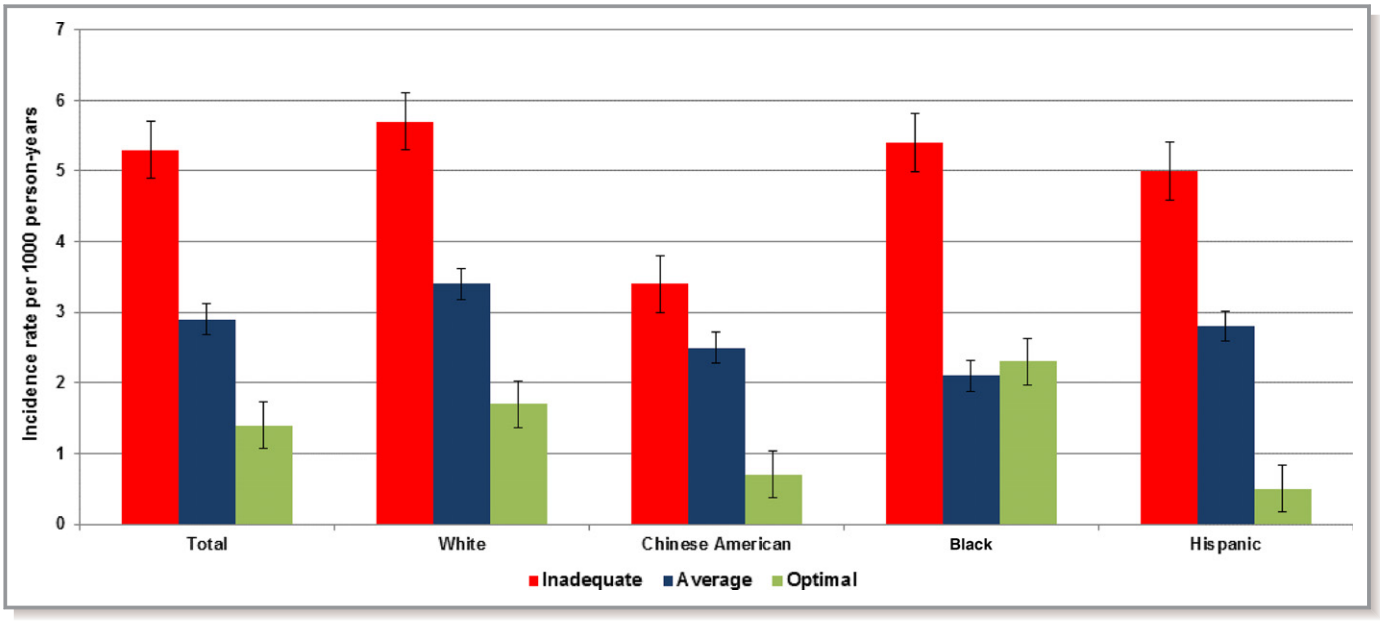


Figure 1. Incidence rates for heart failure per 1000 person-years by Life's Simple 7 Score. The Life's Simple 7 score ranged from 0 to 14 and was classified into inadequate (0–8), average (9–10), and optimal (11–14) based on points assigned to each category of the Life's Simple 7 metrics.

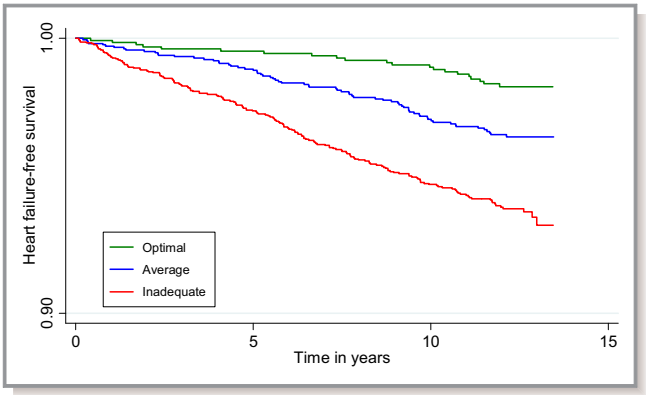


Figure 2. Kaplan–Meier analysis of time to incident heart failure by categories of the Life's Simple 7 Score. The Life's Simple 7 score ranged from 0 to 14 and was classified into inadequate (0–8), average (9–10), and optimal (11–14) based on points assigned to each category of the Life's Simple 7 metrics.

participants. The proportion of current smokers, mean BMI, systolic and diastolic blood pressure levels were highest among black participants while Hispanic participants had the lowest mean dietary score, highest mean cholesterol, and fasting glucose levels. A lower proportion of black and Hispanic participants achieved optimal LS7 scores and greater numbers of ideal metrics compared with white and Chinese American participants. The racial/ethnic differences in the risk of HF in this study is attributable to the higher prevalence of risk factors and lower achievement of ideal LS7 metrics among black and Hispanic participants; nevertheless previous research has demonstrated that factors such as disparities in access to and quality of health care play a major role in the differences observed across the racial/ethnic groups.[25,30]

HF is responsible for a significant clinical and socioeconomic burden. People with HF often experience a reduction in quality of life, higher mortality rates, and increased risk for other CVD events.[31–34] More than half of the people diagnosed with HF will die within 5 years.[32,33] An estimated 870 000 new cases of HF are documented in the United States annually, and, if the current trend continues, it is projected that by 2030 over 8 million people, aged 18 years or older, will have the disease.[5] The financial burden associated with managing HF is also expected to increase by over 120% to ≈$70 billion in the next 14 years. To address this public health issue, the American Heart Association emphasizes the prevention of risk factors in its 2020 strategic impact goals. The goals are to "improve the CVH of all Americans by 20% and reduce the mortality from CVDs and stroke by 20%."[7] The LS7 metrics and the construct of "ideal CVH" were introduced to evaluate the achievement of the goals by monitoring the changing CVH status of individuals and populations within the United States.[7] Several studies have documented that the achievement of ideal CVH is associated with a lower incidence of CVDs and all-cause mortality.[11–16,35] Thus, the morbidity, mortality, and socioeconomic burden associated with HF can likely be reduced by encouraging the public to improve their cardiovascular health by adopting healthy lifestyles and achieving greater numbers of ideal LS7 metrics in midlife.[7,19]

Table 3. Hazard Ratios for HF by Baseline Levels of Life's Simple 7 Metrics

	Total	White	Chinese American	Black	Hispanic
Hazard ratios for heart failure by number of ideal Life's Simple 7 metrics					
0 to 1	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
2	0.93 (0.60–1.44)	2.47 (0.95–6.39)	0.83 (0.08–8.41)	0.72 (0.36–1.45)	0.57 (0.25–1.26)
3	0.68 (0.45–1.05)	1.26 (0.49–3.27)	1.12 (0.13–9.75)	0.56 (0.28–1.12)	0.58 (0.28–1.23)
4	0.52 (0.33–0.83)	1.14 (0.44–2.99)	0.99 (0.12–8.38)	0.37 (0.16–0.85)	0.27 (0.10–0.71)
5	0.34 (0.18–0.63)	0.69 (0.23–2.10)	0.41 (0.04–4.71)	0.32 (0.10–1.01)	0.19 (0.04–0.87)
6 to 7	0.15 (0.04–0.65)	0.49 (0.09–2.57)	–	–	–
P for trend	<0.0001	0.0003	0.5399	0.0406	0.0264
Hazard ratios for heart failure by Life's Simple 7 score					
Inadequate (0–8)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Average (9–10)	0.57 (0.43–0.76)	0.58 (0.38–0.88)	0.80 (0.31–2.10)	0.40 (0.21–0.76)	0.62 (0.33–1.16)
Optimal (11–14)	0.31 (0.19–0.49)	0.31 (0.17–0.58)	0.24 (0.05–1.13)	0.48 (0.19–1.20)	0.11 (0.01–0.79)
P for trend	<0.0001	<0.0001	0.0773	0.0041	0.0035

– signifies extremely small hazard ratios. Hazard ratios were adjusted for age, sex, race/ethnicity, education, income, and health insurance. Hazard ratios stratified by race/ethnicity were not adjusted for race/ethnicity. *P* for trend was calculated using log-rank test.

Table 4. Hazard Ratios for HF by Baseline Levels of Life's Simple 7 Metrics

	Total	White	Chinese American	Black	Hispanic
Smoking					
Poor	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Intermediate	0.51 (0.12–2.12)	0.46 (0.06–3.54)	–	1.17 (0.15–8.91)	–
Ideal	0.64 (0.45–0.93)	0.56 (0.31–1.03)	–	0.57 (0.33–0.99)	1.02 (0.40–2.62)
Body mass index					
Poor	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Intermediate	0.64 (0.48–0.84)	0.73 (0.48–1.13)	0.34 (0.07–1.71)	0.54 (0.32–0.91)	0.55 (0.30–1.00)
Ideal	0.58 (0.41–0.81)	0.45 (0.27–0.77)	0.28 (0.06–1.32)	0.58 (0.30–1.13)	0.99 (0.51–1.96)
Physical activity					
Poor	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Intermediate	0.96 (0.66–1.39)	0.95 (0.51–1.76)	1.33 (0.29–6.04)	1.09 (0.55–2.17)	0.79 (0.38–1.63)
Ideal	0.72 (0.54–0.96)	0.76 (0.46–1.24)	1.39 (0.38 5.11)	0.85 (0.49–1.45)	0.41 (0.22–0.74)
Diet					
Poor	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Intermediate	1.05 (0.82–1.36)	0.97 (0.65–1.43)	0.61 (0.21–1.80)	1.26 (0.79–2.02)	1.00 (0.59–1.68)
Ideal	1.12 (0.35–3.57)	1.58 (0.38–6.69)	–	1.57 (0.21–11.79)	–
Total cholesterol					
Poor	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Intermediate	1.12 (0.74–1.69)	0.95 (0.52–1.74)	0.73 (0.15–3.69)	1.71 (0.66–4.43)	1.12 (0.49–2.55)
Ideal	1.28 (0.85–1.92)	1.16 (0.64–2.11)	1.09 (0.24–5.00)	1.72 (0.67–4.40)	1.13 (0.51–2.50)
Blood pressure					
Poor	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Intermediate	0.55 (0.41–0.75)	0.52 (0.32–0.83)	0.41 (0.11–1.47)	0.37 (0.19–0.72)	1.01 (0.57–1.79)
Ideal	0.40 (0.27–0.57)	0.45 (0.27–0.75)	0.34 (0.09–1.25)	0.40 (0.19–0.85)	0.33 (0.13–0.82)
Blood glucose					
Poor	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Intermediate	0.53 (0.36–0.76)	0.74 (0.35–1.57)	0.60 (0.19–1.92)	0.44 (0.23–0.83)	0.52 (0.25–1.06)
Ideal	0.36 (0.26–0.48)	0.53 (0.28–1.00)	0.24 (0.08–0.71)	0.31 (0.19–0.52)	0.34 (0.19–0.61)

– signifies extremely small hazard ratios. Hazard ratios were adjusted for age, sex, race/ethnicity, education, income, and health insurance. Hazard ratios stratified by race/ethnicity were not adjusted for race/ethnicity.

Strengths of our study include the large ethnically diverse population that included Chinese and Hispanic study participants who were not included in previous studies.[18,19] The findings from these 2 populations underscore the importance of CVD risk factor prevention across all racial/ethnic groups. Additional strengths include the standardized methods/procedures for the measurement of the LS7 metrics and the inclusion of only participants free of CVD at baseline. HF events were carefully adjudicated by trained physicians, and the longitudinal design of the study allowed for the assessment of incident HF rather than HF prevalence.

Our study has limitations. Because the same objective criteria were used by MESA in diagnosing incident HF in all 4 racial/ethnic groups and no adjustment made for race/ethnicity, incident HF may have been underdiagnosed in Chinese American participants because left ventricular dimensions are mostly smaller and ejection fraction higher in Asian populations compared with people of European or African descent.[36] Overall, participants with average and optimal scores had a lower risk for HF regardless of HF subtype (preserved and reduced ejection fraction) in comparison to those with inadequate scores although the associations were not statistically significant. However, the low number of events precluded the assessment of our associations across all 4 racial/ethnic groups by HF subtype because of the limited power for subanalysis. Additionally, a single baseline measurement of the LS7 metrics may not reflect past or future CVH status of study participants. The

data collected on smoking, physical activity, and diet from the self-administered questionnaires may be subject to recall bias. Future modifications of the LS7 metrics could make BMI specific for each racial/ethnic group because some studies have demonstrated that Asians are at a higher risk of weight-related diseases, such as CVDs, at lower BMIs.[37–40]

In conclusion, our study shows that favorable Life's Simple 7 status, as indicated by higher scores or a greater number of metrics at ideal levels, is associated with a lower risk of incident HF. Of note, patterns were the same for all racial/ethnic groups. These findings suggest that prevention of risk factors has the potential to reduce the burden of HF and the associated healthcare costs.

Acknowledgments

The authors thank the other investigators, the staff, and the participants of the Multi-Ethnic Study of Atherosclerosis for their valuable contributions. A full list of participating MESA investigators and institutions can be found at http://www.mesa-nhlbi.org.

Sources of Funding

The Multi-Ethnic Study of Atherosclerosis is supported by contracts N01-HC-95159, N01-HC-95160, N01-HC-95161, N01-HC-95162, N01-HC-95163, N01-HC-95164, N01-HC-95164, N01-HC-95165, N01-HC-95166, N01-HC-95167, N01-HC-95168, and N01-HC-95169 from the National Heart, Lung, and Blood Institute (NHLBI) and by grants UL1-RR-024156 and UL1-RR-025005 from the National Center for Research Resources (NCRR).

Disclosures

None.

References

1. Schocken DD, Benjamin EJ, Fonarow GC, Krumholz HM, Levy D, Mensah GA, Narula J, Shor ES, Young JB, Hong Y. Prevention of heart failure: a scientific statement from the American Heart Association Councils on Epidemiology and Prevention, Clinical Cardiology, Cardiovascular Nursing, and High Blood Pressure Research; Quality of Care and Outcomes Research Interdisciplinary Working Group; and Functional Genomics and Translational Biology Interdisciplinary Working Group. *Circulation*. 2008;117:2544–2565.
2. Roger VL. Epidemiology of heart failure. *Circ Res*. 2013;113:646–659.
3. Sanderson J, Tse TF. Heart failure: a global disease requiring a global response. *Heart*. 2003;89:585–586.
4. Vigen R, Maddox TM, Allen LA. Aging of the United States population: impact on heart failure. *Curr Heart Fail Rep*. 2012;9:369–374.
5. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, de Ferranti S, Després JP, Fullerton HJ, Howard VJ, Huffman MD, Judd SE, Kissela BM, Lackland DT, Lichtman JH, Lisabeth LD, Liu S, Mackey RH, Matchar DB, McGuire DK, Mohler ER III, Moy CS, Muntner P, Mussolino ME, Nasir K, Neumar RW, Nichol G, Palaniappan L, Pandey DK, Reeves MJ, Rodriguez CJ, Sorlie PD, Stein J, Towfighi A, Turan TN, Virani SS, Willey JZ, Woo D, Yeh RW, Turner MB; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics–2015 update: a report from the American Heart Association. *Circulation*. 2015;131:e29–e322.
6. Butler J. Primary prevention of heart failure. *ISRN Cardiol*. 2012;2012:982417.
7. Lloyd-Jones DM, Hong Y, Labarthe D, Mozaffarian D, Appel LJ, Van Horn L, Greenlund K, Daniels S, Nichol G, Tomaselli GF, Arnett DK, Fonarow GC, Ho PM, Lauer MS, Masoudi FA, Robertson RM, Roger V, Schwamm LH, Sorlie P, Yancy CW, Rosamond WD; American Heart Association Strategic Planning Task Force and Statistics Committee. Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic Impact Goal through 2020 and beyond. *Circulation*. 2010;121:586–613.
8. Stamler J, Stamler R, Neaton JD, Wentworth D, Daviglus ML, Garside D, Dyer AR, Liu K, Greenland P. Low risk-factor profile and long-term cardiovascular and noncardiovascular mortality and life expectancy: findings for 5 large cohorts of young adult and middle-aged men and women. *JAMA*. 1999;282:2012–2018.
9. Stampfer MJ, Hu FB, Manson JE, Rimm EB, Willett WC. Primary prevention of coronary heart disease in women through diet and lifestyle. *N Engl J Med*. 2000;343:16–22.
10. Sidebottom AC, Sillah A, Miedema MD, Vock DM, Pereira R, Benson G, Boucher JL, Knickelbine T, Lindberg R, VanWormer JJ. Changes in cardiovascular risk factors after 5 years of implementation of a population-based program to reduce cardiovascular disease: the Heart of New Ulm Project. *Am Heart J*. 2016;175:66–76.
11. Ford ES, Greenlund KJ, Hong Y. Ideal cardiovascular health and mortality from all causes and diseases of the circulatory system among adults in the United States. *Circulation*. 2012;125:987–995.
12. Kim JY, Ko YJ, Rhee CW, Park BJ, Kim DH, Bae JM, Shin MH, Lee MS, Li ZM, Ahn YO. Cardiovascular health metrics and all-cause and cardiovascular disease mortality among middle-aged men in Korea: the Seoul male cohort study. *J Prev Med Public Health*. 2013;46:319–328.
13. Liu Y, Chi HJ, Cui LF, Yang XC, Wu YT, Huang Z, Zhao HY, Gao JS, Wu SL, Cai J. The ideal cardiovascular health metrics associated inversely with mortality from all causes and from cardiovascular diseases among adults in a Northern Chinese industrial city. *PLoS ONE*. 2014;9:e89161.
14. Folsom AR, Yatsuya H, Nettleton JA, Lutsey PL, Cushman M, Rosamond WD; ARIC Study Investigators. Community prevalence of ideal cardiovascular health, by the American Heart Association definition, and relationship with cardiovascular disease incidence. *J Am Coll Cardiol*. 2011;57:1690–1696.
15. Yang Q, Cogswell ME, Flanders WD, Hong Y, Zhang Z, Loustalot F, Gillespie C, Merritt R, Hu FB. Trends in cardiovascular health metrics and associations with all-cause and CVD mortality among US adults. *JAMA*. 2012;307:1273–1283.
16. Dong C, Rundek T, Wright CB, Anwar Z, Elkind MS, Sacco RL. Ideal cardiovascular health predicts lower risks of myocardial infarction, stroke, and vascular death across whites, blacks, and hispanics: the Northern Manhattan study. *Circulation*. 2012;125:2975–2984.
17. Lin MP, Ovbiagele B, Markovic D, Towfighi A. "Life's simple 7"and long-term mortality after stroke. *J Am Heart Assoc*. 2015;4:e001470. DOI: 10.1161/JAHA.114.001470.
18. Nayor M, Enserro DM, Vasan RS, Xanthakis V. Cardiovascular health status and incidence of heart failure in the Framingham Offspring study. *Circ Heart Fail*. 2016;9:e002416.
19. Folsom AR, Shah AM, Lutsey PL, Roetker NS, Alonso A, Avery CL, Miedema MD, Konety S, Chang PP, Solomon SD. American Heart Association's Life's Simple 7: avoiding heart failure and preserving cardiac structure and function. *Am J Med*. 2015;128:e2.
20. Bild DE, Bluemke DA, Burke GL, Detrano R, Diez Roux AV, Folsom AR, Greenland P, Jacob DR Jr, Kronmal R, Liu K, Nelson JC, O'Leary D, Saad MF, Shea S, Szklo M, Tracy RP. Multi-ethnic study of atherosclerosis: objectives and design. *Am J Epidemiol*. 2002;156:871–881.
21. Ainsworth BE, Irwin ML, Addy CL, Whitt MC, Stolarczyk LM. Moderate physical activity patterns of minority women: the Cross-Cultural Activity Participation Study. *J Womens Health Gend Based Med*. 1999;8:805–813.
22. Block G, Woods M, Potosky A, Clifford C. Validation of a self-administered diet history questionnaire using multiple diet records. *J Clin Epidemiol*. 1990;43:1327–1335.
23. Mayer-Davis EJ, Vitolins MZ, Carmichael SL, Hemphill S, Tsaroucha G, Rushing J, Levin S. Validity and reproducibility of a food frequency interview in a multicultural epidemiologic study. *Ann Epidemiol*. 1999;9:314–324.
24. Bahrami H, Bluemke DA, Kronmal R, Bertoni AG, Lloyd-Jones DM, Shahar E, Szklo M, Lima JA. Novel metabolic risk factors for incident heart failure and their relationship with obesity: the MESA (Multi-Ethnic Study of Atherosclerosis) study. *J Am Coll Cardiol*. 2008a;51:1775–1783.
25. Bahrami H, Kronmal R, Bluemke DA, Olson J, Shea S, Liu K, Burke GL, Lima JA. Differences in the incidence of congestive heart failure by ethnicity: the multi-ethnic study of atherosclerosis. *Arch Intern Med*. 2008b;168:2138–2145.
26. Ebong IA, Goff DC Jr, Rodriguez CJ, Chen H, Sibley CT, Bertoni AG. Association of lipids with incident heart failure among adults with and without diabetes

mellitus: Multiethnic Study of Atherosclerosis. *Circ Heart Fail*. 2013;6:371–378.

27. Habibi M, Chahal H, Opdahl A, Gjesdal O, Helle-Valle TM, Heckbert SR, McClelland R, Wu C, Shea S, Hundley G, Bluemke DA, Lima JA. Association of CMR-measured LA function with heart failure development: results from the MESA study. *JACC Cardiovasc Imaging*. 2014;7:570–579.
28. Unger E, Diez-Roux AV, Lloyd-Jones DM, Mujahid MS, Nettleton JA, Bertoni A, Badon SE, Ning H, Allen NB. Association of neighborhood characteristics with cardiovascular health in the Multi-Ethnic Study of Atherosclerosis. *Circ Cardiovasc Qual Outcomes*. 2014;7:524–531.
29. Lloyd-Jones DM. Improving the cardiovascular health of the US population. *JAMA*. 2012;307:1314–1316.
30. Alexander M, Grumbach K, Selby J, Brown AF, Washington E. Hospitalization for congestive heart failure: explaining racial differences. *JAMA*. 1995;274:1037–1042.
31. Juenger J, Schellberg D, Kraemer S, Haunstetter A, Zugck C, Herzog W, Haass M. Health related quality of life in patients with congestive heart failure: comparison with other chronic diseases and relation to functional variables. *Heart*. 2002;87:235–241.
32. Roger VL, Weston SA, Redfield MM, Hellermann-Homan JP, Killian J, Yawn BP, Jacobsen SJ. Trends in heart failure incidence and survival in a community-based population. *JAMA*. 2004;292:344–350.
33. National Center for Health Statistics. Mortality Multiple Cause Micro-data Files. 2016; Available at: http://www.cdc.gov/nchs/data_access/Vitalstatsonline.htm#Mortality_Multiple. Accessed March 7, 2016.
34. Mosterd A, Hoes AW. Clinical epidemiology of heart failure. *Heart*. 2007;93:1137–1146.
35. González HM, Tarraf W, Rodríguez CJ, Gallo LC, Sacco RL, Talavera GA, Heiss G, Kizer JR, Hernandez R, Davis S, Schneiderman N, Daviglus ML, Kaplan RC. Cardiovascular health among diverse Hispanics/Latinos: Hispanic Community Health Study/Study of Latinos (HCHS/SOL) results. *Am Heart J*. 2016;176:134–144.
36. Echocardiographic Normal Ranges Meta-Analysis of the Left Heart Collaboration. Ethnic-specific normative reference values for echocardiographic LA and LV size, LV mass, and systolic function: The EchoNoRMAL Study. *JACC Cardiovasc Imaging*. 2015;8:656–665.
37. Shai I, Jiang R, Manson JE, Stampfer MJ, Willett WC, Colditz GA, Hu FB. Ethnicity, obesity, and risk of type 2 diabetes in women: a 20-year follow-up study. *Diabetes Care*. 2006;29:1585–1590.
38. Deurenberg-Yap M, Schmidt G, van Staveren WA, Deurenberg P. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. *Int J Obes Relat Metab Disord*. 2000;24:1011–1017.
39. Wen CP, David Cheng TY, Tsai SP, Chan HT, Hsu HL, Hsu CC, Eriksen MP. Are Asians at greater mortality risks for being overweight than Caucasians? Redefining obesity for Asians. *Public Health Nutr*. 2009;12:497–506.
40. Pan WH, Flegal KM, Chang HY, Yeh WT, Yeh CJ, Lee WC. Body mass index and obesity-related metabolic disorders in Taiwanese and US whites and blacks: implications for definitions of overweight and obesity for Asians. *Am J Clin Nutr*. 2004;79:31–39.

SUPPLEMENTAL MATERIAL

Table S1. Distribution of Life's Simple 7 Metrics

LS7 Metrics	Score	Definition	% MESA Participants, N=6506
Smoking	0	Current smoker	12.9%
	1	Former smoker, quit ≤12 mo ago	1.2%
	2	Never smoker or quit >12 mo ago	85.9%
Body Mass Index	0	≥30 kg/m^2	31.9%
	1	25.0–29.99 kg/m^2	39.3%
	2	<25.0 kg/m^2	28.8%
Physical Activity*	0	No exercise	22.8%
	1	1–149 min of moderate exercise or 1–74 min of vigorous exercise/week	17.3%
	2	150+ min of moderate exercise or 75+ min of vigorous exercise/week	59.8%
Diet	0	0–1 components of healthy diet	45.2%
	1	2–3 components of healthy diet	53.7%
	2	4–5 components of healthy diet	1.1%
Total Cholesterol	0	≥240 mg/dL	13.4%
	1	200–239 mg/dL or treated to <200 mg/dL	39.1%
	2	<200 mg/dL, unmedicated	47.5%
Blood Pressure	0	SBP ≥140 mmHg or DBP ≥90 mmHg	37.5%
	1	SBP 120–139 mmHg or DBP 80–89 mmHg or treated to <120/80 mmHg	28.0%
	2	<120/80 mm Hg, unmedicated	34.6%
Blood Glucose	0	≥126 mg/dL fasting	10.8%
	1	100–125 mg/dL fasting or treated to <100 mg/dL	15.2%
	2	<100 mg/dL fasting, unmedicated	74.1%

Adapted from Lloyd Jones et al [1] and Unger et al [2], DBP indicates diastolic blood pressure and SBP, systolic blood pressure. Poor=0 point, Intermediate=1 point, ideal =2 points. *When combining vigorous and moderate exercise, vigorous exercise was weighted double.

Table S2. Baseline Characteristics of Participants by Development of Heart Failure			
	Yes	No	P Value
Characteristics	n=262	n=6,244	
Age	69 (8.9)	62.0 (10.2)	<.0001
Female	41%	53%	<.0001
White	110 (42%)	2,429 (39%)	
Chinese American	19 (7%)	776 (12%)	0.870
African American	75 (29%)	1,641 (26%)	
Hispanic	58 (22%)	1,398 (22%)	
Education ≥ Bachelor's Degree	31.3%	36.0%	0.975
Income >$40,000	40.1%	50.0%	0.002
No health insurance	6.5%	9%	0.157
Current Smoking	14%	13%	0.765
Body-mass Index (kilograms/meter^2)	29.7 (6)	28.2 (5)	<.0001
Physical Activity (min/week)	349 (539)	404 (608)	0.148
Healthy diet score (0-5)	1.6 (0.9)	1.6 (0.9)	0.635
Total Cholesterol (mg/dL)	189 (35)	194 (36)	0.009
Systolic blood pressure (mmHg)	138 (23)	126 (21)	<.0001
Diastolic blood pressure (mmHg)	74 (12)	72 (10)	<.0001
Fasting Glucose (mg/dL)	109 (46)	97 (30)	<.0001
Baseline categories of Ideal Life's Simple 7 Metrics			
0-2	38.6%	25.8%	
3-5	60.7%	69.9%	<.0001
6-7	0.8%	4.3%	
Baseline Total Life's Simple 7 Score			
Inadequate (0-8)	65.7%	46.6%	
Average (9-10)	26.3%	32.9%	<.0001
Optimal (11-14)	8.0%	20.6%	

Table S3. Hazard Ratios for Heart Failure after exclusion of participants with non-fatal CHD*

	Total	White	Chinese American	African American	Hispanic
Hazard Ratios for Heart Failure by Number of Ideal Life's Simple 7 Metrics					
0-1	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
2	0.83 (0.49-1.38)	8.34 (1.12-62.11)	0.51 (0.04-6.08)	0.58 (0.28-1.22)	0.31 (0.11-0.93)
3	0.72 (0.44-1.18)	4.35 (0.59-32.29)	0.48 (0.05-4.97)	0.54 (0.27-1.09)	0.64 (0.26-1.56)
4	0.49 (0.28-0.84)	3.28 (0.44-24.66)	0.66 (0.07-6.06)	0.27 (0.10-0.68)	0.29 (0.09-0.92)
5	0.33 (0.16-0.68)	1.98 (0.24-16.72)	0.18 (0.01-2.97)	0.34 (0.11-1.06)	0.13 (0.02-1.12)
6-7	0.21 (0.05-0.90)	2.06 (0.18-22.93)	-	-	-
P for trend	0.0001	0.0014	0.5499	0.0177	0.0510
Hazard Ratios for Heart Failure by Life's Simple 7 Score					
Inadequate (0-8)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Average (9-10)	0.52 (0.36-0.73)	0.48 (0.29-0.80)	0.82 (0.25-2.73)	0.37 (0.18-0.76)	0.64 (0.29-1.43)
Optimal (11-14)	0.32 (0.19-0.55)	0.30 (0.15-0.61)	0.18 (0.02-1.58)	0.44 (0.16-1.23)	0.18 (0.02-1.34)
P for trend	<0.0001	0.0005	0.1512	0.0041	0.0412

* Seventy-two participants with non-fatal CHD were excluded. - signifies extremely small Hazard ratios. Hazard ratios were adjusted for age, sex, race/ethnicity, education, income and health insurance. Hazard ratios stratified by race/ethnicity were not adjusted for race/ethnicity. P for trend was calculated using Log rank test.

Table S4. Incidence Rates of Heart Failure per 1000 Person-years by sex and age

	Total	<65	≥65	Women	Men
Incidence Rates of Heart Failure by Number of Ideal Life's Simple 7 Metrics					
0-1	5.9 (4.0-8.5)	4.8 (2.8-8.2)	7.4 (4.4-12.2)	4.6 (2.6-8.1)	7.5 (4.6-12.2)
2	5.6 (4.4-7.0)	3.2 (2.0-4.8)	8.6 (6.5-11.3)	4.8 (3.4-6.7)	6.5 (4.7-8.8)
3	4.1 (3.3-5.0)	1.7 (1.1-2.6)	7.3 (5.8-9.3)	3.3 (2.4-4.5)	5.0 (3.8-6.5)
4	2.9 (2.2-3.8)	1.0 (0.5-1.8)	5.9 (4.3-7.9)	1.8 (1.1-2.9)	4.2 (3.0-5.8)
5	1.6 (1.0-2.6)	1.0 (0.5-2.1)	2.9 (1.6-5.5)	0.9 (0.4-2.2)	2.4 (1.4-4.3)
6-7	0.6 (0.2-2.5)	0	2.4 (0.6-9.5)	0.5 (0.1-3.8)	0.8 (0.1-5.5)
Incidence Rates of Heart Failure by Life's Simple 7 Score					
Inadequate (0-8)	5.3 (4.5-6.1)	2.8 (2.1-3.7)	8.6 (7.2-10.3)	4.2 (3.3-5.3)	6.4 (5.3-7.8)
Average (9-10)	2.9 (2.3-3.7)	0.9 (0.5-1.6)	5.9 (4.5-7.6)	2.0 (1.4-3.0)	3.9 (2.9-5.2)
Optimal (11-14)	1.4 (0.9-2.1)	0.8 (0.4-1.6)	2.4 (1.4-4.2)	1.0 (0.5-2.0)	1.9 (1.1-3.3)

Table S5. Hazard Ratios for Heart Failure by age (<65 & ≥65) and sex

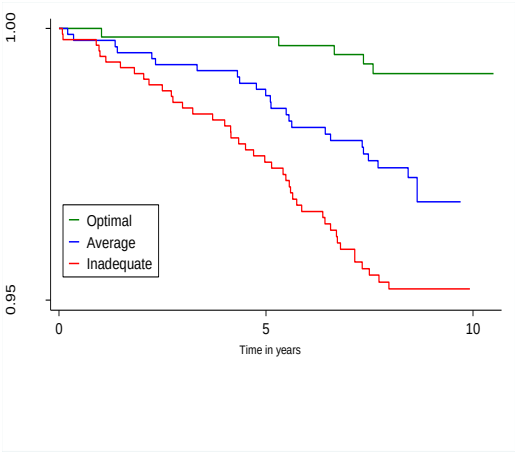
Hazard Ratios for Heart Failure by Number of Ideal Life's Simple 7 Metrics					
	Total	**<65**	**≥65**	**Women**	**Men**
0-1	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
2	0.93 (0.60-1.44)	0.69 (0.35-1.37)	1.18 (0.66-2.10)	1.03 (0.53-2.00)	0.84 (0.47-1.50)
3	0.68 (0.45-1.05)	0.38 (0.19-0.77)	1.00 (0.57-1.75)	0.73 (0.38-1.40)	0.64 (0.36-1.12)
4	0.52 (0.33-0.83)	0.24 (0.10-0.53)	0.81 (0.45-1.47)	0.42 (0.20-0.88)	0.58 (0.32-1.04)
5	0.34 (0.18-0.63)	0.25 (0.10-0.65)	0.41 (0.18-0.92)	0.26 (0.09-0.76)	0.37 (0.17-0.79)
6-7	0.15 (0.04-0.65)	-	0.33 (0.08-1.48)	0.18 (0.02-1.39)	0.13 (0.02-0.99)
P for trend	<0.0001	<0.0001	0.0136	<0.0001	0.0033
Hazard Ratios for Heart Failure by Life's Simple 7 Score					
Inadequate (0-8)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Average (9-10)	0.57 (0.43-0.76)	0.36 (0.19-0.67)	0.68 (0.49-0.95)	0.47 (0.30-0.75)	0.64 (0.45-0.93)
Optimal (11-14)	0.31 (0.19-0.49)	0.34 (0.16-0.73)	0.28 (0.15-0.50)	0.27 (0.13-0.57)	0.33 (0.18-0.59)
P for trend	<0.0001	0.0001	<0.0001	<0.0001	<0.0001

-signifies extremely small Hazard ratios. Hazard ratios were adjusted for age, sex, race/ethnicity, education, income and health insurance. Hazard ratios stratified by race/ethnicity was not adjusted for race/ethnicity. P for trend was calculated using Log rank test.

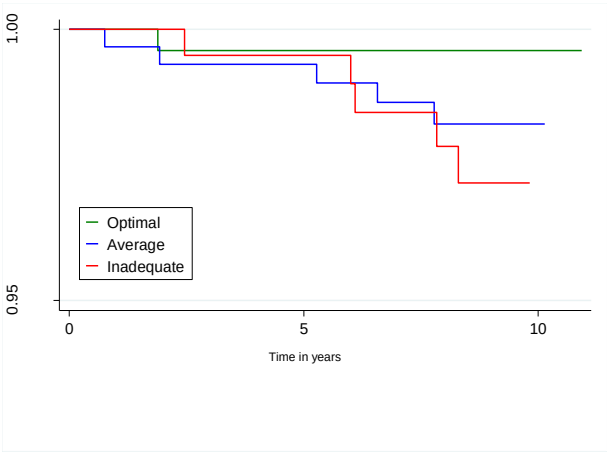
Table S6. Hazard Ratios by Heart Failure Subtype		
LS7 score	**Preserved ejection fraction HF**	**Reduced ejection fraction HF**
Inadequate (0-8)	1 (Ref)	1 (Ref)
Average (9-10)	0.37 (0.12-1.13)	0.47 (0.14-1.60)
Optimal (11-14)	0.56 (0.28-1.12)	0.82 (0.44-1.52)

Figure S1. Kaplan Meier analysis of time to incident heart failure by categories of the Life's Simple 7 Score.

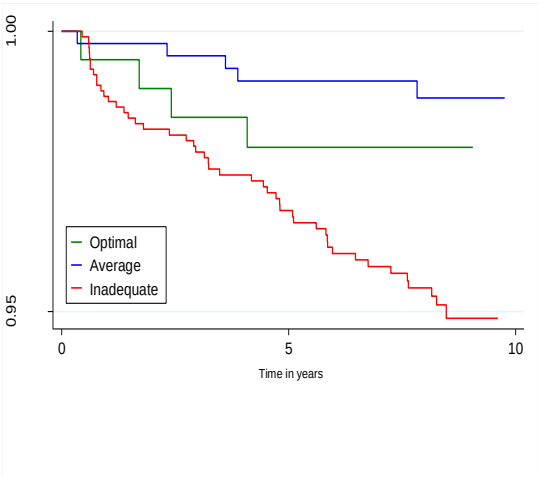
White Participants



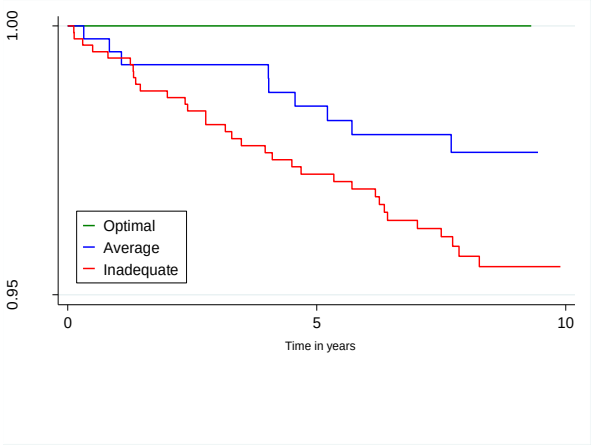
Chinese American Participants



African American Participants



Hispanic Participants



The Life's Simple 7 score ranged from 0-14 and was classified into inadequate (0-8), average (9-10) and optimal (11-14) based on points assigned to each category of the LS7 metrics

Supplemental References:

1. Lloyd-Jones DM, Hong Y, Labarthe D, Mozaffarian D, Appel LJ, Van Horn L, Greenlund K, Daniels S, Nichol G, Tomaselli GF, Arnett DK, Fonarow GC, Ho PM, Lauer MS, Masoudi FA, Robertson RM, Roger V, Schwamm LH, Sorlie P, Yancy CW, Rosamond WD; American Heart Association Strategic Planning Task Force and Statistics Committee. Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic Impact Goal through 2020 and beyond. *Circulation.* 2010;121:586-613.

2. Unger E, Diez-Roux AV, Lloyd-Jones DM, Mujahid MS, Nettleton JA, Bertoni A, Badon SE, Ning H, Allen NB. Association of neighborhood characteristics with cardiovascular health in the Multi-Ethnic Study of Atherosclerosis. *Circ Cardiovasc Qual Outcomes.* 2014;7:524-31.

Life's Simple 7 and Incident Heart Failure: The Multi–Ethnic Study of Atherosclerosis

Oluseye Ogunmoroti, Ebenezer Oni, Erin D. Michos, Erica S. Spatz, Norrina B. Allen, Jamal S. Rana, Salim S Virani, Ron Blankstein, Konstantinos N. Aronis, Roger S. Blumenthal, Emir Veledar, Moyses Szklo, Michael J. Blaha and Khurram Nasir

J Am Heart Assoc. 2017;6:e005180; originally published June 27, 2017;
doi: 10.1161/JAHA.116.005180
The *Journal of the American Heart Association* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Online ISSN: 2047-9980