Epidemiology and Prevention

Ideal Cardiovascular Health Predicts Lower Risks of Myocardial Infarction, Stroke, and Vascular Death Across Whites, Blacks, and Hispanics

The Northern Manhattan Study

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Background—Evidence of the relationship of cardiovascular health (CVH), defined by the American Heart Association, and specific cardiovascular outcomes is lacking, particularly among Hispanics. This study sought to evaluate the relationship between the number of ideal CVH metrics and cardiovascular risk, overall and by event subtype, in a multiethnic community-based prospective cohort.

Methods and Results—A total of 2981 subjects (mean age, 69±10 years; 54% Caribbean Hispanic, 25% black, 21% white) free of myocardial infarction and stroke at baseline in the Northern Manhattan Study were prospectively followed up (median follow-up, 11 years). The relationship between the number of ideal CVH metrics and the risk of cardiovascular disease, including myocardial infarction, stroke, and vascular death, was investigated. Overall, a strong gradient relationship was observed between the adjusted hazard ratios for cardiovascular disease and the number of ideal CVH metrics: 0.73 (95% confidence interval, 0.60–0.89), 0.61 (95% confidence interval, 0.50–0.76), 0.49 (95% confidence interval, 0.38–0.63), and 0.41 (95% confidence interval, 0.26–0.63) for those having 2, 3, 4, and 5 to 6 ideal CVH metrics, respectively, compared with those having 0 to 1 ideal CVH metrics (P for trend <0.0001). Similar graded relationships were found between the number of ideal CVH metrics and the adjusted incidence rate for each specific outcome and among whites, blacks, and Caribbean Hispanics.

Conclusions—Our findings demonstrated a steep gradient relationship between ideal CVH and individual cardiovascular disease end points, including stroke, that was similar for whites, blacks, and Caribbean Hispanics. This evidence supports the application of the AHA ideal cardiovascular health metrics for cardiovascular disease risk assessment and health promotion for all Americans regardless of race-ethnic background. (Circulation. 2012;125:2975-2984.)

Key Words: cardiovascular health ■ epidemiology ■ ethnic groups ■ myocardial infarction ■ stroke

Heart disease and stroke present major global public health problems accounting for the leading causes of death, disability, and healthcare costs.1 Although mortality has declined for cardiovascular disease (CVD) in the last several decades,2–6 the aging of the population and the increasing prevalence of obesity and diabetes mellitus are projected to increase the burden of these conditions.7 Moreover, substantial disparities in the mortality and incidence of CVD across race-ethnic subgroups have been documented, with greater burdens among blacks and Hispanics.8–10 The healthcare costs of CVD are projected to triple, from $273 billion in 2010 to $818 billion in 2030, unless prevention strategies are implemented more successfully.10

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Clinical Perspective on p 2984

In 2010, the American Heart Association set its 2020 Strategic Impact Goal to improve the cardiovascular health (CVH) of all Americans by 20% while reducing deaths from CVDs and stroke by 20%.11 Using the wealth of evidence on 7 modifiable CVD risk factors (smoking, body mass index, physical activity, diet, blood pressure, total cholesterol, fasting glucose), the AHA has defined ideal CVH metrics as ideal, intermediate, and poor. A greater emphasis has been placed on promoting CVH by focusing on lifestyle and diet modifications to move from poor and intermediate to ideal
health. Efforts to promote and achieve ideal CVH will be even more challenging in minority populations.

The definition of ideal CVH metrics has been derived largely from evidence collected in white cohorts. To date, only 2 studies have reported the prevalence of the 7 ideal CVH metrics newly defined by AHA and risk of CVD events associated with ideal CVH in biethnic (whites and blacks) community-based cohorts (Heart Strategies Concentrating on Risk Evaluation [Heart SCORE] and Atherosclerosis Risk in Communities Study [ARIC]). Neither of these 2 reports evaluated the relationship of ideal CVH and individual CVD outcome events such as stroke. Although Hispanics are the fastest growing and largest minority group in the United States, no studies have addressed ideal CVH in this population. The Northern Manhattan Study (NOMAS) is a prospective community-based cohort study among a multiethnic population with a significant representation of Caribbean Hispanics. In this analysis, we sought to evaluate the gradient between the number of ideal CVH factors and risk of CVD events, overall and by individual event type, and to determine how well these ideal CVH metrics predict CVD in whites, blacks, and Caribbean Hispanics living in the same community.

Methods

Study Population

NOMAS is a longitudinal study of 3298 subjects recruited through random-digit dialing in a community between 1993 and 2001 and followed up annually since 1993. NOMAS was designed to identify novel determinants of stroke and CVDs in 3 race-ethnic groups. The study was approved by the institutional review boards of Columbia University and the University of Miami, and written informed consent was obtained from all participants. Details of enrollment were given previously. Briefly, the enrollment of subjects into the study was based on the following criteria: age ≥40 years, no history of stroke, and Northern Manhattan resident for ≥3 months in a household with a telephone. The overall response rate from the random-digit dialing (telephone screen completion rate, 91%) and in-person enrollment (75% of contacted telephone screen subjects enrolled) was 68%. Of the 3298 stroke-free subjects, 238 with a history of myocardial infarction (MI) at entry and 79 subjects who were not classified as Hispanic, white, or black were excluded from the present analysis. This led to a final study population of 2981 participants.

Ascertainment of Baseline Characteristics

All subjects had a thorough baseline evaluation that included comprehensive medical history, physical examination, review of medical records, and fasting blood samples. Race-ethnicity was defined through self-identification from a series of questions modeled after the US Census. Hispanics were asked to identify their country of origin. Our Hispanic group was composed mainly of Caribbean Hispanics from the Dominican Republic, Puerto Rico, Cuba, and other Latin American countries. White subjects were those who classified themselves as white without any Hispanic origin, and black subjects were those who classified themselves as black without any Hispanic origin.

Standardized questions were adapted from the Centers for Disease Control and Prevention Behavioral Risk Factor Surveillance System. Smoking was based on self-reported age of starting smoking and age of quitting smoking. Leisure-time physical activity was measured with a questionnaire based on the National Health Interview Survey. Diet was assessed through a structured in-person interview using questions adapted from the National Cancer Institute food frequency questionnaire. Blood pressure, height, weight, and fasting glucose were measured with standard methods as described previously. Fasting total cholesterol was measured with a Hitachi 705 automated spectrophotometer (Boehringer Mannheim, Mannheim, Germany).

Classification of CVH

In accordance with AHA definitions, 7 CVH factors were classified into ideal, intermediate, or poor: (1) smoking: ideal (never or quit ≥1 year), intermediate (quit ≥1 year), and poor (current); (2) body mass index: ideal (<25 kg/m²), intermediate (25 to <30 kg/m²), and poor (≥30 kg/m²); (3) physical activity: ideal (≥150 min/wk moderate intensity, ≥75 min/wk vigorous intensity, or equivalent combination), intermediate (1–149 min/wk moderate intensity, 1–74 min/wk vigorous intensity, or equivalent combination), and poor (no moderate and vigorous activity); (4) diet: ideal (4–5 healthy components), intermediate (2–3 healthy components), and poor (0–1 healthy component) based on 5 health dietary metrics (≥4.5 cups of fruits and vegetables a day, 2 or more 3.5-oz servings of fish a week, 3 or more 1-oz equivalent servings fiber-rich whole grains per day, <1500 mg sodium/d, and ≤450 kcal sugar-sweetened beverages a week); (5) total cholesterol: ideal (untreated and <200 mg/dL), intermediate (treated to <200 mg/dL or 200–239 mg/dL), and poor (≥240 mg/dL); (6) blood pressure: ideal (untreated and <120/80 mm Hg), intermediate (treated to <120/80 mm Hg or 120–139/80–89 mm Hg), and poor (≥140/90 mm Hg); and (7) fasting plasma glucose: ideal (untreated and <100 mg/dL), intermediate (treated to <100 mg/dL or 100–125/mg/dL), and poor (≥126 mg/dL).

Ascertainment of Incident CVD Events

NOMAS participants have been followed up annually by telephone interview with an average annual contact rate of 99%. A positive screen for any potential cardiac or neurological event was followed up by an in-person assessment to determine whether a vascular outcome occurred. All admissions and discharges to New York–Presbyterian Hospital were prospectively screened to detect hospitalizations and outcomes that may not have been captured by telephone interview. The 3 outcomes of primary interest were any stroke, MI, and any vascular death. Stroke was verified and classified by at least 2 study neurologists as described in prior reports. MI was adjudicated by study team cardiologists according to previously published criteria. For those who developed both MI and stroke, we counted the first event of MI and stroke and censored the second one at the time of occurrence of the first event. Causes of death were determined from death certificates, medical records of hospitalizations, family interviews, and primary care physicians. Vascular causes of death included stroke, MI, heart failure, cardiac arrhythmia, and other vascular causes regardless of their status of the incident MI and stroke.

Statistical Analysis

The F test was used to examine the differences in age, and the χ² test was used to compare the frequencies of categorical variables and ideal CVH metrics among the racial/ethnic groups. Direct standardization method was used to calculate the age- and sex-adjusted prevalence of ideal CVH metrics based on the distribution of age (5-year band) and sex in the total cohort as the standard. Logistic regression models were used to compare the prevalence of ideal CVH metrics across race-ethnic groups after adjustment for age and sex. For each participant, the time (years) at risk for a cardiovascular event was computed from the date of enrollment to the occurrence of incident cardiovascular event, death, loss to follow-up, or the most recent follow-up date, whichever came first. To examine the relationship between the number of ideal CVH metrics and cardiovascular risk, we classified 2981 NOMAS participants into 5 groups: 0 to 1, 2, 3, 4, and 5 to 6 ideal CVH metrics present at baseline. We
collapsed 0 with 1 and 5 with 6 ideal metrics because of relatively few subjects who had 0 (2.3% of total cohort) or 6 (0.5% of total cohort) ideal health metrics. Poisson regression models were used to calculate the adjusted incidence of CVD events, which were directly standardized to the distribution of age and sex in total cohort. Cox proportional hazards models were used to estimate the cumulative hazard function and multivariable-adjusted hazard ratio (HRs) and 95% confidence intervals (CIs) after adjustment for age, sex, and race/ethnicity. Overall C statistics were computed to evaluate the discriminatory capability of the models with the number of ideal CVH metrics. Analyses were done for the incidence of CVD (MI, stroke, or vascular death) and for stroke or MI individually. Separate analyses were done for all-cause mortality and vascular and nonvascular death.

We calculated interactions with race-ethnicity and performed stratified analyses by race-ethnicity to explore the gradient relationship between the number of ideal CVH metrics and CVD and across race-ethnic groups. In addition, regression analyses were performed to examine the gradient relationship between the number of 4 ideal CVH behaviors (smoking, body mass index, physical activity, and diet) and CVD risk and between the number of 3 ideal CVH factors (blood pressure, total cholesterol, and fasting plasma glucose) and CVD risk. All data analyses were performed with SAS statistical software version 9.2 (SAS Institute Inc, Cary, NC).

Considering that the standard deviation in the number of ideal CVH metrics was 1.08 and the overall cumulative risk was 7.0% for MI, 8.5% for stroke, 13.7% for vascular death, and 24.0% for CVD, we had >80% power (α = 0.05) to detect a corresponding HR of 0.84 (MI), 0.85 (stroke), 0.88 (vascular death), and 0.91 (CVD) for per 1-number increase in ideal health metrics for the whole sample (n = 2981); of 0.78, 0.80, 0.84, and 0.88 for Hispanics (n = 1617); of 0.70, 0.72, 0.77, and 0.82 for blacks (n = 745); and of 0.67, 0.70, 0.75, and 0.81 for whites, respectively.

**Results**

**Sample Characteristics and Prevalence of Ideal CVH at Baseline**

Table 1 presents baseline sample characteristics and the prevalence of ideal CVH for the total cohort, whites (20.8%), blacks (25.0%), and Caribbean Hispanics (54.2%). Among the 2981 participants, 63.7% were women and the mean age was 69 ± 10 years with 36.3% < 64 years and 26.4% > 75 years. On average, Caribbean Hispanics were 6 years younger than blacks and 7 years younger than whites. Overall, no person had all 7 ideal CVH factors, only 4.4% of the cohort had 5 or 6 CVH factors, and the majority of the cohort (62.4%) had only 2 or 3 ideal factors. A significantly greater prevalence of having 5 to 6 ideal CVH factors was seen among whites (7.7%) compared with blacks (4.3%) and Caribbean Hispanics (3.2%), and the disparity remained similar after adjustment for age and sex (Figure I and II in the online-only Data Supplement).

Among the 4 health behaviors, the prevalence of ideal nonsmoking behavior was high overall, although lowest among blacks. Ideal body mass index was present in 30.7% of the total cohort, greatest among whites (47.2%), lower among blacks (30.3%), and lowest among Caribbean Hispanics (24.6%). Similarly, ideal physical activity was present in 33.3% of the total cohort, greatest among whites (45.2%), lower among blacks (37.6%), and lowest among Caribbean Hispanics (26.8%). However, only 0.4% of the total cohort met the ideal diet definition, and the diet component of ideal CVH was equally poor across all 3 race-ethnic groups.

For each of the 3 health factors, the prevalence of ideal blood pressure was low overall and lower among blacks (5.3%) and Caribbean Hispanics (5.0%) compared with whites (9.1%). The prevalence of ideal fasting glucose was 63.1% overall, greatest among whites (66.9%), and lower among blacks (61.5%) and Caribbean Hispanics (62.3%). The prevalence of ideal total cholesterol was lower among whites (35.3%) and greater among blacks (46.0%) and Caribbean Hispanics (43.0%).

**Ideal CVH and CVD Risk, Overall and by Race/Ethnicity**

During a median follow-up of 11 years, 722 individuals developed an incident CVD event, including stroke, MI, and vascular death. The overall incidence rate of CVD was 24.0 per 1000 person-years in the total cohort. The age- and sex-adjusted incidence rate (crude rate) of CVD was 28.8 (32.7), 31.6 (31.9), and 25.1 (17.8) per 1000 person-years in whites, blacks, and Caribbean Hispanics, respectively. After adjustment for age, sex, and race-ethnicity, the overall CVD incidence rate in the total cohort was lower among those with a greater number of ideal CVH metrics, with an adjusted incidence rate of 41.3, 30.4, 25.9, 20.7, and 17.6 per 1000 person-years for those having 0 to 1, 2, 3, 4, and 5 to 6 ideal CVH metrics, respectively. A similar trend of lower adjusted incidence rates with an increase in the number of ideal CVH metrics was observed in whites (from 44.8–19.1 per 1000 person-years), blacks (from 46.1–19.6 per 1000 person-years), and Caribbean Hispanics (from 35.8–15.2 person-years; Figure 1). Cox regression analysis did not detect a significant interaction between race-ethnicity and the number of ideal CVH metrics in the HRs for CVD risk (Wald χ² = 9.50; df = 8; P = 0.30) and showed a clear gradient relationship between the HRs of CVD events and the number of ideal CVH metrics overall and across race-ethnic groups (all P for trend ≤ 0.001). Subjects with 5 to 6 ideal CVH metrics had a much lower risk compared with those with 0 to 1 ideal CVH metric for CVD in the total cohort (HR, 0.41; 95% CI, 0.26–0.63), whites (HR, 0.48; 95% CI, 0.25–0.92), blacks (HR, 0.31; 95% CI, 0.12–0.78), and Caribbean Hispanics (HR, 0.33; 95% CI, 0.14–0.77). The discriminatory capabilities of Cox regression models with the number of ideal CVH metrics were similar for the overall group or each subgroup, with a C statistic ranging from 0.63 to 0.68 (Table 2).

Figure 2 shows the adjusted incidence rates of CVD by combinations of the numbers of ideal health behaviors and ideal health factors based on an additive model. The gradient for lower CVD incidence rates with a greater number of ideal health behaviors was observed across each of the subgroups by number of ideal health factors. Moreover, the rate was lower with a greater number of ideal health factors when controlling for the number of ideal health behaviors. Similarly, Cox regression analysis including both the number of ideal health behaviors and the number of ideal health factors in the model also showed that lower CVD risk is associated with increased number of ideal health behaviors (Wald χ² = 15.84; df = 3; P = 0.001) and the number of ideal health factors (Wald χ² = 22.79; df = 3; P < 0.0001), but there is no
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total Cohort (n=2981)</th>
<th>White (n=619)</th>
<th>Black (n=745)</th>
<th>Caribbean Hispanic (n=1617)</th>
<th>P for χ²/F test</th>
<th>P Adjusted for Age and Sex*</th>
</tr>
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<tbody>
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<td>Age, mean (SD), y</td>
<td>69 (10)</td>
<td>73 (10)</td>
<td>72 (10)</td>
<td>66 (9)</td>
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<td>Female, %</td>
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<td>60.7</td>
<td>67.2</td>
<td>63.3</td>
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<td>Smoking, %</td>
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<td></td>
<td></td>
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<tr>
<td>Ideal (never or quit &gt;1 y)</td>
<td>80.5</td>
<td>85.3</td>
<td>74.9</td>
<td>81.3</td>
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<td>&lt;0.0001</td>
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<td>Intermediate (quit &lt;1 y)</td>
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<td>1.3</td>
<td>2.2</td>
<td>2.4</td>
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<td>Poor (current)</td>
<td>17.3</td>
<td>13.4</td>
<td>23.0</td>
<td>16.3</td>
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<td>Body mass index, %</td>
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<td>&lt;0.0001</td>
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<tr>
<td>Ideal (&lt;25 kg/m²)</td>
<td>30.7</td>
<td>47.2</td>
<td>30.3</td>
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<tr>
<td>Intermediate (25–&lt;30 kg/m²)</td>
<td>41.8</td>
<td>35.0</td>
<td>39.0</td>
<td>45.7</td>
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<tr>
<td>Poor (≥30 kg/m²)</td>
<td>27.5</td>
<td>17.9</td>
<td>30.7</td>
<td>29.7</td>
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<tr>
<td>Physical activity, %</td>
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<td></td>
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<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
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<tr>
<td>Ideal (&gt;75 min/wk vigorous, ≥150 min/wk moderate, or equivalent combination)</td>
<td>33.3</td>
<td>45.2</td>
<td>37.6</td>
<td>26.8</td>
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<tr>
<td>Intermediate (1–74 min/wk vigorous, 1–149 min/wk moderate, or equivalent combination)</td>
<td>24.9</td>
<td>24.2</td>
<td>28.5</td>
<td>23.6</td>
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<tr>
<td>Poor (no moderate and vigorous activity)</td>
<td>41.7</td>
<td>30.5</td>
<td>34.0</td>
<td>49.6</td>
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<tr>
<td>Diet, %†</td>
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<td></td>
<td></td>
<td></td>
<td>0.66</td>
<td>0.62</td>
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<tr>
<td>Ideal (4–5 healthy components)</td>
<td>0.4</td>
<td>0.2</td>
<td>0.5</td>
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<tr>
<td>Intermediate (2–3 healthy components)</td>
<td>24.7</td>
<td>23.2</td>
<td>25.9</td>
<td>24.8</td>
<td></td>
<td></td>
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<tr>
<td>Poor (0–1 healthy component)</td>
<td>74.9</td>
<td>76.6</td>
<td>73.6</td>
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<td>Blood pressure, %</td>
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<td>&lt;0.0001</td>
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<tr>
<td>Ideal (untreated and &lt;120/&lt;80 mm Hg)</td>
<td>5.9</td>
<td>9.1</td>
<td>5.3</td>
<td>5.0</td>
<td></td>
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<tr>
<td>Intermediate (treated to &lt;120/&lt;80 mm Hg or 120–139/80–89 mm Hg)</td>
<td>56.8</td>
<td>60.6</td>
<td>51.4</td>
<td>57.9</td>
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<tr>
<td>Poor (≥140/90 mm Hg)</td>
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<td>30.3</td>
<td>43.4</td>
<td>37.2</td>
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<td>Total cholesterol, %</td>
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<td>&lt;0.0001</td>
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<tr>
<td>Ideal (untreated and &lt;200 mg/dL)</td>
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<td>35.3</td>
<td>46.0</td>
<td>43.0</td>
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<td>Intermediate (treated to &lt;200 mg/dL or 200–239 mg/dL)</td>
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<td>45.5</td>
<td>37.8</td>
<td>40.2</td>
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<tr>
<td>Poor (≥240 mg/dL)</td>
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<td>19.2</td>
<td>16.2</td>
<td>16.8</td>
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<td>Plasma glucose, %</td>
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<td>Ideal (untreated and &lt;100 mg/dL)</td>
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<td>61.5</td>
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<td>Intermediate (treated to &lt;100 mg/dL or 100–125/mg/dL)</td>
<td>21.1</td>
<td>22.1</td>
<td>21.3</td>
<td>20.5</td>
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<tr>
<td>Poor (≥126 mg/dL)</td>
<td>15.9</td>
<td>11.0</td>
<td>17.2</td>
<td>17.2</td>
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<td>No. of ideal health metrics, %</td>
<td></td>
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<td>0</td>
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<td>1</td>
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<td>2</td>
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<tr>
<td>6</td>
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<td>0.8</td>
<td>0.5</td>
<td>0.4</td>
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</table>

*P values were based on Wald χ² test with 2 df in the multiple binary (ideal versus other for individual metrics or 5–6 vs 0–4 for the number of ideal health metrics) logistic regression after adjustment for age and sex.
†A total of 308 subjects were missing baseline diet data; the proportions of subjects with missing diet data were 9.5%, 11.9%, and 9.9% in whites, blacks, and Caribbean Hispanics, respectively (P=0.24 for χ² test with 2 df).
significant interaction between the 2 numbers (Wald $\chi^2=6.74$; $df=9$; $P=0.66$), suggesting that both ideal health behaviors and ideal health factors were independently associated with the lower CVD risk.

**Ideal CVH and Risk of MI and Stroke by Race/Ethnicity**

During the follow-up, 208 individuals had MI and 252 individuals had stroke as the first CVD event. For MI, the age- and sex-adjusted incidence rate (crude rate) was 10.5 (11.9), 5.5 (5.6), and 7.6 (5.4) per 1000 person-years in whites, blacks, and Caribbean Hispanics, respectively. For stroke, the age- and sex-adjusted incidence rate (crude rate) was 6.3 (7.1), 11.0 (11.1), and 9.6 (7.4) per 1000 person-years in whites, blacks, and Caribbean Hispanics, respectively. Figure 3 presents the age- and sex-adjusted incidence rates of MI and stroke according to the number of ideal CVH metrics in each race-ethnic group. Similar to the pattern of the relationship between the number of ideal CVH metrics and CVD risk, with an increasing number of ideal CVH metrics present, the adjusted incidence rate was lower for MI and stroke in whites, blacks, and Caribbean Hispanics, even

![Figure 1. Incidence rates of cardiovascular disease (CVD) by the number of ideal health metrics in the total cohort, whites, blacks, and Caribbean Hispanics. Incidence rates of cardiovascular disease by the number of ideal health metrics were adjusted for age, sex, and race-ethnicity if applicable. Northern Manhattan Study (NOMAS), 1993 to 2011. PYS indicates person-years.](image)

### Table 2. Hazard Ratios of Cardiovascular Events by the Number of Ideal Cardiovascular Health Metrics

<table>
<thead>
<tr>
<th>Event</th>
<th>Ideal Health Metrics, n</th>
<th>Total Cohort</th>
<th>White</th>
<th>Black</th>
<th>Caribbean Hispanic</th>
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<tbody>
<tr>
<td></td>
<td>Cases, n</td>
<td>HR (95% CI)*</td>
<td>Cases, n</td>
<td>HR (95% CI)†</td>
<td>Cases, n</td>
</tr>
<tr>
<td><strong>CVD‡</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–1</td>
<td>165</td>
<td>Reference</td>
<td>30</td>
<td>Reference</td>
<td>54</td>
</tr>
<tr>
<td>2</td>
<td>228</td>
<td>0.73 (0.60–0.89)</td>
<td>54</td>
<td>0.66 (0.42–1.04)</td>
<td>76</td>
</tr>
<tr>
<td>3</td>
<td>212</td>
<td>0.61 (0.50–0.76)</td>
<td>54</td>
<td>0.47 (0.30–0.74)</td>
<td>62</td>
</tr>
<tr>
<td>4</td>
<td>93</td>
<td>0.49 (0.38–0.63)</td>
<td>39</td>
<td>0.45 (0.27–0.72)</td>
<td>30</td>
</tr>
<tr>
<td>≥5</td>
<td>24</td>
<td>0.41 (0.26–0.63)</td>
<td>13</td>
<td>0.48 (0.25–0.92)</td>
<td>5</td>
</tr>
<tr>
<td><strong>P for trend</strong></td>
<td></td>
<td>&lt;0.0001</td>
<td>0.001</td>
<td>&lt;0.0001</td>
<td>0.002</td>
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<tr>
<td>C statistic (95% CI)</td>
<td></td>
<td>0.68 (0.60–0.75)</td>
<td>0.67 (0.52–0.81)</td>
<td>0.63 (0.49–0.77)</td>
<td>0.67 (0.56–0.78)</td>
</tr>
<tr>
<td><strong>Myocardial infarction</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–1</td>
<td>48</td>
<td>Reference</td>
<td>11</td>
<td>Reference</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>0.78 (0.54–1.12)</td>
<td>25</td>
<td>0.86 (0.42–1.75)</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>56</td>
<td>0.57 (0.38–0.84)</td>
<td>18</td>
<td>0.45 (0.21–0.96)</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>0.53 (0.33–0.85)</td>
<td>15</td>
<td>0.52 (0.23–1.14)</td>
<td>8</td>
</tr>
<tr>
<td>≥5</td>
<td>3</td>
<td>0.16 (0.05–0.52)</td>
<td>2</td>
<td>0.22 (0.05–0.98)</td>
<td>0</td>
</tr>
<tr>
<td><strong>P for trend</strong></td>
<td></td>
<td>&lt;0.0001</td>
<td>0.006</td>
<td>0.125</td>
<td>0.006</td>
</tr>
<tr>
<td>C statistic (95% CI)</td>
<td></td>
<td>0.69 (0.55–0.81)</td>
<td>0.67 (0.42–0.88)</td>
<td>0.60 (0.37–0.81)</td>
<td>0.69 (0.48–0.86)</td>
</tr>
<tr>
<td><strong>Stroke</strong></td>
<td>0–1</td>
<td>64</td>
<td>7</td>
<td>Reference</td>
<td>22</td>
</tr>
<tr>
<td>2</td>
<td>81</td>
<td>0.71 (0.51–0.99)</td>
<td>12</td>
<td>0.71 (0.28–1.80)</td>
<td>29</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>0.60 (0.42–0.84)</td>
<td>13</td>
<td>0.59 (0.23–1.50)</td>
<td>17</td>
</tr>
<tr>
<td>4</td>
<td>29</td>
<td>0.49 (0.31–0.76)</td>
<td>7</td>
<td>0.44 (0.15–1.23)</td>
<td>11</td>
</tr>
<tr>
<td>≥5</td>
<td>8</td>
<td>0.43 (0.21–0.91)</td>
<td>4</td>
<td>0.73 (0.21–2.51)</td>
<td>1</td>
</tr>
<tr>
<td><strong>P for trend</strong></td>
<td></td>
<td>0.0002</td>
<td>0.26</td>
<td>0.003</td>
<td>0.04</td>
</tr>
<tr>
<td>C statistic (95% CI)</td>
<td></td>
<td>0.65 (0.52–0.77)</td>
<td>0.65 (0.33–0.92)</td>
<td>0.65 (0.33–0.93)</td>
<td>0.66 (0.49–0.82)</td>
</tr>
</tbody>
</table>

HR indicates hazard ratio; CI, confidence interval; and CVD, cardiovascular disease.

*HR and 95% CI after adjustment for age, sex, and race-ethnicity based on Cox regression.
†HR and 95% CI after adjustment for age and sex based on Cox regression.
‡CVD includes the first event of myocardial infarction, stroke, or vascular death.
though there were differences in the overall incidence rates across race-ethnic groups. Cox proportional hazard model also demonstrated a similar gradient relationship between the number of ideal CVH metrics and the HR for MI and stroke across the race-ethnic subgroups, although no statistical significance was reached for MI in blacks and for stroke in whites because of the small number of the events, with a discriminatory capability of C statistic ranging from 0.60 to 0.69 (Table 2). No significant interaction was detected between race-ethnicity and the number of ideal CVH metrics in the HRs for MI (Wald $\chi^2=5.70; df=8; P=0.68$) and stroke (Wald $\chi^2=7.48; df=8; P=0.49$).

### Ideal CVH and Vascular and Nonvascular Death by Race/Ethnicity

During the follow-up, there were 1123 deaths, including 435 vascular and 688 nonvascular deaths. For vascular death, the age- and sex-adjusted (crude rate) mortality rate was 17.1 (20.1), 19.3 (19.5), and 14.0 (9.0) per 1000 person-years in whites, blacks, and Caribbean Hispanics, respectively. For nonvascular death, the age- and sex-adjusted (crude rate) mortality rate was 25.6 (29.8), 31.2 (31.1), and 21.0 (14.7) per 1000 person-years in whites, blacks, and Caribbean Hispanics, respectively. Figure 4 shows the age- and sex-adjusted mortality rates of vascular and nonvascular deaths according to the number of ideal CVH metrics in each race-ethnic group. Compared with nonvascular death, vascular death showed a clearer gradient related to the number of ideal CVH metrics in the total cohort or specific ethnic group (Table 3).

### Discussion

In this multiethnic community-based prospective cohort of older individuals, the presence of a greater number of the ideal CVH metrics at baseline was associated with a markedly lower risk of CVD over a median follow-up of 11 years. A similar pattern was also found for each outcome of stroke, MI, and vascular death in the separate analyses. This strong graded relationship was observed and the magnitude of the effects was quantitatively similar across whites, blacks, and Caribbean Hispanics. In addition, the lower CVD risk was associated with higher numbers of both ideal health behaviors (nonsmoking, body mass index $<25$ kg/m$^2$, adequate physical activity, healthy dietary quality) and health factors (untreated blood pressure $<120/80$ mm Hg, untreated total cholesterol $<200$ mg/dL, untreated fasting glucose $<100$ mg/dL). Despite race-ethnic disparities in the prevalence of
ideal CVH, our data provide evidence to support the uniform application of the AHA ideal CVH metrics for CVD risk assessment and health promotion for all Americans regardless of their race-ethnic backgrounds.

Our data indicated that there were substantial race-ethnic disparities in the prevalence of ideal health metrics and that these disparities partially accounted for the differences in CVD risk. Figure 1 shows that the CVD incidence rates were

Table 3. Hazard Ratios of Death by the Number of Ideal Cardiovascular Health Metrics

<table>
<thead>
<tr>
<th>Death</th>
<th>Ideal Health Metrics, n</th>
<th>Total Cohort</th>
<th>White</th>
<th>Black</th>
<th>Caribbean Hispanic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases, n</td>
<td>HR (95% CI)*</td>
<td>Cases, n</td>
<td>HR (95% CI)†</td>
<td>Cases, n</td>
</tr>
<tr>
<td>All cause</td>
<td>0–1</td>
<td>211 Reference</td>
<td>33 Reference</td>
<td>116 Reference</td>
<td>141 Reference</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>344 0.87 (0.73–1.03)</td>
<td>87 1.03 (0.69–1.54)</td>
<td>116 0.85 (0.64–1.15)</td>
<td>141 0.84 (0.65–1.08)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>342 0.78 (0.66–0.93)</td>
<td>99 0.85 (0.57–1.27)</td>
<td>120 0.75 (0.56–1.00)</td>
<td>123 0.82 (0.63–1.06)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>178 0.72 (0.59–0.89)</td>
<td>70 0.78 (0.51–1.19)</td>
<td>62 0.77 (0.55–1.09)</td>
<td>46 0.65 (0.46–0.92)</td>
</tr>
<tr>
<td></td>
<td>≥5</td>
<td>48 0.59 (0.43–0.81)</td>
<td>24 0.78 (0.46–1.33)</td>
<td>10 0.45 (0.23–0.87)</td>
<td>14 0.53 (0.30–0.93)</td>
</tr>
<tr>
<td>P for trend</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0001</td>
</tr>
<tr>
<td>C statistic (95% CI)</td>
<td></td>
<td>0.70 (0.64–0.75)</td>
<td>0.68 (0.56–0.80)</td>
<td>0.68 (0.56–0.78)</td>
<td>0.69 (0.59–0.78)</td>
</tr>
<tr>
<td>Vascular</td>
<td>0–1</td>
<td>95 Reference</td>
<td>19 Reference</td>
<td>33 Reference</td>
<td>43 Reference</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>127 0.70 (0.53–0.91)</td>
<td>35 0.69 (0.39–1.21)</td>
<td>42 0.65 (0.41–1.03)</td>
<td>50 0.72 (0.48–1.08)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>136 0.67 (0.51–0.87)</td>
<td>36 0.49 (0.28–0.87)</td>
<td>46 0.60 (0.38–0.95)</td>
<td>54 0.88 (0.59–1.31)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>59 0.51 (0.37–0.72)</td>
<td>26 0.46 (0.25–0.84)</td>
<td>21 0.55 (0.32–0.97)</td>
<td>12 0.43 (0.23–0.82)</td>
</tr>
<tr>
<td></td>
<td>≥5</td>
<td>18 0.48 (0.29–0.80)</td>
<td>10 0.54 (0.25–1.17)</td>
<td>5 0.49 (0.19–1.25)</td>
<td>3 0.30 (0.09–0.99)</td>
</tr>
<tr>
<td>P for trend</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
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<tr>
<td>C statistic (95% CI)</td>
<td></td>
<td>0.70 (0.64–0.75)</td>
<td>0.68 (0.56–0.80)</td>
<td>0.68 (0.56–0.78)</td>
<td>0.69 (0.59–0.78)</td>
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<tr>
<td>Nonvascular</td>
<td>0–1</td>
<td>116 Reference</td>
<td>14 Reference</td>
<td>41 Reference</td>
<td>61 Reference</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>217 1.01 (0.81–1.27)</td>
<td>52 1.50 (0.83–2.71)</td>
<td>74 1.02 (0.69–1.49)</td>
<td>91 0.92 (0.67–1.28)</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>206 0.88 (0.70–1.10)</td>
<td>63 1.34 (0.76–2.44)</td>
<td>74 0.86 (0.59–1.27)</td>
<td>69 0.78 (0.55–1.10)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>119 0.90 (0.69–0.17)</td>
<td>44 1.23 (0.67–2.26)</td>
<td>41 0.95 (0.61–1.48)</td>
<td>34 0.80 (0.52–1.22)</td>
</tr>
<tr>
<td></td>
<td>≥5</td>
<td>30 0.68 (0.45–1.02)</td>
<td>14 1.12 (0.53–2.36)</td>
<td>5 0.41 (0.16–1.04)</td>
<td>11 0.67 (0.35–1.30)</td>
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<tr>
<td>P for trend</td>
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<td>0.04</td>
<td>0.71</td>
<td>0.13</td>
<td>0.09</td>
</tr>
<tr>
<td>C statistic (95% CI)</td>
<td></td>
<td>0.68 (0.60–0.75)</td>
<td>0.65 (0.49–0.79)</td>
<td>0.66 (0.52–0.78)</td>
<td>0.68 (0.55–0.79)</td>
</tr>
</tbody>
</table>

HR indicates hazard ratio; CI, confidence interval.

*HR and 95% CI after adjustment for age, sex, and race-ethnicity based on Cox regression.
†HR and 95% CI after adjustment for age and sex based on Cox regression.
similar between whites and blacks after adjustment for the number of ideal health metrics. However, similar to the national data with lower CVD mortality in Hispanics compared with whites and blacks, our data showed that Hispanics had a lower risk for CVD even after adjustment for age, sex, and the number of ideal health metrics, suggesting that other factors, including genetic and sociocultural factors, may also contribute to this paradox. On the other hand, the observed prevalence of ideal diet in our study was equally low and agrees well with the national data (<0.5% ideal diet in both adults and children), suggesting that more longitudinal studies may be needed to evaluate the applicability of this metric across race-ethnic groups.

Prior studies have not evaluated the relationship between ideal CVH and specific event types or among Hispanics. In the ARIC study of middle-aged men and women, a strong graded relationship was reported between an individual’s number of ideal CVH metrics and the future overall CVD risk both in whites and blacks. The age-, sex-, and race-adjusted incidence rate of CVD was nearly 8-fold higher in the ARIC participants having 0 ideal CVH metric (32 per 1000 person-years) compared with those having 6 ideal CVH metrics (4 per 1000 person-years). No CVD events were observed among the individuals having 7 ideal CVH metrics after 20 years of follow-up in their relatively young cohort.

In contrast to the ARIC cohort, the NOMAS cohort, which has an older age distribution, had no participants with all 7 ideal CVH metrics and a much lower prevalence of 5 to 6 ideal CVH metrics (4.4% versus 12.2%). Our findings clearly demonstrated a gradient in the adjusted HRs across the number of ideal CVH metrics and extended this graded association to Caribbean Hispanics and to each separate CVD event. Although we studied an older cohort, we were able to document a 59% lower CVD risk for those having 5 to 6 ideal CVH metrics compared with those having 0 to 1 ideal CVH metric. We were able to extend the results of ARIC beyond middle-aged adults and demonstrate a graded relationship between the number of ideal CVH metrics in an older, urban, and multiethnic population. Interestingly, the greatest reduction in adjusted CVD incidence rate was found in the comparison of 0 to 1 with 2 ideal health metrics than for other increments of 1 health metric unit, suggesting that having even 2 ideal health metrics may lower CVD risk by ≈27% (HR = 0.73; Table 2). This sends an important message about initiating steps to ideal health even among those with the least ideal health.

Our results have several important implications for the promotion of ideal CVH and the prevention of CVD. Our data indicate that the prevalence of having ≥5 ideal CVH metrics is low. No one in our entire cohort had all 7 ideal CVH metrics, and a very small proportion had ≥5 ideal CVH metrics. More aggressive efforts are needed to begin at younger ages and to shift more of the population toward ideal CVH, obesity, and diet that are just as important as policies controlling vascular factors such as blood pressure, cholesterol, and blood glucose to lower CVD risk. Whereas there has been a decline in CVD mortality in the United States, the increased obesity and physical inactivity and low consumption of healthy foods in the US population will likely lead to an increasing number of persons with CVD. Initiatives such as the Million Hearts program and follow-up to the United Nations political declaration on noncommunicable disease that target tobacco control, obesity, and diet will be essential to the future reduction of CVDs and stroke.

Strengths of our study include the community-based random-sampling method, the inclusion of a triethnic cohort with a sizeable number of Hispanics from the same community that allows comparisons and helps minimize socioeconomic confounding, the availability of blood assessments and comprehensive data on health behaviors, and the excellent retention of the cohort with follow-up for as long as 16 years. Nevertheless, several limitations also deserve mention. First, the sample size was relatively small for whites and blacks but larger for Caribbean Hispanics, limiting our ability to detect race-ethnic differences and to generalize the findings to all Hispanics, given that Hispanics are a heterogeneous population. However, the observed gradients were consistent, steep, statistically significant, and in agreement with other studies. In addition, this consistency of risk gradients across ethnic groups was seen in multiple regions of the world in the INTERHEART study. Second, the crude scale used and the treatment of each individual metric as having an equal magnitude of effect could oversimplify the association. Third, this study did not include other cardiovascular events such as congestive heart failure, and the incidence rate of overall CVD could be underestimated. Fourth, CVH was...
defined from baseline assessments. Given >10 years of follow-up, it is very likely that the levels of CVH factors may change over time, leading to the underestimation of true associations. In addition, the categories defined by the AHA for some metrics may be less than ideal. For example, some studies have shown that there is a continuous positive relationship between vascular risk and blood total cholesterol down to 160 mg/dL without threshold.27,28 The overall C statistics were <0.7, suggesting that these weaknesses may lead to an underestimation of the true association between CVH metrics and CVD risk.23,26 Thus, Stamler et al.29 and Daviglus and Liu30 have demonstrated even larger protective effects.

Conclusions
Our data documented a clear gradient relationship between ideal CVH and CVD risk across each race-ethnic subgroup and for each event type, including stroke, MI, and vascular death. This evidence supports the application of the AHA ideal CVH metrics for CVD risk assessment and health promotion for all Americans.

Acknowledgments
We thank the study participants for their collaboration and all the staff of the NOMAS for their dedication to the study, especially Janet DeRosa.

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This work is supported by a grant from the National Institute of Neurological Disorders and Stroke (R37 NS 29993) and Evelyn F. McKnight Brain Institute.

Disclosures
None.

References


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**CLINICAL PERSPECTIVE**

Evidence of the beneficial effects of the American Heart Association ideal cardiovascular health definition among diverse populations is lacking and could have significant public health implications. In the triethnic, community-based, prospective Northern Manhattan Study cohort, 2981 adults ≥40 years of age and free of stroke and myocardial infarction at baseline were followed up for a median of 11 years. We observed a steep gradient relationship between the adjusted hazard ratios for the incidence of myocardial infarction, stroke, or cardiovascular death and the number of ideal health metrics defined by the American Heart Association: 0.73 (95% confidence interval, 0.60–0.89), 0.61 (95% confidence interval, 0.50–0.76), 0.49 (95% confidence interval, 0.38–0.63), and 0.41 (95% confidence interval, 0.26–0.63) for those having 2, 3, 4, and 5 to 6 ideal health metrics, respectively, compared with those having 0 to 1 ideal health metric (*P* for trend <0.0001). Lower cardiovascular death incidence rates were independently associated with a greater number of ideal health behaviors (smoking, physical activity, body mass index, and diet) when controlled for the number of ideal health factors (total cholesterol, blood pressure and glucose). A similar graded relationship was also observed between the number of ideal health metrics and the adjusted incidence rate for myocardial infarction, stroke, and vascular death among whites, blacks, and Caribbean Hispanics. These findings support the application of the AHA ideal cardiovascular health metrics for cardiovascular death risk assessment and health promotion for all Americans regardless of race-ethnic background. The results imply that to lower cardiovascular death risk, environments and policies improving health behaviors are just as important as programs controlling vascular factors.
Supplemental Figure 1. Overall and age- and sex-adjusted prevalence (%) of ideal cardiovascular health in white, black and Caribbean Hispanic (C-Hispanic) subgroups according to the number of ideal health metrics.
Supplemental Figure 2. Age and sex-adjusted prevalence (%) of ideal, intermediate and poor cardiovascular metrics in white, black and Caribbean Hispanic (C-Hispanic) subgroups.