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

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**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

**H**eat failure (HF) prevention is a top public health priority.<sup>1</sup> Approximately 23 million people have HF worldwide,<sup>2</sup> a number that is expected to rise because of the

aging population and increasing prevalence of risk factors.<sup>3,4</sup> In the United States, an estimated 5.7 million people have HF, with a total annual cost of \$30.7 billion.<sup>5</sup> Incidence and

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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>

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## 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.<sup>1,6</sup>

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).<sup>7</sup> Ideal CVH is defined as meeting the ideal levels for 7 health behaviors and factors called Life's Simple 7 (LS7) metrics.<sup>7</sup> 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.<sup>8–10</sup> Although research has shown that ideal CVH is associated with a lower incidence of CVDs,<sup>11–17</sup> few studies have examined the association between the LS7 metrics and the incidence of HF in an ethnically diverse population.<sup>18,19</sup>

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.<sup>20</sup> 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<sup>2</sup>) 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.<sup>21</sup> 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.<sup>22,23</sup> 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).<sup>7</sup> 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.<sup>24–27</sup> 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).<sup>7,28</sup> 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.<sup>29</sup> As previously described, we considered 0 to 8, 9 to 10, and 11 to 14 points as inadequate, average, and optimal scores, respectively.<sup>28</sup> 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 <sup>2</sup>	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

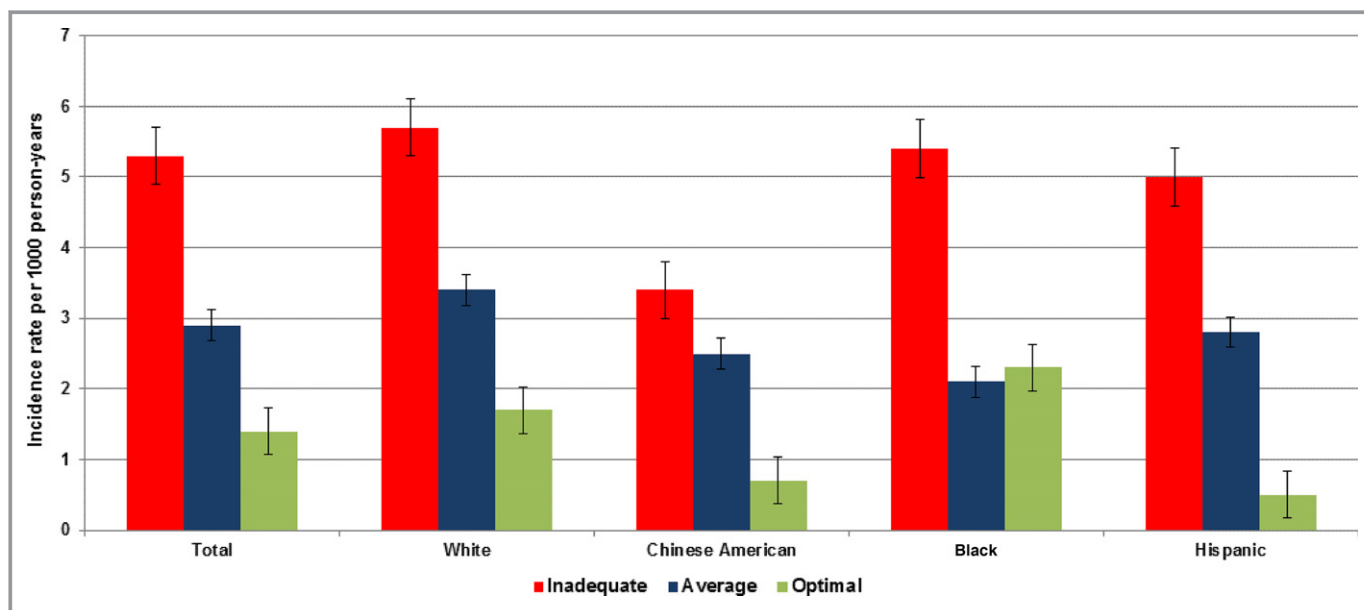
	Total	White	Chinese American	Black	Hispanic
Incidence rates of heart failure by number of Ideal Life's Simple 7 Metrics					
0 to 1	5.9 (4.1–8.5)	3.3 (1.4–7.9)	4.0 (0.6–28.4)	7.8 (4.4–13.7)	6.9 (3.7–12.8)
2	5.6 (4.4–7.0)	7.5 (5.2–10.6)	2.6 (0.9–8.2)	5.2 (3.5–7.9)	4.7 (2.9–7.6)
3	4.1 (3.3–5.0)	4.0 (2.8–5.6)	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.

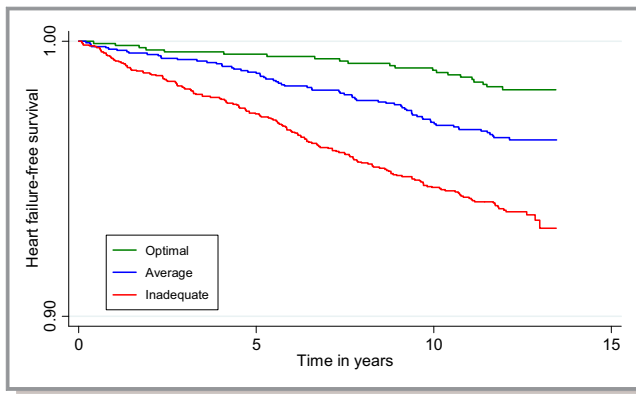
The findings of this study are consistent with the results of 2 recently published studies that examined the association between the LS7 metrics and incidence of HF among the offspring of the original cohort of the Framingham study and the ARIC (Atherosclerosis Risk in Communities) Study.<sup>18,19</sup> 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,<sup>19</sup> 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.<sup>25</sup> 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.<sup>25,30</sup>

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.<sup>31–34</sup> More than half of the people diagnosed with HF will die within 5 years.<sup>32,33</sup> 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.<sup>5</sup> 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%.”<sup>7</sup> 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.<sup>7</sup> Several studies have documented that the achievement of ideal CVH is associated with a lower incidence of CVDs and all-cause mortality.<sup>11–16,35</sup> 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.<sup>7,19</sup>

**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)	–	–	–
<i>P</i> 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)
<i>P</i> 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
<b>Smoking</b>					
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)
<b>Body mass index</b>					
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)
<b>Physical activity</b>					
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)
<b>Diet</b>					
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)	–
<b>Total cholesterol</b>					
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)
<b>Blood pressure</b>					
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)
<b>Blood glucose</b>					
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.<sup>18,19</sup> 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.<sup>36</sup> 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.<sup>37–40</sup>

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.

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## Disclosures

None.

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# SUPPLEMENTAL MATERIAL

**Table S1. Distribution of Life's Simple 7 Metrics**

LS7 Metrics	Score	Definition	% MESA Participants, N=6506
<b>Smoking</b>	0	Current smoker	12.9%
	1	Former smoker, quit ≤12 mo ago	1.2%
	2	Never smoker or quit >12 mo ago	85.9%
<b>Body Mass Index</b>	0	≥30 kg/m <sup>2</sup>	31.9%
	1	25.0–29.99 kg/m <sup>2</sup>	39.3%
	2	<25.0 kg/m <sup>2</sup>	28.8%
<b>Physical Activity*</b>	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%
<b>Diet</b>	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%
<b>Total Cholesterol</b>	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%
<b>Blood Pressure</b>	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%
<b>Blood Glucose</b>	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
<b>Characteristics</b>	n=262	n=6,244	
<b>Age</b>	69 (8.9)	62.0 (10.2)	<.0001
<b>Female</b>	41%	53%	<.0001
<b>White</b>	110 (42%)	2,429 (39%)	
<b>Chinese American</b>	19 (7%)	776 (12%)	0.870
<b>African American</b>	75 (29%)	1,641 (26%)	
<b>Hispanic</b>	58 (22%)	1,398 (22%)	
<b>Education <math>\geq</math> Bachelor's Degree</b>	31.3%	36.0%	0.975
<b>Income &gt;\$40,000</b>	40.1%	50.0%	0.002
<b>No health insurance</b>	6.5%	9%	0.157
<b>Current Smoking</b>	14%	13%	0.765
<b>Body-mass Index (kilograms/meter<sup>2</sup>)</b>	29.7 (6)	28.2 (5)	<.0001
<b>Physical Activity (min/week)</b>	349 (539)	404 (608)	0.148
<b>Healthy diet score (0-5)</b>	1.6 (0.9)	1.6 (0.9)	0.635
<b>Total Cholesterol (mg/dL)</b>	189 (35)	194 (36)	0.009
<b>Systolic blood pressure (mmHg)</b>	138 (23)	126 (21)	<.0001
<b>Diastolic blood pressure (mmHg)</b>	74 (12)	72 (10)	<.0001
<b>Fasting Glucose (mg/dL)</b>	109 (46)	97 (30)	<.0001
<b>Baseline categories of Ideal Life's Simple 7 Metrics</b>			
<b>0-2</b>	38.6%	25.8%	
<b>3-5</b>	60.7%	69.9%	<.0001
<b>6-7</b>	0.8%	4.3%	
<b>Baseline Total Life's Simple 7 Score</b>			
<b>Inadequate (0-8)</b>	65.7%	46.6%	
<b>Average (9-10)</b>	26.3%	32.9%	<.0001
<b>Optimal (11-14)</b>	8.0%	20.6%	

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

<b>Hazard Ratios for Heart Failure by Number of Ideal Life's Simple 7 Metrics</b>					
	<b>Total</b>	<b>White</b>	<b>Chinese American</b>	<b>African American</b>	<b>Hispanic</b>
<b>0-1</b>	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
<b>2</b>	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)
<b>3</b>	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)
<b>4</b>	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)
<b>5</b>	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)
<b>6-7</b>	0.21 (0.05-0.90)	2.06 (0.18-22.93)	-	-	-
<b>P for trend</b>	0.0001	0.0014	0.5499	0.0177	0.0510
<b>Hazard Ratios for Heart Failure by Life's Simple 7 Score</b>					
<b>Inadequate (0-8)</b>	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
<b>Average (9-10)</b>	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)
<b>Optimal (11-14)</b>	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)
<b>P for trend</b>	<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**

<b>Incidence Rates of Heart Failure by Number of Ideal Life's Simple 7 Metrics</b>					
	<b>Total</b>	<b>&lt;65</b>	<b>≥65</b>	<b>Women</b>	<b>Men</b>
<b>0-1</b>	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)
<b>2</b>	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)
<b>3</b>	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)
<b>4</b>	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)
<b>5</b>	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)
<b>6-7</b>	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)
<b>Incidence Rates of Heart Failure by Life's Simple 7 Score</b>					
<b>Inadequate (0-8)</b>	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)
<b>Average (9-10)</b>	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)
<b>Optimal (11-14)</b>	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**

<b>Hazard Ratios for Heart Failure by Number of Ideal Life's Simple 7 Metrics</b>					
	<b>Total</b>	<b>&lt;65</b>	<b>≥65</b>	<b>Women</b>	<b>Men</b>
<b>0-1</b>	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
<b>2</b>	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)
<b>3</b>	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)
<b>4</b>	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)
<b>5</b>	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)
<b>6-7</b>	0.15 (0.04-0.65)	-	0.33 (0.08-1.48)	0.18 (0.02-1.39)	0.13 (0.02-0.99)
<b>P for trend</b>	<0.0001	<0.0001	0.0136	<0.0001	0.0033
<b>Hazard Ratios for Heart Failure by Life's Simple 7 Score</b>					
<b>Inadequate (0-8)</b>	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
<b>Average (9-10)</b>	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)
<b>Optimal (11-14)</b>	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)
<b>P for trend</b>	<0.0001	0.0001	<0.0001	<0.0001	<0.0001

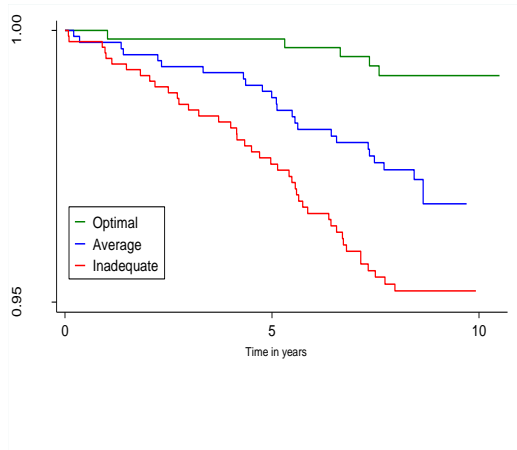
-signifies extremely small Hazard ratios. Hazard ratios were adjusted for age, sex, race/ethnicity, education, income and health insurance. Hazard ratios stratified by race/ethnicity was not adjusted for race/ethnicity. P for trend was calculated using Log rank test.



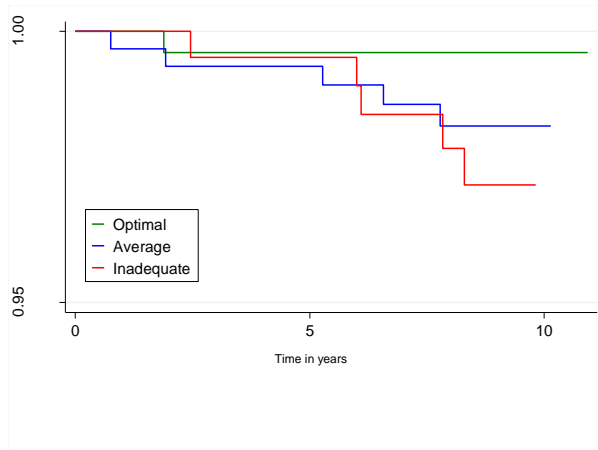
<b>Table S6. Hazard Ratios by Heart Failure Subtype</b>		
<b>LS7 score</b>	<b>Preserved ejection fraction HF</b>	<b>Reduced ejection fraction HF</b>
<b>Inadequate (0-8)</b>	1 (Ref)	1 (Ref)
<b>Average (9-10)</b>	0.37 (0.12-1.13)	0.47 (0.14-1.60)
<b>Optimal (11-14)</b>	0.56 (0.28-1.12)	0.82 (0.44-1.52)

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

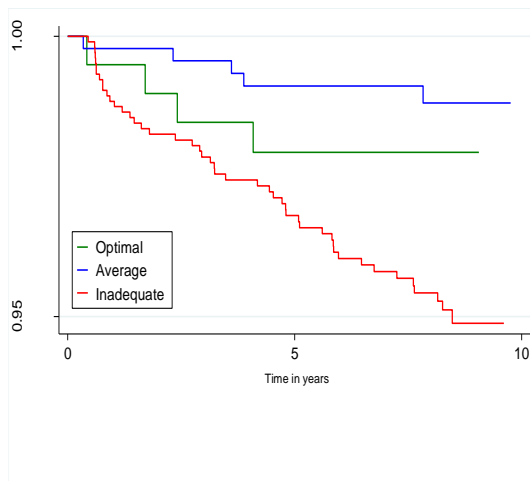
### White Participants



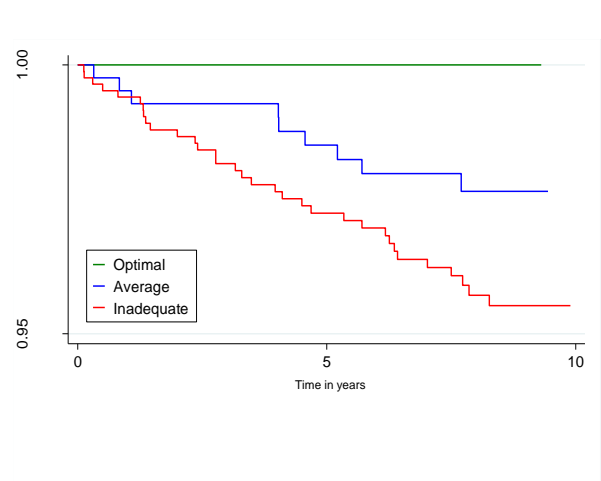
### Chinese American Participants



### 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:

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