Original Report: Cardiovascular Disease and Related Risk Factors

Differences in Cardiovascular Mortality Risk among African Americans in the Minnesota Heart Survey: 1985-2015 vs The Atherosclerosis Risk in Communities Study Cohort: 1987-2015

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Geographic differences in cardiovascular disease (CVD) mortality among African Americans (AAs) are well-established, but not well-characterized. Using the Minnesota Heart Survey (MHS) and Atherosclerosis Risk in Communities (ARIC) Study, we aimed to assess whether CVD risk factors drive geographic disparities in CVD mortality among AAs.

ARIC risk factors were measured between1987-1989 from a population-based sample of AAs, aged 45 to 64 years, living in Jackson, MS and Forsyth County, NC. Similar measures were made at MHS baseline, 1985, in AAs from Minneapolis-St. Paul, MN. CVD mortality was identified using ICD codes for underlying cause of death. We compared MHS and ARIC on CVD death rates using Poisson regression, risk factor prevalences, and hazard ratios using Cox regression.

After CVD risk factor adjustment, AA men in MHS had 3.4 (95% CI: 2.1, 4.7) CVD deaths per 1000 person-years vs 9.9 (95% CI: 8.7, 11.1) in ARIC. AA women in MHS had 2.7 (95% CI: 1.8, 3.6) CVD deaths per 1000 person-years vs 6.7 (95% CI: 6.0, 7.4) in ARIC. A 2-fold higher CVD mortality rate remained in ARIC vs MHS after additional adjustment for education and income. ARIC had higher total cholesterol, hypertension, diabetes, and BMI, as well as less education and income than MHS. Risk factor hazard ratios of CVD death did not differ.

The CVD death rate was lower in AAs in Minnesota (MHS) than AAs in the Southeast (ARIC). While our findings support maintaining low risk for CVD prevention, differences in CVD mortality reflect unidentified geographic variation. *Ethn Dis*. 2019;29(1):47-52; doi:10.18865/ed.29.1.47

Introduction

Cardiovascular disease (CVD) mortality has declined across the United States due to improved prevention and treatment, but striking disparities by geographic region and race remain.[1,2] Previous studies have identified the Southeastern United States as having the highest rates of CVD mortality whereas the west coast and Minnesota (MN) have the lowest.[2-4] African Americans (AAs) consistently have higher rates of CVD death compared with other race groups.[5-7] Geographic and racial disparities involve complex factors that are often overlooked when studying CVD.[8] From 2013-2015, AAs in the Southeastern states of North Carolina (NC) and Mississippi (MS) had a 1.5- and 2-fold higher incidence of CVD death, respectively, compared with AAs in MN.[3,9]

We examined geographic disparities among AAs using data from the Atherosclerosis Risk in Communities (ARIC) Study and the Minnesota Heart Survey (MHS). AAs in ARIC were primarily enrolled from the Southeast (Jackson, MS and Forsyth County, NC)[10] while MHS enrolled AAs from Minneapolis-St. Paul, MN.[11] We hypothesized that AAs in ARIC would have a higher rate and hazard of CVD mortality and higher prevalence of CVD risk factors compared with AAs in MHS, reflecting geographic differences in CVD risk.

Methods

The MHS enrolled a population-based probability sample of 1,254 AAs living in Minneapolis-St. Paul, MN and recruited from predominantly AA census tracts in 1985.[11,12] After IRB approval, individuals between the ages of 35 and 74 years were

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invited to participate and provided informed consent. During a home interview, age, race, sex, education, and income were assessed, as well as self-reported use of antihypertensive treatments, diabetes, and smoking status. During a subsequent survey center exam, blood was collected and used to measure serum total and HDL cholesterol using CDC-standardized methods; blood pressure was taken with a random-zero sphygmomanometer, using the average of two measures for analysis; and weight and height were measured for body mass index (BMI).[12] Of 1,254 enrolled participants, 1,065 attended all exams and were considered for analysis to represent AAs in MN.

We hypothesized that AAs in ARIC have a higher rate and hazard of CVD mortality and higher prevalence of CVD risk factors compared with AAs in MHS, reflecting geographic differences in CVD risk.

In ARIC, after IRB approval and informed consent were gained, 15,792 participants (4,624 AAs) were enrolled between 1987 and 1989 using population-based probability sampling of individuals, aged 45 to 64 years from: Forsyth County, NC; Jackson, MS; the suburbs of Minneapolis, MN; and Washington County, MD.[10,13] AAs were primarily recruited in Jackson, MS and Forsyth County, NC, thus ARIC AA participants will represent AAs from the Southeast.[10,13] At the visit 1 clinical exam, data were collected on the same risk factors assessed in MHS including age, race, sex, weight and height (BMI), self-reported use of antihypertensive treatments, self-reported diabetes, smoking status, education, income, as well as a blood sample to measure plasma total and HDL cholesterol using CDC-standardized methods. Blood pressure was measured thrice by random-zero sphygmomanometer, and the average of the last two was used in analysis.[10]

MHS and ARIC participants were excluded if they were not AA and a few AAs in ARIC who were not from MS or NC were excluded. MHS participants aged >64 years or <45 years were excluded to match the age range in ARIC. Participants were excluded if they were missing any CVD risk factors including MHS participants who did not attend the survey center exam. Data were not collected on history of CVD in MHS, preventing exclusion of participants with prevalent CVD from both studies; however, baseline prevalence of CVD was 4% in ARIC, and we expect a similarly small prevalence in MHS.

CVD and total mortality were identified in MHS using linkage to State and National Death Index records (1985-2015) and in ARIC via annual/semi-annual calls in addition to linkage to State and National Death Index records (1987-2015). Underlying causes of death with ICD10 'I' codes or ICD9 codes 390-459 were classified as CVD-related.

For analysis, cumulative incidence rates of CVD death were calculated using Poisson regression and stratified by sex, study, and state (NC/MS: only applicable to ARIC). Risk factor means and prevalences were compared to determine whether they explain CVD death rate differences. Risk factors included sex, age, total cholesterol, HDL cholesterol, hypertension (use of anti-hypertensive treatment, systolic blood pressure ≥ 140 mm Hg, or diastolic blood pressure of ≥ 90 mm Hg), self-reported diabetes, smoking status, BMI, education, and income. Study-specific Cox proportional-hazards models were used to estimate hazard ratios of CVD death for each risk factor, including a competing risk of non-CVD-related death. This allowed us to estimate instantaneous risk of CVD death while controlling for non-CVD related mortality. Multiplicative interactions were tested for each risk factor by study. A sensitivity analysis was run using the full MHS sample (ages 35-74; n=1,065), but results did not differ and are not shown.

Results

After exclusions, there were 584 AAs in MHS (MN) and 4,211 AAs in ARIC (NC/MS) at baseline. Of those, 91 (16%) and 821 (19%) died of a CVD-related cause, respectively. Incidence of CVD death was lower in MHS than ARIC (Figure 1). Af-

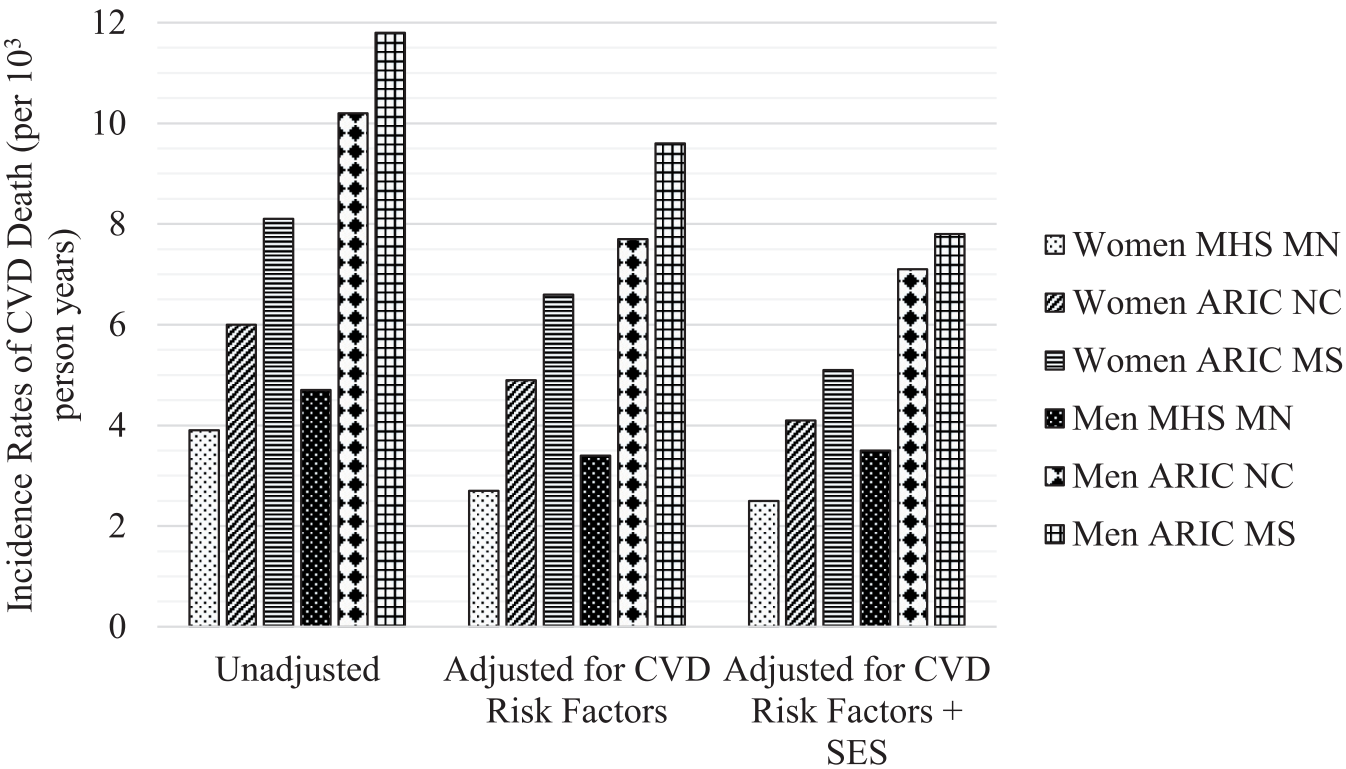

Figure 1. Unadjusted and adjusted incidence rates (per 1,000 person years) of CVD death stratified by gender, study, and study center among African Americans in MHS (1985) and ARIC (1987-89)
Adjusted by pooling MHS and ARIC
CVD risk factor adjustment for age, total cholesterol (mg/dL), HDL cholesterol (mg/dL), systolic blood pressure (mm/Hg), use of anti-hypertensive medication, diabetes status, current smoking, and BMI (kg/m^2)
SES risk factor adjustment for CVD risk factors plus self-reported income and education
BMI, body mass index; SD, standard deviation; MN, Minnesota; NC, North Carolina; MS, Mississippi.

ter adjusting for CVD risk factors, AA men in MHS (MN) had a rate of 3.4 (95% CI: 2.1, 4.7) CVD deaths per 1000 person-years compared with 9.9 (95% CI: 8.7, 11.1) overall in ARIC (NC/MS), an almost 3-fold difference. For AA women, MHS (MN) had 2.7 (95% CI: 1.8, 3.6) CVD deaths per 1000 person-years versus 6.7 (95% CI: 6.0, 7.4) in ARIC (NC/MS), a 2.5-fold difference. With additional adjustment for education and income, mortality rate differences were attenuated to 2-fold higher for men and women in ARIC (MN) vs MHS (NC/MS). Within ARIC, participants from NC had lower incidence of CVD death than those from MS.

Risk factor prevalence paralleled CVD death rates at baseline. Compared with MHS (MN), ARIC (NC/MS) had significantly higher mean total cholesterol (215 vs 202 mg/dL), albeit higher HDL cholesterol (55 vs 53 mg/dL), greater anti-hypertensive medication use (41% vs 30%) and hypertension (56% vs 41%), diabetes (13% vs 11%), and BMI (30 vs 29 kg/m^2) (Table 1). Systolic blood pressure and smoking did not statistically significantly differ. ARIC AAs had significantly lower levels of education (42% with less than high school vs 28%) and lower income (58% making <$16,000 vs 44% making <$15,000 in MHS). These differences persisted when looking only among those who died of a CVD-related cause.

Despite risk factor disparities, hazard ratios of CVD death associ-

Table 1. Baseline characteristics of African American participants in MHS (1985) and ARIC (1987-1989)

Risk Factors	MHS (MN)			ARIC (NC, MS)		
	Total, N = 584	Non-CVD Death, N = 205	CVD Death, N = 91	Total, N = 4211	Non-CVD Death, N = 1276	CVD Death, N = 821
Age, mean years ± SD	53.6 ± 6.7	55.9 ± 6.6	55.9 ± 6.8	53.6 ± 5.8	55.5 ± 5.8	55.8 ± 5.7
Male, %	38.2	43.4	41.8	38.0	45.1	44.5
Total cholesterol,[a] mean mg/dL ± SD	202.3 ± 41.0	204.5 ± 38.7	206.7 ± 48.1	215.0 ± 45.5	213.4 ± 46.2	220.6 ± 48.6
HDL cholesterol,[a] mean mg/dL ± SD	53.0 ± 15.3	52.1 ± 14.7	54.4 ± 18.3	55.0 ± 17.6	54.1 ± 19.1	51.6 ± 16.2
Systolic blood pressure, mean mm Hg±SD	128.6 ± 17.8	130.4 ± 16.9	140.0 ± 20.3	129.0 ± 21.6	131.7 ± 22.7	137.9 ± 25.4
Antihypertensive medication use,[a] %	29.8	38.1	38.5	40.8	42.5	56.6
Hypertension,[a,b] %	41.3	48.3	56.0	56.1	59.8	76.1
Diabetes,[a,b] %	10.5	14.2	17.6	13.4	18.6	25.6
Smoking, %	33.7	50.0	36.3	29.9	39.5	34.9
BMI,[a] mean kg/m² ± SD	28.8 ± 5.3	28.8 ± 5.6	30.2 ± 6.0	29.6 ± 6.2	29.4 ± 6.5	30.3 ± 6.6
Education,[a,c] %						
Less than high school	28.0	31.4	38.5	41.9	49.3	54.7
High school or vocational school	35.3	32.4	36.3	28.2	27.5	25.3
Some college or more	36.7	36.3	25.3	29.9	23.2	20.0
Income,[a,d] %						
< $15,000/16,000	43.5	42.4	59.3	58.2	67.1	70.2
≥ $15,000/16,000 and < $50,000	50.9	53.2	36.3	35.7	29.6	27.5
≥ $50,000	5.7	4.4	4.4	6.2	3.4	2.3

a. Statistically significant difference (P<.05) between studies.
b. Hypertension defined as systolic blood pressure > 140 mm Hg, or diastolic blood pressure > 90 mm Hg, or self-report of antihypertensive medication use.
c. Education defined as:1) less than high school graduate; 2) high school graduate or vocational school; 3) some college or more.
d. Income defined as: 1) < $15,000 in MHS or < $16,000 in ARIC; 2) $15,000- $50,000 in MHS or $16,000 - $50,000 in ARIC; and 3) > $50,000 in ARIC and MHS.
BMI, body mass index; SD, standard deviation; MN, Minnesota; NC, North Carolina; MS, Mississippi.

Table 2. Study specific hazard ratios (95% CI) among African Americans in MHS (1985-2015) and ARIC (1987-2014)

Risk Factors	Cox Regression		Cox Regression with Competing Risk of non-CVD Death	
	MHS (MN)	ARIC (NC, MS)	MHS (MN)	ARIC (NC, MS)
	HR[b] (95% CI)	HR[b] (95% CI)	HR[b] (95% CI)	HR[b] (95% CI)
Male	1.81 (1.03, 3.20)	1.65 (1.41, 1.94)	1.44 (.80, 2.59)	1.42 (1.20, 1.67)
Age, years	1.09 (1.04, 1.13)	1.07 (1.06, 1.09)	1.05 (1.01, 1.10)	1.05 (1.03, 1.06)
Total cholesterol, SD mg/dL	1.15 (0.91, 1.45)	1.11(1.03, 1.19)	1.09 (.84, 1.41)	1.13 (1.05, 1.22)
HDL cholesterol,[a] SD mg/dL	1.12 (0.90, 1.40)	.85 (.78, .93)	1.16 (.90, 1.50)	.86 (.78, .94)
Systolic blood pressure, SD mm Hg	1.60 (1.28, 2.01)	1.43 (1.34, 1.53)	1.61(1.29, 2.02)	1.32 (1.23, 1.42)
Antihypertensive medication use, yes/no	1.29 (0.76, 2.18)	1.66 (1.43, 1.93)	.98 (.55, 1.74)	1.59 (1.36, 1.86)
Diabetes, yes/no	1.87 (1.00, 3.51)	2.25 (1.89, 2.68)	1.47 (.74, 2.90)	1.82 (1.50, 2.20)
Current smoking, yes/no	2.09 (1.22, 3.56)	1.75 (1.49, 2.05)	1.36 (.80, 2.33)	1.35 (1.15, 1.59)
BMI, SD kg/m²	1.44 (1.09, 1.90)	1.05 (.97, 1.14)	1.27 (.96, 1.68)	1.07 (.99, 1.17)
Education,[c] unit change	.65 (.47, .89)	.86 (.78, .95)	.67 (.47, .94)	.86 (.78, .95)
Income,[d] unit change	.77 (.47, 1.27)	.73 (.63, .86)	.77 (.42, 1.41)	.79 (.68, .92)

a. In a model pooling studies, there was a statistically significant (P<.05) interaction by study (MHS; ARIC) only with HDL cholesterol on CVD death.
b. HRs estimated in study specific models including all listed variables.
c. Education defined as:1) less that high school graduate; 2) high school graduate or vocational school; 3) some college or more.
d. Income defined as: 1) $0 - $15,000 in MHS and $0 - $16,000 in ARIC; 2) $15,000/16,000 - $50,000; and 3) more than $50,000.
BMI, body mass index; SD, standard deviation; MN, Minnesota; NC, North Carolina; MS, Mississippi.

ated with each risk factor did not differ between studies (Table 2). When tested, the only significant (P=.03) interaction term was by study and HDL cholesterol on CVD death.

Discussion

The CVD death rate was lower among AAs in MHS (MN) compared with those in ARIC (NC/MS) largely due to lower risk factors. After adjustment for major CVD risk factors as well as education and income, the association was attenuated, but remained 2-fold higher in ARIC (NC/MS) than MHS (MN), suggesting risk factors alone do not fully explain the disparity. Among CVD risk factors, total cholesterol, hypertension, and self-reported diabetes were consistently higher while education and income were significantly lower in ARIC vs MHS. Education and income were strong independent risk factors, and future research should further examine regional differences in socioeconomic status (SES) among AAs, as it is clear SES plays an important role in CVD mortality. The hazard of CVD death for each risk factor did not differ significantly between studies, indicating that risk factors increased individual CVD risk similarly in MHS (MN) and ARIC (NC/MS).

There were some limitations to this analysis. MHS and ARIC are separate cohorts representing AAs in communities in MN and NC/MS and should not be considered statewide samples. Participants in both studies were recruited using population-based probability sampling of their communities; data measurement and collection were similar including CDC-standardized lipid laboratories. While MHS was a smaller study originally designed as a multi-wave analysis of CVD health in MN, we felt the cohorts were comparable due to their timing, population of interest, comparable measures, and standardized methods. Further, according to Census data, only 1.3% – 2.2% of Minnesotans were AA between 1980 and 1990 and most lived in Minneapolis-St. Paul. To our knowledge, no other cohort of AAs from MN during this time is available, making this analysis a unique contribution to the geographic disparities literature.[11]

The CVD death rate was lower among AAs in MHS (MN) compared with those in ARIC (NC/MS) largely due to lower risk factors.

We were unable to adjust for diet, physical activity, access to health care, and other potential confounders that can vary by region. Nevertheless, we adjusted for major CVD risk factors as well as measures of SES (education and income). The association would not likely have changed meaningfully with the inclusion of additional confounding variables. Finally, data on incident CVD were not available in MHS causing us to rely on CVD-related underlying cause of death from state and National Death Index records for both cohorts. Underlying cause of death may vary by region, though total CVD mortality is generally accurately classified.

The pattern of CVD rates we observed in AAs parallels state rankings of overall CVD mortality and mortality rate differences, with Minnesota having the lowest CVD death rates, compared with high rates in North Carolina and Mississippi.[14] While remaining study differences reflect incompletely identified geographic variation, traditional risk factors are effective in predicting CVD outcomes across race and geography.[15-17] Our analysis clearly supports maintaining low risk as a key to CVD prevention in AAs.

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Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: George, Folsom, Wagenknecht; Acquisition of data: George, Folsom, Steffen, Wagenknecht, Mosley; Data analysis and interpretation: George, Wagenknecht; Manuscript draft: George, Steffen, Mosley; Statistical expertise: George, Acquisition of funding: Wagenknecht, Mosley; Administrative: George, Folsom, Steffen; Supervision: Folsom, Wagenknecht

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