Original Report:
Cardivascular Disease
and Risk Factors

Sociodemographic Determinants of Life's Simple 7: Implications for Achieving Cardiovascular Health and Health Equity Goals

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Background: Life's Simple 7 (LS7; nutrition, physical activity, cigarette use, body mass index, blood pressure, cholesterol, glucose) predicts cardiovascular health. The principal objective of our study was to define demographic and socioeconomic factors associated with LS7 to better inform programs addressing cardiovascular health and health equity.

Methods: National Health and Nutrition Examination Surveys 1999–2016 data were analyzed on non-Hispanic White [NHW], NH Black [NHB], and Hispanic adults aged ≥20 years without cardiovascular disease. Each LS7 variable was assigned 0, 1, or 2 points for poor, intermediate, and ideal levels, respectively. Composite LS7 scores were grouped as poor (0–4 points), intermediate (5–9), and ideal (10–14).

Results: 32,803 adults were included. Mean composite LS7 scores were below ideal across race/ethnicity groups. After adjusting for confounders, NHBs were less likely to have optimal LS7 scores than NHW (multivariable odds ratios (OR .44; 95% CI .37–.53), whereas Hispanics tended to have better scores (1.18; .96–1.44). Hispanics had more ideal LS7 scores than NHBs, although Hispanics had lower incomes and less education, which were independently associated with fewer ideal LS7 scores. Adults aged ≥45 years were less likely to have ideal LS7 scores (.11; .09–.12) than adults aged <45 years.

Conclusions: NHBs were the least likely to have optimal scores, despite higher incomes and more education than Hispanics, consistent with structural racism and Hispanic paradox. Programs to optimize lifestyle should begin in childhood to mitigate precipitous age-related declines in LS7 scores, especially in at-risk groups. Promoting higher education and reducing poverty are also important. *Ethn Dis*. 2020;30(4):637-650; doi:10.18865/ed.30.4.637

Keywords: Life's Simple 7; Lifestyle; Body Mass Index; Blood Pressure; Cholesterol; Glucose; Cardiovascular Risk; Health Equity

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Introduction

Life's Simple 7 (LS7), developed by the American Heart Association to track and improve cardiovascular health from 2010 to 2020, 2030 and beyond,[1,2] consists of seven variables: nutrition, physical activity, cigarette use, body mass index (BMI), blood pressure (BP), cholesterol and glucose. Healthy People 2020 identified the same seven items to reduce cardiovascular disease (CVD) events by 20%, and Million Hearts 2022 selected similar variables to prevent 1 million CVD events.[3,4] Thus, consensus exists on modifiable behavioral and biometric variables to improve cardiovascular health.

Each LS7 item defines levels of ideal, intermediate and poor cardiovascular health. Among adults initially free of CVD, those with ideal rather than poor LS7 scores are less likely to develop hypertension, type 2 diabetes (T2D), coronary heart disease, heart failure, atrial fibrillation, and stroke.[5–11] Higher LS7 scores predict less chronic disease in other health domains,[12] which also links LS7 with non-cardiovascular health.

When cardiovascular risk factors are treated and controlled, excess residual risk persists compared with individuals without risk factors.[13] More prevalent hypertension and T2D in non-Hispanic Black (NHB) than non-Hispanic White (NHW) adults precludes equivalent CVD outcomes, even with identical risk factor control. Cardiovascular health equity requires a greater focus on preventing CVD

risk factors in groups at high risk.

Incident and prevalent hypertension are ~50% greater in NHB than NHW adults aged <50 years.[5,14] Among NHB adults in the Jackson Heart Study, two-thirds had ideal scores for three or fewer LS7 items.[5] Over 8-years follow-up, incident hypertension was 22%, 44% and 70% less among those with two, three, and four ideal LS7 factors, respectively, than those with 0–1. Improving LS7 scores in minorities could reduce racial disparities in incident and ultimately prevalent hypertension.

a closer look at the demographic differences and moderating socioeconomic factors impacting LS7 is relevant and could inform complementary public health and population health care programs to improve cardiovascular health and health equity.[1,2,15]

Given the national emphasis on cardiovascular health and health equity,[1-4] a closer look at the demographic differences and moderating socioeconomic factors impacting LS7 is relevant and could inform complementary public health and population health care programs to improve cardiovascular health and health equity.[1,2,15] LS7 findings in NHB and Hispanic relative to NHW adults were also examined in the context of structural racism and the Hispanic paradox.[16,17] In brief, NHBs have worse health status and social determinants than NHWs, whereas Hispanics have better-than-expected health for their level of social determinants.

Methods

Participants

National Health and Nutrition Examination Surveys (NHANES) are conducted by the National Center for Health Statistics, in the Centers for Disease Control and Prevention, with informed consent.[18] Hispanic and NHB respondents were oversampled to allow stable estimates for these groups. Non-Hispanic Asians and American Indians/Alaska Natives were not included given small sample sizes. Individual mobile exam center dietary interview sample weights were used to represent the US population for each two-year cycle. This study included participants in NHANES 1999 through 2016 to examine time trends and identify factors independently associated with LS7 variables and demographic differences. Participants were aged ≥20 years, free of CVD, and had values for each LS7 variable. Participants were characterized by age, sex, race, ethnicity, education, income, and health care insurance status.

Measures

Age was determined on the date of household screening relative to the self-reported birthdate.

Sex was defined by the participant's response to the dichotomous variable male or female.

Race was derived by self-identified response as White, Black, Asian, and Other, including multi-racial except that multi-racial individuals who selected Black or White as their main race were included in these two respective categories.

Educational attainment was determined by the participant's response to highest degree of education completed grouped as individuals who 1) denied or 2) endorsed having a high school or General Education Development (GED) diploma and 3) had some college or associate degree and college education or higher.

Income relative to the federal poverty level (FPL) was determined by dividing family income by the number of family members appropriate for each year and state in the United States per the NHANES database.

Health care insurance status was dichotomized as insured or uninsured based on the participant's response to "Are you covered by health insurance or some other health care plan (include health insurance through employment, purchased directly, or government program like Medicaid or Medicare that provides medical care or help to pay medical bills)?

LS7 scores: for each LS7 item, 2 points were assigned for ideal, 1 point for intermediate, and 0 points for poor cardiovascular health.[15] Composite scores provide an assessment of cardiovascular and

non-cardiovascular risk[10,12] and were grouped as ideal (10–14), intermediate (5–9), and poor (0–4).

Nutrition: the five components of the LS7 diet are consistent with Dietary Approaches to Stop Hypertension (DASH).[1] Since LS7 dietary assessment was unavailable in NHANES, a DASH score was calculated from intake of nine items estimated from 24-hour dietary recall (total and saturated fat, protein, fiber, calcium, potassium, magnesium, sodium, potassium). One point was given for each item in the ideal range and .5 point for each item in the mid-range.[19] Composite DASH scores were grouped into ≥6 (ideal [2 points]), 4.5 to <6 (intermediate [1 point]), <4.5 (poor [0 points]).

Leisure time physical activity (PA) was calculated in minutes per week.[20] Each minute of high-intensity PA equaled two minutes moderate-intensity PA.[1,15,20] Participants were grouped as ≥150 minutes/week (2 points), 1–149 min/week (1 point), or <1 min/week (0 points) of moderate PA.

Cigarette smoking: Individuals who never smoked or quit >12 months ago received two points, those quitting ≤12 months ago one point, and current smokers no points.[20]

Cardiovascular disease was defined by participant reporting that a physician had told them they had a heart attack, stroke, or heart failure.

Body mass index (BMI, kg/m^2) was scored as <25 (2 points), 25 to <30 (1 point) and ≥30 (0 points).[20]

Blood pressure (BP, mm Hg) was determined by averaging the second and third BP values. Participants with untreated BP <120/<80 received 2 points, BP of 120–139/80–89 untreated or treated to <130/<80 one point, and untreated BP ≥140 systolic or ≥90 diastolic or treated BP ≥130 systolic or ≥80 diastolic 0 points.

Total cholesterol (mg/dL) categories included untreated values <200 (2 points), untreated values 200–239 or treated <200 (1 point), and untreated values ≥240 or treated ≥200 (0 points).[15,20]

Blood glucose*:* as fasting glucose was obtained on roughly one-half of NHANES participants, glycosylated hemoglobin (HbA1c) was used. Categories included HbA1c <5.7% (normal, 2 points), 5.7–6.4% in untreated (pre-T2D), or treated to <6.5% (intermediate, 1 point) and HbA1c ≥6.5% (treated or untreated, 0 points). Treatment was defined by self-report of insulin or oral hypoglycemic agents.

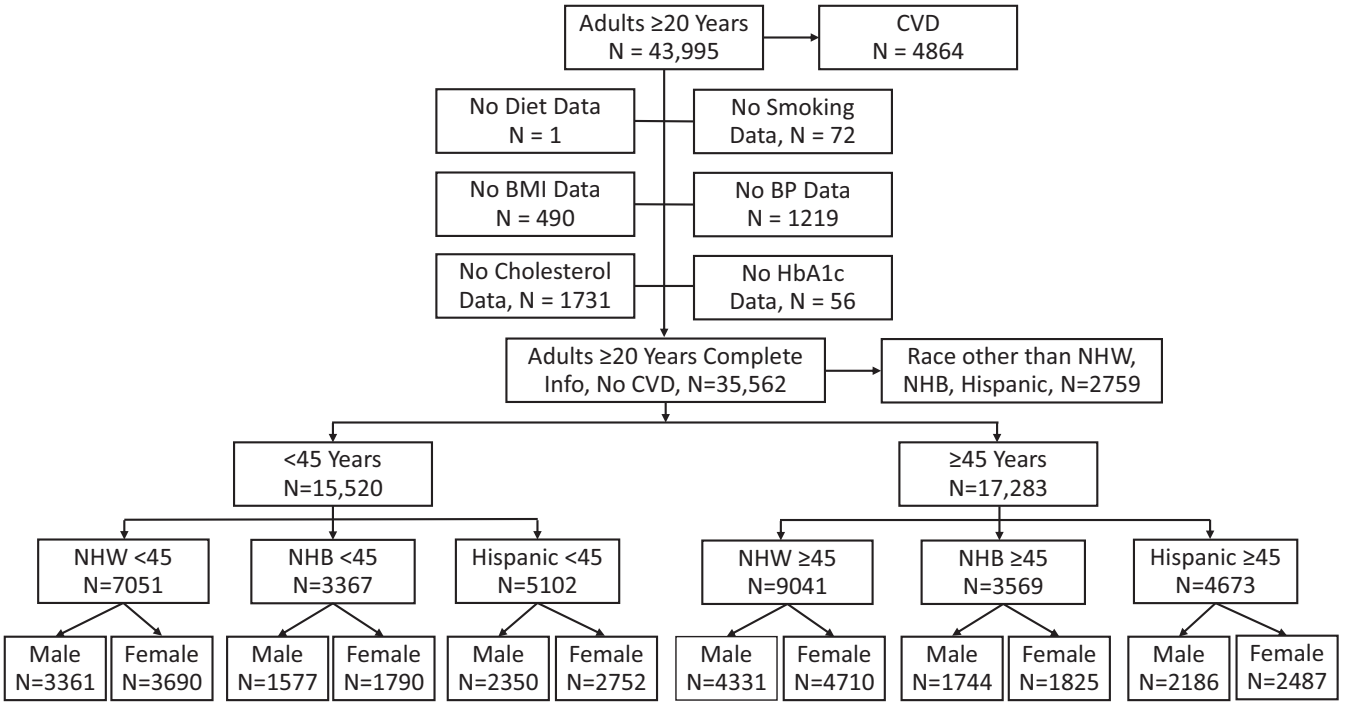

Figure 1. The flow diagram shows the steps taken in deriving the NHANES study sample for this analysis. Exclusions are provided on the upper part of the figure. Disaggregation by age, race-ethnicity, and sex is shown on the lower part of the figure.

Data Analysis

SAS Enterprise Guide 7.1 (Cary, NC) survey procedures were used for within survey analyses. Appropriate weights accounting for unequal probabilities of selection, oversampling, and nonresponse were employed. NHANES reporting guidelines were followed. Socioeconomic data and LS7 scores were stratified by 6-year periods to allow for assessment of trends over time: 1999–2004, 2005–2010, and 2011–2016. Data were age-adjusted to the 1999–2004 NHANES distribution. Sociodemographic and LS7 scores were examined by race/ethnicity for each sex, stratified by aged <45 years and ≥45 years. The Rao-Scott chi-square test in the PROC SURVEYFREQ was used to test for differences in distribution of categorical variables. P-values <.01 were accepted as statistically significant in view of the multiple comparisons.

Multinomial logit models were used to estimate multivariate-adjusted odds ratios of LS7 composite and individual item scores. Odds ratios were calculated for ideal vs poor scores for the LS7 composite

Table 1. Selected characteristics of NHB, NHW, and Hispanic adults aged ≥20 years in three time periods[a]

Time Period	1999–2004	2005–2010	2011–2016
NHANES, n	10,612	12,668	12,282
US population estimate, millions	180.8	197.1	209.1
Age, years	44.3 (44.1,44.6)	44.4 (44.2,44.6)	44.2 (43.9,44.6)
Female, %	51.7 (50.4,53.0)	52.7 (51.8,53.6)	51.5 (50.5,52.6)
Non-Hispanic White (NHW), %	72.1 (68.9,75.4)	70.5 (66.7,74.2)[b]	64.5 (60.3,68.7)[b]
Non-Hipanic Black (NHB), %	10.2 (8.3,12.2)	10.6 (8.7,12.4)	10.8 (8.5,13.1)
Hispanic, %	13.1 (10.2,16.1)	13.5 (10.9,16.1)	15.9 (12.7,19.0)
Education, <high school, %	18.2 (16.9,19.5)	17.5 (15.9,19.1)[b]	13.7 (11.7,15.7)[b]
High school, %	25.5 (23.8,27.2)	23.8 (22.3,25.2)	20.4 (18.8,22.0)
At least some college, %	56.2 (54.0,58.4)	58.7 (56.3,61.1)	65.9 (63.0,68.8)
Income, federal poverty, <200%, %	32.6 (30.1,35.2)	32.6 (30.7,34.5)	36.0 (32.9,39.1)
200–399%, %	29.8 (28.2,31.4)	29.0 (27.2,30.8)	28.1 (26,30.2)
≥400%, %	37.6 (34.8,40.4)	38.4 (35.9,40.8)	35.9 (32.6,39.2)
Health care insurance, yes, %	81.2 (79.8,82.7)[b]	78.9 (77.4,80.4)[b]	81.2 (79.4,83)
No, %	18.8 (17.3,20.2)	21.1 (19.6,22.6)	18.8 (17.0,20.6)
LS7 composite score	8.2 (8.1,8.4)	8.2 (8.0,8.3)	8.2 (8.1,8.3)
DASH catetory, ≥6, %	2.8 (2.3,3.2)[b]	3.5 (2.9,4)	3.1 (2.5,3.6)
3-<6, %	31.3 (30.1,32.4)	34.3 (32.8,35.7)	33.0 (31.6,34.4)
<3, %	66.0 (64.6,67.3)	62.3 (60.8,63.8)	63.9 (62.4,65.5)
Physical activity ≥150 min/week, %	42.4 (40.2,44.7)[b]	40.1 (37.8,42.5)[b]	41.8 (39.8,43.9)[b]
1–149, %	23.8 (22.5,25)	19.7 (18.6,20.8)	16.2 (15.1,17.3)
<1, %	33.8 (31.9,35.8)	40.2 (37.5,42.9)	42.0 (39.6,44.4)
Cigarettes, never/quit >12 months, %	72.0 (70.4,73.7)	73.6 (72.0,75.1)[b]	77.7 (76.2,79.2)[b]
Quit ≤12 months, %	3.3 (2.6,4.0)	3.3 (2.8,3.8)	3.3 (2.8,3.8)
Current smoker, %	24.7 (23.1,26.3)	23.2 (21.7,24.6)	19.0 (17.6,20.4)
BMI, <25, %	35.3 (33.7,36.9)[b]	32.7 (31.0,34.4)	30.8 (29.1,32.4)[b]
25-<30, %	34.6 (33.1,36.1)	33.7 (32.3,35.1)	33.2 (31.9,34.5)
≥30, %	30.1 (28.3,31.9)	33.6 (32.0,35.2)	36.1 (34.4,37.7)
BP, <120/<80, %	43.0 (41.1,44.8)	46.2 (44.5,47.9)	45.2 (43.7,46.7)
120–139/80-89, treated <130/<80	35.9 (34.5,37.3)	35.3 (33.8,36.8)	36.7 (35.3,38.1)
≥140/≥90 or treated ≥130/≥80	21.2 (19.9,22.4)	18.5 (17.3,19.8)	18.1 (17.0,19.3)
Total cholesterol, <200 untreated, %	46.4 (45.1,47.7)[b]	46.5 (45.1,47.9)	50.4 (48.9,52.0)[b]
200–239, treated <200, %	33.6 (32.5,34.7)	35.6 (34.3,36.8)	33.8 (32.1,35.4)
≥240, treated ≥200, %	20.0 (18.8,21.3)	17.9 (16.8,19.1)	15.8 (14.7,16.9)
HbA1c, <5.7%, %	82.8 (81.4,84.1)[b]	74.4 (73.3,75.6)[b]	71.5 (70.2,72.9)[b]
5.7-6.4%, treated <6.5%, %	12.3 (11.3,13.4)	20.1 (19.2,21.0)	21.9 (20.8,23.0)
≥6.5%, untreated or treated, %	4.9 (4.3,5.6)	5.5 (5.0,6.0)	6.6 (5.9,7.3)

a. Data provided are weighted percentages and 95% CIs.
b. P<.01. Symbols in column 1 indicate a different distribution of values for that variable vs column 2, column 2 vs column 3, and column 3 vs column 1.
For each LS7 variable, the first level is "ideal", second level "intermediate," and third level "poor."

Table 2. LS7 Scores for adults aged <45 years by race/ethnicity for women and men without CVD: NHANES 1999–2016[d]

	Women				Men			
	NHW	NHB	Hispanic		NHW	NHB	Hispanic	
LS7 composite, mean	9.3 (9.2, 9.5)	8.2 (8.1, 8.4)	9.1 (9.0, 9.2)	a,b,c	8.7 (8.6,8.8)	8.4 (8.3, 8.5)	8.3 (8.1, 8.4)	a,c
Diet (DASH score)				a,b				a,b,c
Ideal, %	2.9 (2.1,3.7)	1.6 (.9,2.3)	3.1 (2.2,3.9)		1.5 (1.0,2.1)	1.3 (.6,2.0)	1.7 (1.0,2.5)	
Intermediate, %	33.6 (31.4,35.8)	21.5 (19.2,23.9)	36.7 (33.9,39.5)		28.6 (26.6,30.7)	22.6 (19.9,25.2)	33.3 (31.0,35.7)	
Poor, %	63.5 (61.2,65.8)	76.9 (74.5,79.3)	60.2 (57.4,63.1)		69.8 (67.7,72)	76.1 (73.4,78.8)	64.9 (62.4,67.4)	
Physical activity				a,c				a,b,c
Ideal, %	46.5 (43.8,49.2)	32.6 (29.2,36.0)	32.2 (29.6,34.9)		53.3 (50.9,55.6)	54.2 (51.1,57.2)	41.9 (39.2,44.7)	
Intermediate, %	23.2 (21.1,25.2)	19.2 (16.9,21.6)	20.5 (17.9,23.1)		19.9 (18.1,21.7)	13.1 (11.1,15.2)	13.6 (11.8,15.5)	
Poor, %	30.3 (27.9,32.7)	48.2 (45,51.3)	47.2 (44.1,50.4)		26.9 (24.7,29.1)	32.7 (29.8,35.6)	44.5 (41.7,47.2)	
Smoking				a,b,c				b
Ideal, %	68.6 (66.4,70.9)	75.7 (73,78.4)	84.3 (82.5,86.1)		64.4 (62.2,66.6)	65.6 (62.2,68.9)	67.9 (65.1,70.8)	
Intermediate, %	4.6 (3.7,5.4)	2.6 (1.7,3.5)	3.1 (2.3,3.9)		5.3 (4.3,6.2)	3.2 (2.1,4.4)	5.2 (3.8,6.6)	
Poor, %	26.8 (24.7,28.9)	21.7 (19.2,24.2)	12.6 (10.9,14.3)		30.3 (28.2,32.4)	31.2 (28.1,34.4)	26.8 (24.1,29.5)	
Body mass index				a,b,c				a,b,c
Ideal	46.3 (43.8,48.9)	24.2 (21.6,26.9)	29.7 (27.1,32.3)		34.3 (32.1,36.6)	36.2 (33.2,39.2)	25.3 (22.7,27.8)	
Intermediate	25.1 (23.3,27.0)	24.1 (21.5,26.7)	32.3 (29.8,34.8)		36.9 (34.9,39)	29.8 (27.1,32.6)	40.5 (38.3,42.7)	
Poor	28.5 (26.4,30.7)	51.7 (48.8,54.5)	38.0 (35.3,40.8)		28.8 (26.6,30.9)	34.0 (31.0,37.0)	34.3 (31.5,37)	
Blood pressure				a,b,c				a,b
Ideal, %	75.5 (73.6,77.5)	61.4 (58.5,64.4)	80.3 (78.5,82.0)		47.1 (44.7,49.5)	40.3 (37.0,43.6)	50.3 (47.3,53.3)	
Intermediate,%	20.8 (18.9,22.7)	27.7 (25.3,30.2)	15.8 (14,17.5)		42.4 (40.2,44.5)	45.1 (41.8,48.3)	40.5 (37.7,43.3)	
Poor,%	3.6 (2.9,4.3)	10.8 (9.2,12.5)	4.0 (3.0,5.0)		10.5 (9.2,11.8)	14.6 (12.9,16.3)	9.2 (7.6,10.9)	
Total cholesterol				a				a,b
Ideal, %	65.0 (63.1,67.0)	69.4 (66.9,71.9)	67.9 (65.5,70.3)		58.6 (56.4,60.8)	66.6 (63.7,69.5)	56.2 (53.3,59.1)	
Intermediate,%	24.8 (22.9,26.6)	23.1 (21.1,25.1)	22.9 (20.8,25)		28.0 (26.2,29.8)	24.6 (22.1,27.1)	30.3 (27.9,32.8)	
Poor,%	10.2 (9.0,11.4)	7.5 (5.9,9.1)	9.2 (7.4,10.9)		13.4 (11.9,14.8)	8.8 (7.2,10.4)	13.5 (11.6,15.3)	
HbA1c				a,b,c				a,b,c
Ideal %	93.2 (92.1,94.3)	79.6 (77.1,82.0)	85.6 (83.8,87.4)		91.7 (90.5,92.8)	75.1 (72.8,77.5)	81.5 (79.3,83.7)	
Intermediate	5.7 (4.6,6.7)	16.0 (14.0,18.0)	11.0 (9.3,12.6)		6.6 (5.6,7.6)	21.5 (19.2,23.7)	15.4 (13.3,17.4)	
Poor	1.1 (.8,1.5)	4.4 (3.2,5.6)	3.4 (2.4,4.5)		1.8 (1.4,2.2)	3.4 (2.4,4.4)	3.2 (2.1,4.2)	

a P<.01, scores for NHW vs NHB (within sex group).
b. P<.01, scores for NHB vs Hispanic (within sex group).
c. P<.01 scores for Hispanic vs NHW (within sex group).
d. Data provided are weighted percentages and 95%CIs.

and component variables; 95% CI not crossing the line of identity (1.0) were deemed statistically significant.

Results

All participants aged ≥20 years from NHANES surveys conducted in 1999-2016 (n=43,995) were selected for inclusion in this study of LS7 (Figure 1). Participants excluded from analyses were those with cardiovascular disease (11.1%, n=4864), missing data elements required to calculate the LS7 score (8.1%, n=3569), or race/ethnicity designated as not belonging to one of the three groups, non-Hispanic White, non-Hispanic Black or Hispanic (6.3%, n=2759). Data from the remaining 32,803 participants (74.6%) were used in the analyses.

Table 1 displays the number of participants included in each of three six-year time periods spanning 1999 to 2016, along with the total composite LS7 scores and distribution of each component. Although composite scores did not vary across the 3 time-points, there were changes in several individual components. In general, healthy diet scores improved, albeit all were very low; the prevalence of smoking declined, and total cholesterol levels improved. On the other hand, health scores fell for physical activity, BMI and glycosylated hemoglobin. Levels of BP control were stable over time.

Among adults aged <45 years, NHWs had higher composite LS7 scores than same sex NHBs and Hispanics. Among women, Hispanics had higher composite LS7 scores than NHBs, whereas among men, NHBs and Hispanics had similar scores (Table 2). Race/ethnicity differences were observed in each LS7 component, stratified by age category and sex. Among younger women, notable differences included higher dietary scores, lower rates of smoking and better BP control for Hispanic participants. NHB women were more likely to have lower cholesterol levels and NHW were more likely to have a higher score for physical activity, BMI, and glycosylated hemoglobin as compared to women in the other race/ethnicity groups.

Race/ethnicity differences for younger men included higher ideal scores in three components for Hispanic men: dietary, non-smoking, and BP control. NHB men had the highest scores for physical activity, BMI, and total cholesterol and NHW men had a higher prevalence of ideal glycosylated hemoglobin levels.

Among adult men and women aged ≥45 years, NHWs had higher composite LS7 scores than NHBs and Hispanics, and Hispanics had higher scores than NHBs (Table 3). Race/ethnicity differences in the LS7 component scores for older women revealed a pattern similar to younger women (Table 2). Unlike younger men, older NHW men had higher rates of ideal

Table 3. LS7 scores in adults aged ≤ 45 years by race/ethnicity for women and men without CVD: NHANES 1999–2016[d]

	Women				Men			
	NHW	NHB	Hispanic		NHW	NHB	Hispanic	
LS7 composite, mean	7.6 (7.5,7.7)	6.3 (6.2,6.4)	7.0 (6.8,7.1)	a,b,c	7.5 (7.4,7.6)	6.6 (6.5,6.7)	6.9 (6.8,7.1)	a,b,c
Diet (DASH score)				a,b,c				b,c
Ideal, %	4.9 (4.1,5.7)	3.8 (2.7,4.8)	7.2 (5.7,8.6)		3.1 (2.4,3.7)	1.9 (1.3,2.6)	2.9 (2,3.7)	
Intermediate, %	38.5 (36.7,40.4)	28.8 (26.1,31.5)	42.6 (39.8,45.5)		29.4 (27.6,31.2)	28.0 (25.4,30.5)	38.6 (35.7,41.5)	
Poor, %	56.6 (54.7,58.4)	67.4 (64.6,70.3)	50.2 (47.3,53.1)		67.5 (65.9,69.2)	70.1 (67.2,73.0)	58.5 (55.6,61.4)	
Physical activity				a,c				a,c
Ideal, %	35.1 (32.8,37.5)	22.6 (20.2,24.9)	22.3 (19.6,25.1)		41.2 (39.0,43.3)	30.8 (28.1,33.6)	30.3 (26.6,34.1)	
Intermediate, %	21.0 (19.5,22.5)	19.5 (17.4,21.6)	16.7 (14.5,18.9)		18.2 (16.5,20.0)	15.5 (13.4,17.7)	15.0 (12.8,17.2)	
Poor, %	43.8 (41.4,46.2)	57.9 (54.7,61.1)	60.9 (57.4,64.5)		40.6 (38.0,43.1)	53.6 (50.6,56.6)	54.7 (50.9,58.4)	
Smoking				a,b,c				a,b
Ideal, %	82.8 (81.2,84.3)	79.0 (76.6,81.3)	86.3 (84.1,88.4)		79.6 (77.9,81.4)	65.7 (63.1,68.3)	75.6 (73.2,78.1)	
Intermediate, %	2.0 (1.4,2.5)	1.3 (.7,1.9)	1.8 (1.1,2.5)		2.2 (1.6,2.8)	2.6 (1.8,3.5)	2.5 (1.7,3.4)	
Poor, %	15.2 (13.8,16.7)	19.7 (17.4,22.1)	11.9 (10.0,13.9)		18.2 (16.6,19.8)	31.7 (29.0,34.4)	21.8 (19.5,24.1)	
Body mass index				a,b,c				a,b
Ideal	33.4 (31.6,35.2)	16.8 (14.6,19.1)	18.3 (16.0,20.7)		21.8 (20.2,23.4)	26.9 (24.2,29.6)	18.4 (16.0,20.8)	
Intermediate	31.4 (29.6,33.1)	26.9 (24.3,29.4)	34.9 (32.2,37.6)		43.6 (41.8,45.4)	38.1 (35.3,40.8)	47.4 (44.0,50.9)	
Poor	35.2 (33.4,37.0)	56.3 (53.6,59.1)	46.7 (43.6,49.9)		34.6 (32.8,36.4)	35.1 (32.3,37.8)	34.1 (30.9,37.3)	
Blood pressure				a,b				a,b
Ideal, %	28.3 (26.5,30.2)	17.8 (15.3,20.3)	28.7 (25.3,32.1)		24.7 (22.9,26.6)	16.6 (13.9,19.4)	27.3 (24.5,30.1)	
Intermediate,%	39.8 (37.9,41.8)	38.0 (35.2,40.9)	39.6 (36.3,42.9)		44.4 (42.8,45.9)	41.5 (38.5,44.5)	43.6 (40.9,46.4)	
Poor,%	31.8 (30.1,33.6)	44.1 (41.1,47.2)	31.7 (28.6,34.7)		30.9 (29,32.8)	41.8 (39,44.7)	29.1 (26.2,32.0)	
Total cholesterol				a,b,c				a,b,c
Ideal, %	25.1 (23.5,26.8)	37.5 (34.8,40.2)	31.6 (28.4,34.7)		32.8 (31.0,34.7)	42.2 (39.2,45.3)	36.2 (33.0,39.5)	
Intermediate,%	44.4 (42.4,46.4)	37.6 (34.9,40.4)	42.3 (39.0,45.7)		46.0 (44.0,48.1)	40.9 (38.0,43.8)	38.4 (35.3,41.6)	
Poor,%	30.4 (28.6,32.2)	24.8 (22.3,27.4)	26.1 (23.5,28.6)		21.1 (19.5,22.8)	16.9 (14.5,19.3)	25.3 (22.1,28.6)	
HbA1c				a,b,c				a,b,c
Ideal %	66.1 (64.3,67.9)	41.4 (38.4,44.5)	46.9 (43.5,50.2)		66.0 (64.3,67.7)	41.9 (38.7,45.0)	47.8 (44.4,51.2)	
Intermediate	27.8 (26.1,29.5)	41.4 (38.8,44.1)	36.4 (33.7,39.2)		24.8 (23.2,26.4)	41.6 (38.5,44.7)	32.1 (29.3,34.9)	
Poor	6.1 (5.3,6.9)	17.1 (15.3,18.9)	16.7 (14.5,18.9)		9.2 (8.1,10.3)	16.6 (14.4,18.7)	20.1 (17.3,22.8)	

a. P<.01, scores for NHW vs NHB (within sex group).
b. P<.01, scores for NHB vs Hispanic (within sex group).
c. P<.01 scores for Hispanic vs NHW (within sex group).
d. Data provided are weighted percentages and 95%CIs.

Table 4. Race/ethnicity multivariate odds of ideal score versus odds of poor score for Life Simple 7

	Odds Ratio (95%CIs)		
Life's Simple 7	**Non-Hispanic White**	**Non-Hispanic Black**	**Hispanic**
Composite score	1.0 (reference)	.44 (.37, .53)	1.18 (.96, 1.44)
Diet (DASH score)	1.0 (reference)	.64 (.50, .80)	1.40 (1.14, 1.73)
Physical activity	1.0 (reference)	.79 (.70, .89)	.87 (.77, .99)
Smoking	1.0 (reference)	1.25 (1.11, 1.39)	2.70 (2.36, 3.07)
Body mass index	1.0 (reference)	.53 (.47, .58)	.56 (.49, .63)
Blood pressure	1.0 (reference)	.51 (.45, .59)	1.31 (1.13, 1.51)
Cholesterol	1.0 (reference)	1.58 (1.41, 1.78)	1.07 (.95, 1.21)
Glycosylated hemoglobin	1.0 (reference)	.33 (.29, .38)	.43 (.36, .50)

ORs adjusted for age (<45, ≥45), sex (women, men), NHANES time-point (1999-2004, 2005-2010, 2011-2016), income (FPL <200%, 200-399%, ≥400%), educational attainment (<high school, high school, ≥some college), health insurance (no, yes).

dietary, physical activity and non-smoking scores. The highest scores for BMI and cholesterol occurred in NHB men; the highest score for BP control in Hispanic men, and better glycosylated hemoglobin in NHW men.

Race/ethnicity differences in components of LS7 showed similarity across the sex and age groups (Tables 2 and 3), with few exceptions. Overall, a higher prevalence of ideal scores was observed in three LS7 components for

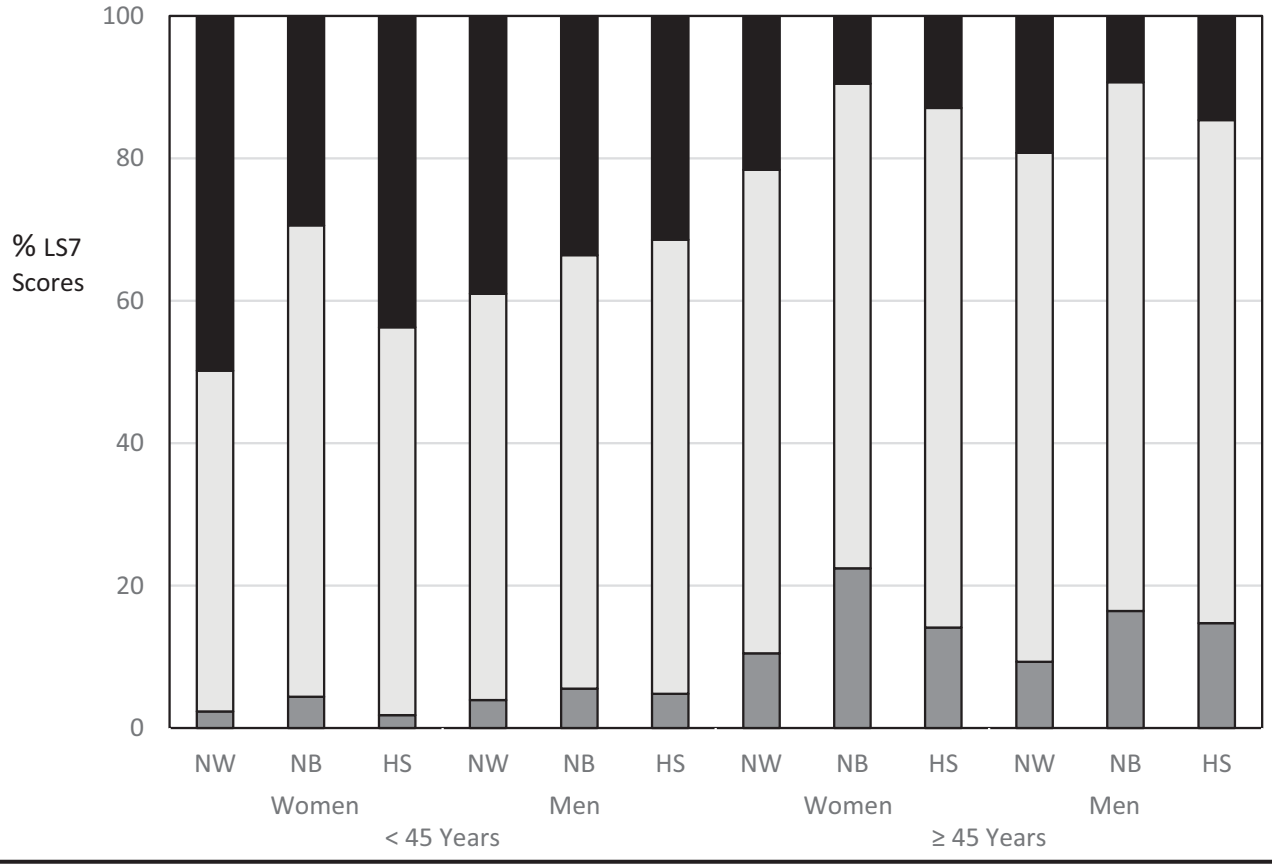

Figure 2. The distribution of composite LS7 scores into ideal- (black), intermediate- (light gray), and low-range (dark gray) values are shown for the 12 groups disaggregated by age (<45 or ≥45 years), sex (women [female], men [male]), and race-ethnicity (non-Hispanic Black [NB], non-Hispanic White [NW]. and Hispanic [HS])

Table 5. Selected social determinants of health in adults by age <45 (top) and ≥45 (lower), race/ethnicity and sex in NHANES 1999–2016

Race/ethnicity, sex group	NHWF <45	NHBF <45	HispF <45	NHWM <45	NHBM <45	HispM <45
Education, ≥some college, %	70.4 (67.6,73.3)[b]	59.1 (56.2,61.9)[b]	43.5 (40.1,46.9)[b]	65.2 (62.2,68.1)[b]	50.3 (46.9,53.7)[b]	34.0 (31.1,36.9)[b]
High school, %	20.0 (18.0,22.1)	22.9 (20.7,25.0)	20.7 (18.5,23.0)	25.5 (23.2,27.8)	28.1 (25.2,31.0)	23.9 (21.2,26.5)
<High school, %	9.5 (8.0,11.1)	18.1 (15.9,20.2)	35.7 (32.5,39.0)	9.3 (7.9,10.7)	21.6 (18.8,24.3)	42.1 (39.2,45.1)
Income (fed poverty) ≥400, %	36.6 (33.6,39.5)v	13.9 (11.6,16.2)	12.7 (10.5,14.8)[b]	41.7 (38.9,44.6)[b]	18.3 (15.6,21.0)[b]	12.2 (10.5,14)[b]
200–399%, %	30.8 (28.8,32.9)	25.9 (23.1,28.7)	22.3 (19.7,24.9)	31.0 (28.9,33.2)	31.3 (28.3,34.3)	26.9 (24.0,29.8)
<200%, %	32.6 (30.1,35.2)	60.1 (56.5,63.8)	65.0 (61.7,68.3)	27.3 (24.9,29.6)	50.4 (46.7,54.1)	60.9 (57.7,64)
Health care insured, %	83.2 (81.4,84.9)[b]	74.9 (72.2,77.5)[b]	57.1 (54.3,59.9)[b]	77.8 (75.9,79.6)[b]	59.7 (56.5,62.9)[b]	46.2 (43.3,49.0)[b]
Uninsured, %	16.8 (15.1,18.6)	25.1 (22.5,27.8)	42.9 (40.1,45.7)	22.2 (20.4,24.1)	40.3 (37.1,43.5)	53.8 (51.0,56.7)
Race/ethnicity age group	**NHWF ≥45**	**NHBF ≥45**	**HispF ≥45**	**NHWM ≥45**	**NHBM ≥45**	**HispM ≥45**
Education, ≥some college, %	62.3 (59.9,64.6)[b]	50.1 (47.1,53.1)[b]	32.8 (29.6,35.9)[b]	65.6 (63.0,68.2)[b]	44.4 (41.1,47.7)[b]	34.7 (31.4,38)[b]
High school	25.9 (24.2,27.5)	24.2 (22.0,26.5)	17.1 (14.8,19.4)	23.6 (21.7,25.4)	26.0 (23.3,28.7)	18.2 (15.7,20.7)
<High school	11.9 (10.4,13.4)	25.7 (23.3,28.1)	50.2 (46.7,53.6)	10.8 (9.4,12.2)	29.6 (26.7,32.5)	47.0 (43.5,50.6)
Income (fed poverty) ≥400, %	46.5(43.7,49.3)[a]	24.0 (20.8,27.1)	17.8(14.7,20.8)[b]	53.3 (50.5,56.1)[b]	29.5 (26.5,32.5)[b]	20.6 (17.6,23.6)[b]
200–399%, %	29.1 (27.1,31.0)	28.1 (25.6,30.7)	26.2 (23.8,28.7)	27.9 (26.0,29.7)	28.3 (25.8,30.8)	28.7 (25.4,32.0)
<200, %	24.4 (22.1,26.8)	47.9 (44.1,51.7)	56.0 (52.2,59.8)	18.8 (16.7,20.9)	42.2 (38.9,45.6)	50.7 (46.7,54.6)
Health care insured, %	92.5 (91.5,93.6)[b]	84.5 (82.3,86.7)[b]	72.5 (69.6,75.3)[b]	91.5 (90.3,92.8)[b]	82.0 (79.5,84.6)[b]	70.8 (67.2,74.4)[b]
Uninsured	7.5 (6.4,8.5)	15.5 (13.3,17.7)	27.5 (24.7,30.4)	8.5 (7.2,9.7)	18.0 (15.4,20.5)	29.2 (25.6,32.8)

F, female; M, male; NHWF, non-Hispanic White female;; NHBF, non-Hispanic Black female; HispF, Hispanic female; NHWM, non-Hispanic White male; NHBM, non-Hispanic Black male; HispM, Hispanic male

a. Data provided are weighted percentages and 95%CIs.

b. P<.01, for comparing within age and sex group by race/ethnicity. Symbols in NHW compare with NHB, NHB to Hispanic, and Hispanic to NHW

Hispanic participants (diet, smoking, BP), one component for NHBs (cholesterol), and three components for NHWs (physical activity, BMI, hemoglobin). The exception was NHB men <45 years who tended to have a higher prevalence of ideal scores for physical activity and BMI than NHW.

After adjusting for age, sex, time, and selected sociodemographic characteristics, the odds of ideal LS7 scores vs the odds of poor scores was compared by race/ethnicity with NHWs as the reference (Table 4). NHBs were 56% less likely (OR .44, P<.05) to have ideal LS7 composite score as NHWs. All 7 components were also statistically significant (P<.05) for NHBs, as they were less likely to have ideal scores for diet (OR=.64), physical activity (OR=.79), BMI (OR=.53), BP (OR=.51), and glycosylated hemoglobin (.33), but were more likely to have ideal scores for smoking (OR 1.24) and cholesterol (OR 1.58) than NHWs. While there was no difference in the composite score for Hispanics compared with NHWs, they were more likely to have ideal scores for diet (OR 1.40), smoking (OR 2.70), BP control (OR 1.31) and less likely to have ideal scores for PA (OR .87), BMI (OR .56) and glycosylated hemoglobin (OR=.43) when compared with NHWs.

The distribution of composite LS7 scores is most favorable in NHW women and least favorable in NHB women in both age groups. Composite LS7 scores are also more favorable in younger than older adults of the same race/ethnicity and sex and in women than men of the same age for NHW and Hispanic adults (Figure 2).

Selected social determinants of health (income, education, and health insurance) are provided in Table 5 for groups demarcated by age, race/ethnicity, and sex. These social determinants of health were generally most favorable in NHW, least favorable in Hispanic, and intermediate in NHB adults.

Multivariable adjusted odds ratios assessing an independent relationship between various social determinants of health and ideal composite LS7 scores and each component are provided in Table 6. Age, at least some college education, and income 400% or more of the FPL were generally most strongly associated with composite LS7 scores. Figures 3 and 4 summarize the study by listing LS7 variables and their impact on CV health, racial and ethnic differences in key social determinants, various factors associated with composite LS7 scores (CV health), and selected initiatives for improving CV health and health equity.

Table 6. Multivariable adjusted[a] odds ratios for factors independently linked with LS7 variables

	LS7 Comp	Nutrition	Phys Activity	Cigarettes	BMI	BP	Cholesterol	HbA1c
Age (20–44 ref)								
≤45	.11 (.09,.12)[b]	1.86 (1.50,2.30)[b]	.49 (.45,.53)[b]	1.63 (1.50,1.78)[b]	.63 (.58,.69)[b]	.10 (.09,.11)[b]	.22 (.20,.24)[b]	.12 (.10, .14)[b]
Sex (Male ref)								
Female	1.37 (1.21,1.55)[b]	1.91 (1.59,2.30)[b]	.73 (.68,.79)[b]	1.40 (1.29,1.51)[b]	1.22 (1.12,1.32)[b]	1.97 (1.79,2.17)[b]	.88 (.81,.96)[b]	1.43 (1.28,1.59)[b]
Race/Ethnicity (NHW ref)								
NHB	.44 (.37,.53)[b]	.64 (.50,.80)[b]	.79 (.70,.89)[b]	1.24 (1.11,1.39)[b]	.53 (.47,.58)[b]	.51 (.45,.59)[b]	1.58 (1.41,1.78)[b]	.33 (.29,.38)[b]
Hispanic	1.18 (.96,1.44)	1.40 (1.14,1.73)	.87 (.77,.99)[b]	2.70 (2.36,3.07)[b]	.56 (.49,.63)[b]	1.31 (1.13,1.51)[b]	1.07 (.95,1.21)	.43 (.36,.50)[b]
Time (1999–2004 ref)								
2005–2010	.87 (.71,1.07)	1.36 (1.07,1.73)	.76 (.65,.89)[b]	1.10 (.98,1.23)	.80 (.70,.92)[b]	1.28 (1.09,1.51)[b]	1.11 (.99,1.26)	.73 (.61,.86)[b]
2011–2016	.78 (.64,.95)[b]	1.09 (.85,1.39)	.72 (.63,.82)[b]	1.31 (1.17,1.47)[b]	.71 (.62,.81)[b]	1.24 (1.05,1.46)[b]	1.35 (1.19,1.53)[b]	.57 (.48,.67)[b]
Income (FPL, <200% reference)								
200–399	1.45 (1.25,1.69)[b]	1.00 (.78,1.28)	1.32 (1.20,1.46)[b]	1.36 (1.23,1.01)[b]	.94 (.85,1.04)	1.07 (.96,1.19)	.89 (.79,1.00)[b]	1.27 (1.10,1.47)[b]
≤400	2.80 (2.20,3.58)[b]	1.11 (.86,1.44)	2.24 (2.00,2.50)[b]	1.95 (1.71,2.23)[b]	1.17 (1.02,1.34)[b]	1.44 (1.26,1.64)[b]	.91 (.80,1.04)	1.89 (1.51,2.37)[b]
Education (<High school ref)								
High school	1.49 (1.21,1.83)[b]	.67 (.50,.91)[b]	1.75 (1.56,1.98)[b]	1.18 (1.05,1.33)[b]	.92 (.81,1.03)	1.17 (1.03,1.35)[b]	.96 (.83,1.12)	1.54 (1.29,1.83)[b]
≤Some college	4.04 (3.39,4.81)[b]	1.19 (.93,1.52)	3.25 (2.90,3.65)[b]	2.35 (2.10,2.62)[b]	1.15 (1.02,1.29)[b]	1.65 (1.45,1.87)[b]	1.13 (.98,1.30)	1.88 (1.57,2.25)[b]
Health Insurance (no health insurance reference)								
Insured	.99 (.85,1.16)	1.34 (1.03,1.74)[b]	1.09 (.97,1.21)	1.91 (1.73,2.10)[b]	.78 (.70,.87)[b]	.76 (.68,.87)[b]	.98 (.87,1.11)	.69 (.58,.81)[b]

a. Multivariate adjustment includes all variables in Table 5 and race/ethnicity group.
b. Statistically significant associations.

Discussion

Life's Simple 7 predicts incident hypertension, T2D, coronary heart disease, heart failure, and stroke.[1,4-10] The AHA, Healthy People 2020, and Million Hearts 2022 all promote LS7 variables to improve cardiovascular health and health equity.[1-4] We examined the relationship of sociodemographic variables to LS7 scores to inform targeted efforts promoting cardiovascular health and health equity.

Race and Ethnicity

NHB adults were roughly half as likely as NHW adults to have ideal composite LS7 scores, whereas Hispanics were marginally more likely than NHW to have optimal scores (Table 4). The specific LS7 variables underlying differences in the composite score included higher scores for nutrition, blood pressure and smoking components in Hispanic than NHB adults that were not offset by the better score for cholesterol in NHB adults.

The lower composite LS7 scores in NHB than NHW adults is associated with the expected differences in multiple social determinants including lower incomes, less education and more uninsured. Structural racism,[17] which contributes to a disproportionately large share of NHB adults living in hyper-segregated urban settings with concentrated poverty and related social disadvantages, probably exacerbates racial differences in cardiovascular health.[21,22]

The lower composite LS7 scores in NHBs than Hispanics occurred despite more adverse social determinants including lower incomes, less education, and more uninsured among Hispanics (Table 5). This observation is consistent with previous reports that Hispanics have better cardiovascular outcomes than NHWs, despite socioeconomic disadvantages – the Hispanic

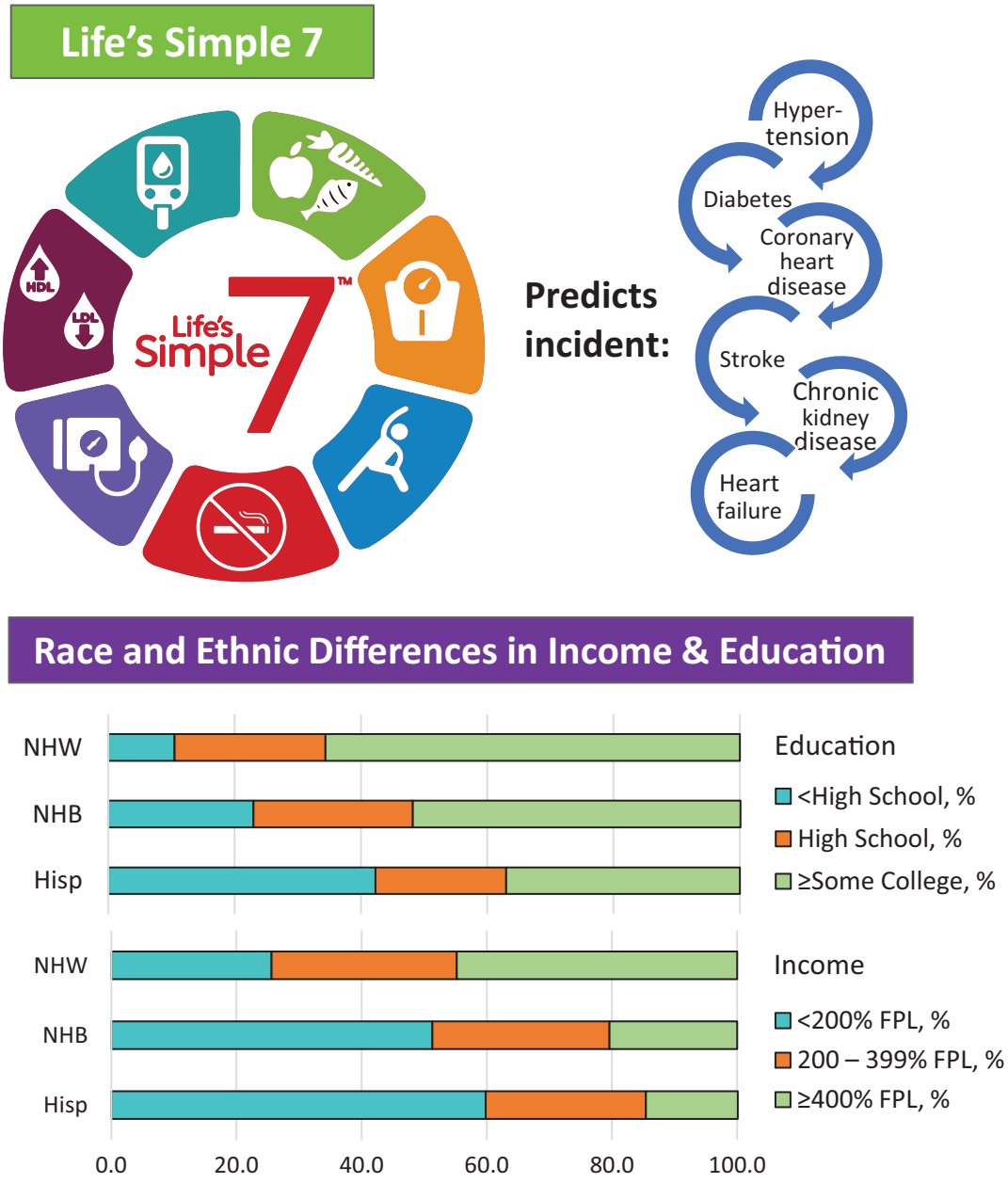

Figure 3. Summary of major findings and implications for cardiovascular health and health equity. Upper: Life's Simple 7 (LS7) items are depicted in a clockwise direction (nutrition, weight, physical activity, cigarette use, BP, cholesterol, and glucose). LS7 scores predict the incidence of several cardiovascular (CV) risk factors and clinical events. Lower: The distribution is shown for education and income (percent federal poverty level [FPL]) among non-Hispanic white (NHW), non-Hispanic Black (NHB), and Hispanic (Hisp) adults. Life's Simple 7 image reprinted with permission https://www.heart.org/en/healthy-living/healthy-lifestyle/my-life-check--lifes-simple-7. (c) 2019 American Heart Association

'paradox.'[16] Previous reports suggested that this paradox may be partially explained by more favorable nutritional patterns in Hispanics, which is supported by our present analysis.

While income and education are important factors impacting health and the composite LS7 score, the racial and ethnic disparities in LS7 transcend factors not included in our multivariate analysis. Independent factors not captured in our analysis

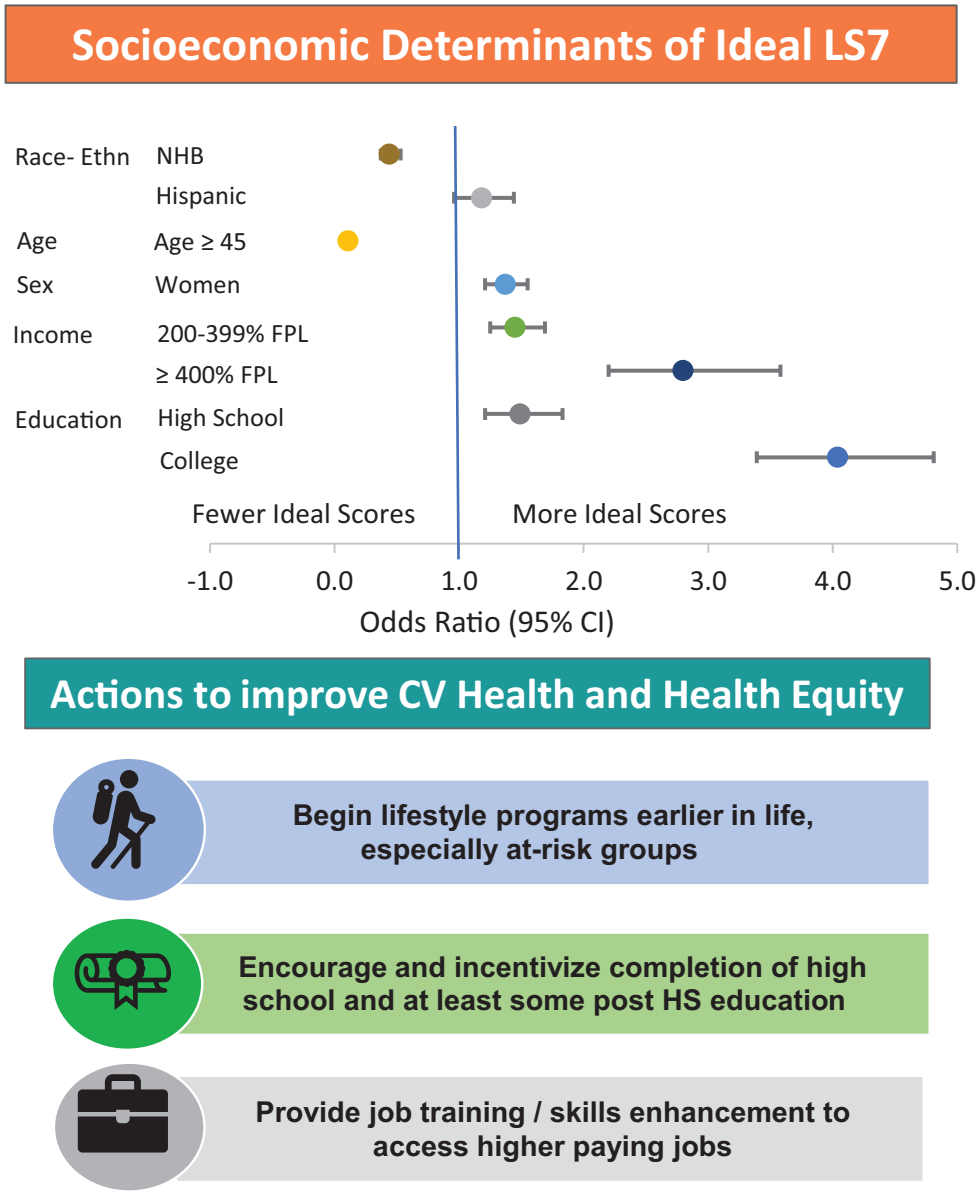

Figure 4. Summary of major findings and implications for cardiovascular health and health equity. Upper: Multivariable odds ratio and 95% confidence intervals (CI) are provided for the association of race-ethn(icity), age, sex, income and education to the probability of ideal LS7 scores. Lower: Three actions to improve CV health and health equity are summarized.

likely contribute to greater cardiovascular risk in NHBs than Hispanics.[15-17] Structural racism emerges as a key factor contributing to health disparities in part through a greater allostatic load, which partially reflects adverse physiological effects of repeated or persistent life stressors.[17,21,22]

Despite challenges, including structural racism, cultural and contextual tailoring of lifestyle programs and more equitable access to care are rational steps in mitigating disparities.[23-25] For example, adults without health care insurance or with public health care insurance have lower income, less education, and greater racial and ethnic minorities than privately insured adults. Yet, adults with public health care insurance achieve hypertension and cholesterol

control comparable to the privately insured.[24,25] Moreover, in the US Veterans Health Administration, access to care is similar across racial groups. In this setting, Black adults had lower cardiovascular mortality and fewer coronary heart disease events than White adults, which contrasts with greater cardiovascular morbidity and mortality for Black adults in the general population.[26] The lower overall LS7 scores for NHBs than NHWs and Hispanics are likely modifiable but will require effective implementation of evidence-based programs, while addressing structural racism and its adverse effects.[17,21,22] Other socioeconomic and demographic factors are also important in addressing suboptimal LS7 scores.

Age

Age was a dominant predictor of composite LS7 scores. Individuals aged ≥45 years were roughly one-tenth as likely to have an ideal range LS7 score than those aged <45 years in multivariable analysis. Adults aged ≥45 years had ideal scores for nutrition and cigarette smoking more often than adults aged <45 years who were offset by fewer ideal scores for physical activity and BMI. Lower composite LS7 scores in older adults were driven largely by lower scores on three modifiable, age-related variables, namely BP, cholesterol, and glucose. Older adults have a higher prevalence of these cardiovascular risk factors. Even when prevalent risk factors are controlled, only one rather than two points is awarded, which is consistent with residual risk.[13]

Given large, age-related declines in several LS7 variables and poorer nutritional patterns and greater cigarette use among younger adults, interventions to ameliorate adverse age-related changes in prevalent hypertension and T2D must begin early in life. Moreover, suboptimal lifestyle patterns and cardiovascular risk in youth and young adults predict adverse cardiovascular outcomes later in life.[27]

Targeting lifestyle intervention in early life is especially important for NHB and Hispanic women who have a high prevalence of obesity and T2D.[15] Effective programs will translate recent dietary recommendations to provide training in nutrition and food preparation and promote access to healthy foods.[28] While access to safe places for physical activity is important, low-intensity physical activity is readily available at home, education and work settings for most people and can prevent T2D.[29]

NHB adults were roughly half as likely as NHW adults to have ideal composite LS7 scores, whereas Hispanics were marginally more likely than NHW to have optimal scores.

Education

Education was another dominant factor associated with LS7 scores. Individuals with at least some college education were ~3–5 times more likely to have ideal composite LS7 scores than those with less than a high school education in multivariable analysis. Adults with at least some higher education were also more likely to have ideal scores for five of seven LS7 items than adults not completing high school. The proportion of adults aged ≥20 years with some higher education rose 10% over time to nearly two thirds, while the proportion without a high school education declined 4.5% to one in seven. Yet, approximately 40% of Hispanics aged <45 years and 50% of those ≥45 years did not complete high school. Despite gains in higher education over time, obesity and T2D increased, and nutrition remained suboptimal.

Education and Income

Previous research estimated that income accounted for only 20% of the link between education and health,[30,31] although higher incomes, especially at least four times the FPL, were independently associated with a nearly threefold greater chance of having ideal composite LS7 scores. Education is linked with better social and psychological skills, larger social networks, less stress, and better health behaviors, better jobs, and less criminal behavior, which translate to health benefits.[30-33] A multi-agency report included evidence-based recommendations to improve graduation rates in the pathway to health equity.[33]

Health Care Insurance

Public or private health care insurance, as a rough proxy for access to health care, attenuates adverse

effects of lesser income and education on treatment and control of CVD risk factors.[23-25] Health care insurance, however, was linked with fewer ideal scores for BP and glucose. While health care insurance improves cardiovascular risk factor control, control does not result in ideal LS7 scores given residual risk. Health care insurance may not prevent or delay incident hypertension and T2D, although the link may be partially explained by individuals with risk factors seeking insurance.

Limitations

NHANES provides repeated cross-sectional rather than longitudinal data on the US population, ie, longitudinal changes identified are implied from cross-sectional data.[34] Our analysis excluded non-Hispanic Asians, American Indians, and Alaskan Natives due to small sample sizes. LS7 uses total cholesterol, although non-HDL cholesterol, accurately captured on non-fasting samples, is more predictive of cardiovascular outcomes.[35] Scoring LS7 variables in treated patients may lead to inconsistencies between reports.[1,13] The original intent was to provide one point for patients with hypertension, hypercholesterolemia and T2D treated to goal.[1] However, treatment goals change over time or are not uniformly defined.[15] Variables required to calculate the LS7 score were missing on 8.1% of adults (Figure 1), and these NHANES participants were excluded from the analysis. Missing data could have led to bias, although >90% of participants were included in the analysis and sample weights accounted for missing individuals to insure appropriate representation of each race-ethnicity population.

Conclusion

Life's Simple 7 is strongly related to incident cardiovascular risk factors and events. Composite LS7 scores decline (worsen) sharply with age and are better in those with higher education and income. Composite LS7 scores are also lower in non-Hispanic Blacks than Hispanics, despite lower income and less education in the latter group, which is consistent with evidence that structural racism adversely impacts health. LS7 scores are similar in Hispanics and NHW, despite large education and income advantages for the latter group, which aligns with reports of the Hispanic health paradox. The findings highlight the importance of effective lifestyle interventions beginning in childhood, especially for groups at-risk for obesity and diabetes including non-Hispanic Blacks and Hispanics. Initiatives to improve education and income, while addressing structural racism are important in pursuing cardiovascular health and health equity.

Acknowledgments

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the American Heart Association, the American Medical Association or the Centers for Disease Control and Prevention.

Disclosures

BME received a lecture honorarium from Merck KGaA, income as a consultant from Albert Einstein College of Medicine (DSMB), and royalties from UpToDate. None of the other authors has any disclosures to report.

Author Contributions

Research concept and design: Egan, Sutherland, Ferdinand, Hong, Sanchez; Acquisition of data: Li; Data analysis and interpretation: Egan, Li, Sutherland, Ferdinand; Manuscript draft: Egan, Sutherland, Jones, Ferdinand, Hong, Sanchez; Statistical expertise: Li, Sutherland; Administrative: Sutherland, Hong, Sanchez; Supervision: Egan

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