Journal of the American College of Cardiology Vol. 61, No. 14, 2013

Published by Elsevier Inc.
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2013.01.022

Lifetime Risk for Heart Failure Among White and Black Americans

Cardiovascular Lifetime Risk Pooling Project

Mark D. Huffman, MD, MPH,*† Jarett D. Berry, MD, MS,‡ Hongyan Ning, MD, MS,* Alan R. Dyer, PhD,* Daniel B. Garside, BS,* Xuan Cai, MS,* Martha L. Daviglus, MD, PhD,* Donald M. Lloyd-Jones, MD, ScM*†

Chicago, Illinois; and Dallas, Texas

Objectives This study sought to estimate lifetime risk for heart failure (HF) by sex and race.

Background Prior estimates of lifetime risk for developing HF range from 20% to 33% in predominantly white cohorts. Short-term risks for HF appear higher for blacks than whites, but only limited comparisons of lifetime risk for HF have been made.

Methods Using public-release and internal datasets from National Heart, Lung, and Blood Institute–sponsored cohorts, we estimated lifetime risks for developing HF to age 95 years, with death free of HF as the competing event, among participants in the CHA (Chicago Heart Association Detection Project in Industry), ARIC (Atherosclerosis Risk in Communities), and CHS (Cardiovascular Health Study) cohorts.

Results There were 39,578 participants (33,652 [85%] white; 5,926 [15%] black) followed for 716,976 person-years; 5,983 participants developed HF. At age 45 years, lifetime risks for HF through age 95 years in CHA and CHS were 30% to 42% in white men, 20% to 29% in black men, 32% to 39% in white women, and 24% to 46% in black women. Results for ARIC demonstrated similar lifetime risks for HF in blacks and whites through age 75 years (limit of follow-up). Lifetime risk for HF was higher with higher blood pressure and body mass index at all ages in both blacks and whites, and did not diminish substantially with advancing index age.

Conclusions These are among the first data to compare lifetime risks for HF between blacks and whites. Lifetime risks for HF are high and appear similar for black and white women, yet are somewhat lower for black compared with white men due to competing risks. (J Am Coll Cardiol 2013;61:1510–7) © 2013 by the American College of Cardiology Foundation

Heart failure (HF) is a growing public health crisis, with increasing morbidity, mortality, and costs (1). Declines in HF incidence over previous decades have flattened, with increases in HF prevalence due to lower case-fatality rates (2,3). Indeed, HF prevalence increased by as much as 30% in Medicare beneficiaries from 1994 to 2003 (4). This increased prevalence of HF, however, may not be solely a result of patients surviving myocardial infarctions (MIs) in the era of revascularization and aggressive medical therapy (5), but more likely is associated with rising rates of obesity, hypertension, and diabetes, as well as improved survival among those with HF (1–4,6–8).

Lifetime risk for developing HF has been estimated to range from 20% to 33%, respectively, in the Framingham (9) and

From the *Department of Preventive Medicine, Northwestern University Feinberg School of Medicine, Chicago, Illinois; †Division of Cardiology, Department of Medicine, Northwestern University Feinberg School of Medicine, Chicago, Illinois; and the ‡Division of Cardiology, Department of Medicine, University of Texas Southwestern Medical Center, Dallas, Texas. This study was supported by the National Heart, Lung, and Blood Institute (NHLBI) grant R21 HL085375 to Dr. Lloyd-Jones for the Lifetime Risk Pooling Project. The most recent follow-up of the Chicago Heart Association Detection in Industry Project was supported by NHLBI grant 5R01HL081141-04. The Atherosclerosis Risk in Communities Study is conducted and supported by the NHLBI in collaboration with the study investigators. This study was conducted with the use of a limited-access dataset obtained by the NHLBI and does not necessarily reflect the opinions or views of the study investigators or the NHLBI. The research reported in this paper was supported by NHLBI contracts HHSN268201200036C, N01-HC-85239, N01-HC-85079 through N01-HC-85086, N01-HC-35129, N01 HC-15103, N01 HC-55222, N01-HC-75150, N01-HC-45133, and grant HL080295, with additional contribution from the National Institute of Neurological Disorders and Stroke. Additional support was provided through National Institute on Aging grants AG-023629, AG-15928, AG-20098, and AG-027058. A full list of principal Cardiovascular Health Study investigators and institutions can be found at http://www.chs-nhlbi.org/pi.htm. Dr. Huffman has received research funding (modest) from Scientific Therapeutic Initiative and (substantial) from the NHLBI. Dr. Berry is on the Speakers' Bureau of Merck. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Manuscript received October 9, 2012; revised manuscript received December 7, 2012, accepted January 8, 2013.

Rotterdam studies (10), 2 cohorts of almost exclusively white individuals of European ancestry. However, these studies used different criteria to define HF (11,12), which may partially account for the differences in lifetime risk.

Whereas short-term risks for HF incidence appear to be significantly higher for blacks than whites in the United States (13,14), only limited comparisons of lifetime risk for HF have been made between white and black individuals (15). Lifetime risk estimates account for the risk of incident HF as well as for the risk of death from competing causes, and overall and noncardiovascular mortality risk is known to be higher among blacks than whites (especially in men). Therefore, it is unknown whether lifetime risks for HF differ between blacks and whites. Further, knowledge of absolute lifetime risk estimates may be useful for policymakers, patients, and physicians alike to estimate the current and future population burden of disease, as well as to estimate individual risks. A similar strategy used for breast cancer risk estimation has been cited as a contributor to increased breast cancer screening in the 1990s (16,17).

We sought to define and compare the lifetime risks for HF by sex and race at selected ages in several diverse population samples by examining the results of prospective, observational studies with data on HF endpoints, namely CHA (the Chicago Heart Association Detection Project in Industry) (18), ARIC (Atherosclerosis Risk In Communities Study) (19), and CHS (Cardiovascular Health Study) (20).

Methods

Cohorts. This analysis was undertaken as part of the Cardiovascular Lifetime Risk Pooling Project (21). Using public-release and internal datasets from National Heart, Lung, and Blood Institute–sponsored cohorts, namely CHA (internal dataset), ARIC (public-release dataset), and CHS (internal dataset), we estimated lifetime risk for developing overt HF.

The CHA study examined 37,572 participants in Chicago, Illinois, between the ages of 18 and 74 years (43% women, 10% black) from 1967 to 1973 (18). CHA participants were followed through 2003. Incident HF was defined by Medicare hospital discharge coding in the CHA cohort (International Classification of Diseases 9th Revision [ICD-9] codes 428.*, primary discharge diagnosis only). Because data were derived from Medicare hospitalization data, only HF hospitalizations from Medicare-eligible participants were captured beginning in 1984, the first year Medicare data were available for public use, through 2003. Follow-up for vital status was completed by direct mail, telephone, contact with employer, and matching of records with Social Security Administration files before 1979; from 1979 to 1994, follow-up was completed through the National Death Index (13). Death certificates were obtained and coded for multiple causes by trained research staff according to the Eighth Revision of the International Classification of Diseases (ICD-8) (22). From 1995 to 1998, the National Death Index-plus service was used to obtain ICD Ninth Revision (ICD-9) cause of death coding and ICD Tenth Revision (ICD-10) coding from 1999 to 2003 (14,23). For this report, the underlying cause of death was used. HF mortality was defined as ICD-8 and ICD-9 code 428 and ICD-10 codes I50.1 to I50.4.

Abbreviations and Acronyms

BMI = body mass index
BP = blood pressure
CI = confidence interval
CVD = cardiovascular disease
HF = heart failure
ICD = International Classification of Diseases
MI = myocardial infarction

The ARIC study enrolled 15,721 participants ages 45 to 64 years at 4 sites (Minneapolis, Minnesota; Jackson, Mississippi; Forsyth County, North Carolina; Washington County, Maryland; 55% women, 27% black) from 1987 to 1989 (19). ARIC participants were followed through 2005. Individuals with prevalent HF were excluded using the Gothenburg criteria. Incident HF cases were ascertained by annual interviews of ARIC participants and review of local hospital discharge logs to find HF hospitalizations and by review of health department death certificates to find HF deaths. Incident HF was defined by Medicare hospital discharge coding for the ARIC cohort (ICD-9 codes 428.*, primary discharge diagnosis only) for hospitalization or by death certificate (ICD-9 codes 428.*; ICD-10 codes I50.*). Incident HF cases were adjudicated by a central committee of physician reviewers, as previously described (13).

The CHS, a cohort of Medicare-eligible older Americans, enrolled 5,888 participants ≥65 years from 4 sites (Sacramento County, California; Allegheny County, Pennsylvania; Forsyth County, North Carolina; Washington County, Maryland; 58% women, 16% black) from 1989 to 1993 (20). CHS participants were followed through 2004. In this cohort, incident HF was defined by a central adjudication committee that relied upon results from semiannual contacts with participants and Medicare hospital discharge data (ICD-9 codes 428.*, primary discharge diagnosis only). HF events were confirmed by physician review of identifying clinical evidence such as physician diagnosis, physical or x-ray findings, or drug treatment with diuretics, digitalis, or vasodilators. The causes of death were adjudicated by the same endpoint central adjudication committee (20).

Statistical analysis. All statistical analyses were performed using SAS statistical software (version 9.1, SAS Institute, Cary, North Carolina). Lifetime risks were estimated using a modified life-table analysis using the Practical Incidence Estimator macro, in which each participant contributes information for each age attained during follow-up, as previously described (24). For the calculation of lifetime risks, a modified Kaplan-Meier method was used that accounts for competing risk from death free of HF to avoid lifetime risk overestimation. In

brief, the modified Kaplan-Meier analysis counts death free of HF as a competing risk rather than a withdrawal (as in the traditional Kaplan-Meier analysis) at the time of event (see the Online Appendix for additional details). All participants free from HF at selected index ages (45, 55, 65, and 75 years) were included. We estimated lifetime risk for HF to age 95 years, with death free of HF as the competing event, as described in the previous text. In order to demonstrate the difference between unadjusted Kaplan-Meier and adjusted lifetime risk estimates, we created cumulative risk curves using the same data. The difference between these curves represents the competing risks of death from causes other than HF.

Participants were also stratified by body mass index (BMI) into 3 groups (BMI <25, 25 to 29, and ≥ 30 kg/m^2) based on height and weight measured within 2 years of the index age in order to evaluate the association between obesity and lifetime risk for HF. We limited these analyses to a follow-up time of 30 years due to smaller sample sizes.

In order to investigate the association between blood pressure (BP) and lifetime risk for HF, we stratified participants by BP level as measured within 2 years of each index age. Again, we limited follow-up time to 30 years due to sample size. The BP strata included: $\leq 120/\leq 80$ mm Hg; 121 to 139 mm Hg (systolic) or 81 to 89 mm Hg (diastolic); 140 to 159 mm Hg (systolic) or 90 to 99 mm Hg (diastolic); and ≥ 160 mm Hg (systolic), ≥ 100 mm Hg (diastolic), or treated hypertension. Participants with treated hypertension were included in this final stratum due to the overall small size of this group, which was not adequately powered to address lifetime risks. It was also not known whether such treated participants were treated to an optimal BP target throughout each study. Inclusion of the treated participants would conservatively underestimate the lifetime risk for HF in this highest BP stratum.

Finally, we performed analyses to examine the remaining lifetime risk for HF attributable to causes other than MI. In this analysis, we excluded participants with a history of recognized or unrecognized MI before or at the index examination and only considered those who developed HF without an intervening MI during follow-up.

Informed consent. All cohorts included here have been approved by the institutional review board from each contributing institution, including Northwestern University. Participants provided informed consent at each examination.

Results

Baseline characteristics for included participants in the CHA, ARIC, and CHS cohorts are shown in Table 1. After the index age of 45 years, CHA participants developed 3,972 HF events over 501,127 person-years of follow-up (7.9 per 1,000 person-years); after age 45, ARIC participants developed 1,010 HF events over 168,516 person-years of follow-up (6.0 per 1,000 person-years); and after the index age of 65 years, CHS participants developed 1,001 HF events over 47,333 person-years of follow-up (21.1 per 1,000 person-years).

In the CHA cohort, the remaining lifetime risks for HF at age 45 through 95 years were 30.2% (95% confidence interval [CI]: 28.9% to 31.5%) for white men, 20.1% (15.8% to 24.4%) for black men (through 90 years), 32.3% (30.8% to 33.8%) for white women, and 23.7% (17.8% to 29.8%) for black women (through 90 years) (Figs. 1A and 1B). The overlap of these estimates in women through index ages 75 years and 85 years indicates that lifetime risks for HF were similar between black and white women, whereas lifetime risks for HF were generally lower among black men than white men in CHA. With advancing index ages, lifetime risks for HF did not decrease, despite an increase in the competing risk of HF-free death in all groups. For example, the lifetime risks for HF in white men in CHA at ages 45 and 55 years were 30.2% (95% CI: 28.9% to 31.5%) and 28.5% (27.1% to 29.9%), respectively.

In the ARIC cohort, the remaining lifetime risk for HF through age 75 years, which was near the limit of follow-up, was 19.1% (17.0% to 21.2%) for white men and 21.3% (17.5% to 25.1%) for black men (Fig. 1A). In women, the lifetime risk for HF through age 75 was 13.4% (11.3% to 15.4%) in white women compared with 23.9% (20.1% to 27.6%) in black women (Fig. 1B). At the index ages of 45 and 55 years, remaining lifetime risks for HF through age 75, the limit of follow-up in the ARIC cohort, appeared higher for whites and blacks in ARIC compared with whites and blacks in CHA.

In the CHS cohort, the remaining lifetime risk for HF at age 65 through 95 years was 41.6% (38.0% to 45.1%) for white men and 29.1% (21.1% to 37.1%) for black men (Fig. 1C). Remaining lifetime risks for HF were 38.5% (35.2% to 41.9%) for white women and 46.1% (38.0% to 54.1%) for black women (Fig. 1D). As seen in the CHA cohort, the lifetime risk for HF in CHS participants also did not substantially decrease with advancing index age.

Lifetime risks for HF by BMI strata. When we stratified participants by BMI, lower BMI strata were associated with lower adjusted cumulative risks for HF in all sex–race groups through age 75 years. Table 2 demonstrates that remaining lifetime risk for HF tended to increase with higher BMI at all index ages for all sex and race groups. For example, lifetime risk for HF among black women at index age of 45 years ranged from 4.4% (0.2% to 8.6%) in women with BMI <25 kg/m^2, to 21.8% (7.5% to 36.1%) in women with BMI ≥ 30 kg/m^2. Similar trends were also seen in the ARIC and CHS cohorts (data not shown).

Lifetime risks for HF by BP strata. When participants were stratified by BP level, lower lifetime risks were seen in participants with optimal BP compared with higher lifetime risks with stage II/treated hypertension. Table 3 demonstrates that remaining cumulative risk for HF, adjusted for the competing risk of death through age 75 years, tended to increase with higher BP for all sex and race groups in CHA

Table 1 Baseline Characteristics of Participants Free From HF From the CHA, ARIC, and CHS Cohorts

	CHA (N = 19,391)	ARIC (N = 15,732)	CHS (N = 4,455)
Index age, yrs	45	45	65
Follow-up, person-years	501,127	168,516	47,333
Total HF events	3,972	1,010	1,001
White men	10,017 (51.7)	5,426 (34.5)	1,492 (33.5)
SBP, mm Hg	142.9 ± 20.3	120.1 ± 16.1	136.1 ± 21.1
DBP, mm Hg	84.3 ± 11.7	73.2 ± 9.8	72.3 ± 11.3
BMI, kg/m^2	27.2 ± 3.6	27.4 ± 4.0	26.4 ± 3.6
BP medication, %	6.8	20.3	34.5
History of diabetes, %	4.1	7.8	8.0
History of myocardial infarction, %	2.7	1.8	9.5
Black men	545 (2.8)	1,629 (10.4)	248 (5.6)
SBP, mm Hg	146.3 ± 24.1	130.5 ± 21.9	138.1 ± 20.9
DBP, mm Hg	87.9 ± 14.3	82.5 ± 13.0	76.6 ± 11.6
BMI, kg/m^2	27.3 ± 4.2	27.6 ± 4.9	26.7 ± 3.9
BP medication, %	6.3	34.4	44.8
History of diabetes, %	3.7	16.2	11.4
History of myocardial infarction, %	1.3	1.9	4.4
White women	8,379 (43.2)	6,050 (38.5)	2,288 (51.0)
SBP, mm Hg	138.3 ± 20.8	117.0 ± 17.6	135.1 ± 21.1
DBP, mm Hg	80.7 ± 11.5	69.5 ± 9.8	69.2 ± 10.8
BMI, kg/m^2	25.2 ± 1.4	26.6 ± 5.5	26.2 ± 4.9
BP medication, %	9.3	19.5	37.7
History of diabetes, %	2.6	6.6	6.5
History of myocardial infarction, %	2.2	0.8	4.7
Black women	450 (2.3)	2,627 (16.7)	427 (9.6)
SBP, mm Hg	140.1 ± 24.4	128.2 ± 21.5	143.1 ± 23.3
DBP, mm Hg	84.3 ± 14.4	78.2 ± 11.7	74.7 ± 11.1
BMI, kg/m^2	26.5 ± 4.9	30.8 ± 6.5	29.4 ± 5.9
BP medication, %	13.3	44.6	62.3
History of diabetes, %	3.9	18.7	9.0
History of myocardial infarction, %	0.9	1.3	4.2

Values are n, n (%), and median ± SD. Sample sizes are lower than total sample sizes for these cohorts because these measures reflect data collected only at prespecified index ages of 45 and 65 years.

ARIC = Atherosclerosis Risk in Communities; BMI = body mass index; BP = blood pressure; CHA = Chicago Heart Association Detection in Industry Project; CHS = Cardiovascular Health Study; DBP = diastolic blood pressure; HF = heart failure; SBP = systolic blood pressure.

at an index age of 45 years. For example, adjusted cumulative risks in white men ranged from 9.8% (5.6% to 13.9%) with BP ≤120/≤80 mm Hg, to 16.3% (13.5% to 19.2%) with systolic BP ≥160 mm Hg, diastolic BP ≥100 mm Hg or treated hypertension. A similar pattern of results was observed at all index ages for all sex–race groups in CHA and the other cohorts (data not shown).

Lifetime risks for HF in the absence of antecedent MI. We performed sex-specific- and race-specific estimates of lifetime risk for HF after accounting for the competing risk of antecedent MI (Table 4). Lifetime risks were lower in participants without prior MI in nearly all sex–race groups but remained high, ranging from 18.6% (14.4% to 22.9%) in black men, to 28.7% (27.3% to 30.2%) in white women at an index age of 45 years in CHA and from 22.1% (15.0% to 29.2%) in black men, to 36.3% (28.8% to 43.8%) in black women at an index age of 65 years in CHS. Similar trends were seen for ARIC, despite the limited follow-up to age 75 years.

Unadjusted risk for HF compared with lifetime risk. Figures 2A (men) and 2B (women) compare unadjusted risks for HF (Kaplan-Meier cumulative incidence) with the lifetime risks for HF in the CHA cohort at the index age of 45 years. Because the unadjusted Kaplan-Meier cumulative incidence does not account for the risk of HF-free death, the competing event, the Kaplan-Meier estimates for cumulative incidence of HF are substantially higher than the adjusted cumulative lifetime risks. The differences between the unadjusted and adjusted cumulative incidence curves represent the burden of competing risk from death free of HF. For example, the unadjusted risk of noncardiovascular disease (non-CVD) death rates in the CHA cohort are shown in Figure 2 separately for black and white men and women at an index age of 45 years (25). After 20 years of

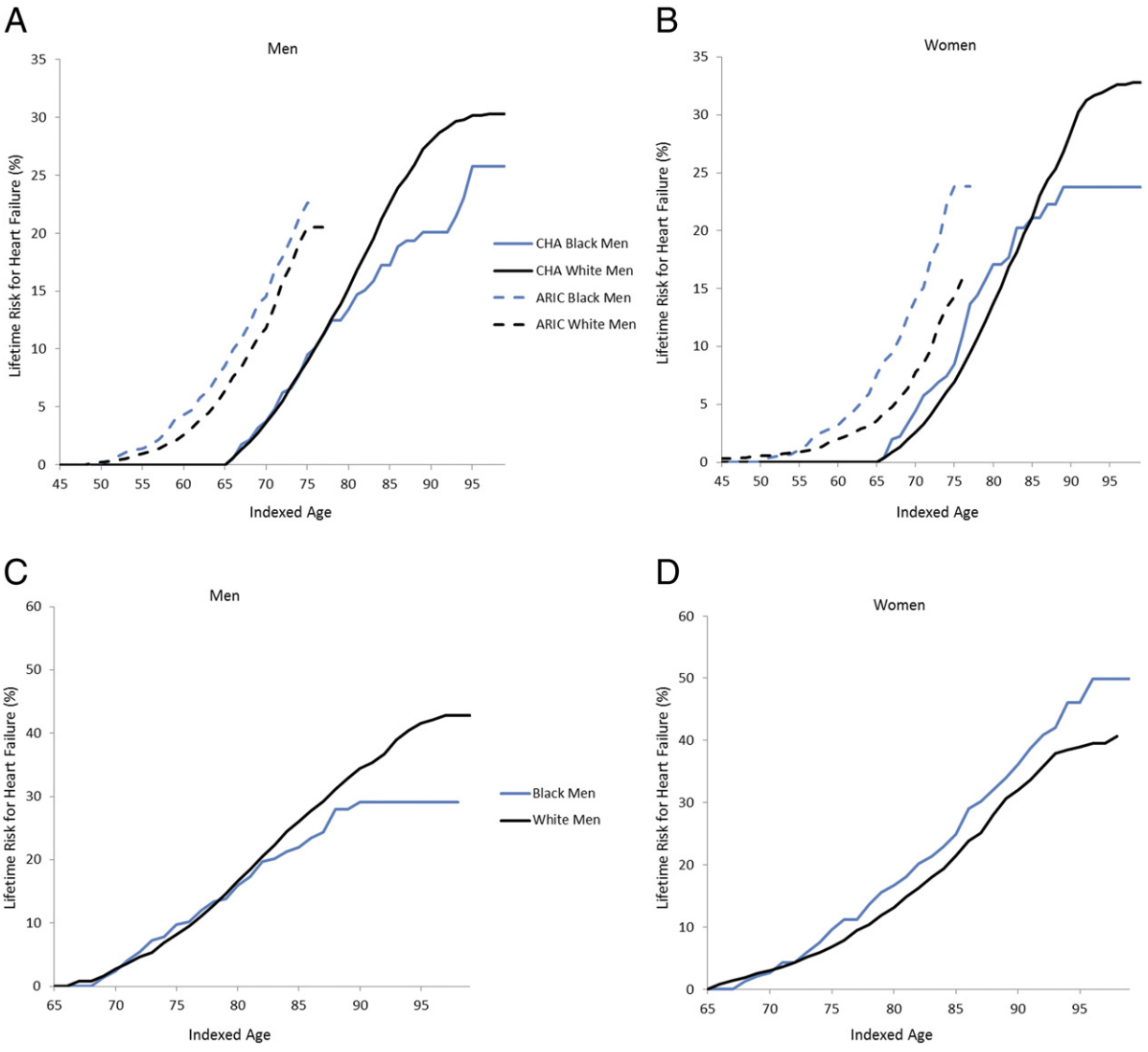

Figure 1 **Lifetime Risks for HF in White and Black Americans**

Lifetime risks (LR) for heart failure (HF) at an index age of 45 years for black and white men **(A)** and women **(B)** in the Chicago Heart Association Detection in Industry Project (CHA) and Atherosclerosis Risk in Communities (ARIC) cohorts and LR for heart failure at an index age of 65 years for black and white men **(C)** and women **(D)** in the Cardiovascular Health Study (CHS).

follow-up, the incidence of non-CVD death in black men was 11.8%, compared with 7.6% in white men. Therefore, the greater burden of non-CVD mortality among black men particularly appears to limit lifetime risks for HF in this group.

Discussion

These are among the first data to explore the lifetime risk for HF in different race/ethnic groups. Overall, remaining lifetime risks for HF are high (20% to 45%) in all groups, and appear similar for black and white women and somewhat lower for black men compared with white men. Despite differences in birth cohort, age, and diagnostic criteria, we find remarkably similar results between blacks and whites. Risk factors for increasing lifetime risks for HF in whites—such as obesity, BP, and nonfatal MI—appear to increase the lifetime risks for HF in blacks in a similar fashion. The rising obesity prevalence in the United States makes this consistent association particularly relevant to the future HF risk. Also, lifetime risk for HF did not diminish with advancing age, because it is more common in older individuals, despite the increased risk of HF-free death, and hence, the shorter remaining lifespan during which HF can occur.

The unadjusted risk for HF in black men was highest among all sex–race groups, as has been described in a

Table 2 30-Year Cumulative Risk for HF at Index Age by Sex–Race Group in the CHA Study by BMI Strata

	Men		Women	
BMI	White	Black	White	Black
<25 kg/m^2	9.1 (7.2–10.9)	12.8 (4.5–21.1)	7.7 (6.3–9.0)	4.4 (0.2–8.6)
25–29 kg/m^2	11.8 (10.3–13.3)	6.0 (1.4–10.7)	11.5 (9.1–13.9)	11.4 (4.0–18.8)
≥30 kg/m^2	19.3 (16.1–22.5)	21.3 (7.3–35.4)	16.6 (12.0–21.2)	21.8 (7.5–36.1)

Values are mean (95% confidence interval). The cumulative risk was adjusted for risk of death at index age 45 years; the follow-up age was 75 years.
Abbreviations as in Table 1.

population of younger adults (26). However, the lower lifetime risks for HF appear to be a product of higher overall risks for HF among African Americans that were counterbalanced by greater competing risks for death from noncardiovascular causes, particularly among African-American men, due to causes such as homicide, renal failure, and HIV (27).

The lifetime risks for developing HF in the present cohorts are higher than previously reported in the Framingham and Rotterdam cohorts. These differences may be related, in part, to how incident HF was defined in each cohort. The Framingham Heart Study, in which the lifetime risks for HF were estimated to be approximately 20% at all index ages, has a more stringent definition of HF as compared with other cohorts (28).

Nevertheless, hospital discharge data, which were used by the cohorts in the present study, demonstrate an increased number of hospitalizations for HF and rising costs associated with these hospitalizations (1). Our use of the primary hospital discharge diagnosis may even underestimate admissions with associated HF diagnoses. Unlike coronary artery disease and stroke, where individuals might "escape" some of their lifetime risk at older index ages (29), lifetime risks for developing new-onset HF continue to remain as high as 40% at age 75 years, despite greater competing risks and substantially shorter remaining lifespan at such an age. If risk factors for HF are not treated more aggressively in both whites and blacks, HF incidence and costs will likely increase further, particularly as the U.S. population ages.

Study limitations. First, we evaluated cohorts that defined HF differently, which likely affected lifetime risk estimates across different populations. However, these cohorts defined HF through hospital discharge coding, which represents a clinically relevant entity. Second, different cohorts had different entry criteria and different index ages, ranging from <45 to ≥65 years, which also limits our analysis of these cohorts across a wider age range. Third, our analysis of ARIC was limited to the public-release dataset, which likely explains our lower estimates compared with the internal dataset with a longer follow-up through 85 years (15). However, our estimates through age 75 years were similar to those recently reported. Fourth, data were collected from participants in different age ranges at different time points, which could lead to birth cohort effects. The differences in lifetime risks for HF between CHA and ARIC may be partially explained by the increased prevalence of obesity that occurred from 1967 to 1973 (CHA enrollment) to 1987 to 1989 (ARIC enrollment). Conversely, because CHA HF events were collected through Medicare discharge data, HF events that occurred before age 65 years or the onset of hemodialysis or disability would have been missed, leading to an underestimation of lifetime risks. The prevalence of HF is <2% in U.S. adults ages <60 years (1), suggesting that few incident cases would have been missed, but data from ARIC indicate that more cases would be missed among black men than other sex–race groups. Similar trends between white and black participants at younger ages as seen in ARIC also suggest that these lifetime risk estimates are likely stable.

Table 3 30-Year Cumulative Risk for HF at Index Age 45 by Sex–Race Group in CHA by BP Strata

	Men		Women	
BP	White	Black	White	Black
≤120/≤80 mm Hg	9.8 (5.6–13.9)	—*	9.9 (6.9–12.8)	6.9 (0–16.1)
121–139 SBP or 81–89 DBP, mm Hg	10.9 (9.1–12.7)	7.5 (1.2–13.8)	8.6 (7.0–10.4)	7.9 (1.3–14.5)
140–159 SBP or 90–99 DBP, mm Hg	12.1 (10.3–14.0)	13.9 (5.9–22.0)	9.2 (7.0–11.4)	6.7 (0–14.0)
≥160 mm Hg SBP or ≥100 mm Hg DBP or treated hypertension	16.3 (13.5–19.2)	12.7 (3.2–22.2)	13.3 (9.7–16.9)	16.0 (6.4–25.5)

Values are means (95% confidence intervals). The cumulative risk was adjusted for risk of death at index age 45 years; the follow-up age was 75 years. *There was an insufficient number of events to provide a stable estimate.
Abbreviations as in Table 1.

Table 4 Cumulative Risk for HF at Selected Index Ages Through Given Follow-Up Ages by Sex/Race Groups

	Men					
	White			Black		
Follow-Up Age (yrs)	75	85	95	75	85	95
CHA						
Index age 45 yrs	7.8 (7.2–8.3)	19.5 (18.6–20.4)	26.1 (24.9–27.3)	8.6 (6.2–10.9)	15.8 (12.2–19.4)	18.6* (14.4–22.9)
Index age 55 yrs	11.4 (10.6–12.3)	18.0 (17.0–19.1)	24.5 (23.2–25.9)	7.7 (4.3–11.0)	15.4 (10.9–19.9)	18.1* (13.1–23.0)
ARIC						
Index age 45 yrs	14.2 (12.4–16.0)	—	—	15.9 (12.6–19.1)	—	—
Index age 55 yrs	13.9 (12.1–15.7)	—	—	16.1 (12.7–19.6)	—	—
CHS						
Index age 65 yrs	5.5 (3.2–7.8)	16.1 (13.4–18.7)	26.4 (23.2–29.7)	8.0 (3.1–12.8)	17.6 (11.5–23.7	22.1* (15.0–29.2)
Index age 75 yrs	—	13.1 (11.0–15.2)	26.0 (22.6–29.3)	—	14.2 (8.5–19.9)	20.7* (13.1–28.3)

Continued on the next page

Conclusions

Lifetime risks for HF are very high for both black and white men and women, underscoring the importance of population-wide preventive efforts to curb the growing burden of HF. These data should help clinicians, researchers, and policymakers to more clearly understand how great of a problem HF currently is and will continue to be unless preventive measures are broadly implemented.

Acknowledgments

The authors thank the investigators of all the cohort studies included in this analysis for their hard work and dedication in collecting the underlying data, and especially the study participants, whose dedication and commitment have formed the basis of profound observations regarding health and disease that have contributed to improved health, longevity, and quality of life for millions of persons.

Reprint requests and correspondence: Dr. Mark D. Huffman, Northwestern University Feinberg School of Medicine, Department of Preventive Medicine, 680 North Lake Shore Drive, Suite 1400, Chicago, Illinois 60611. E-mail: m-huffman@northwestern.edu.

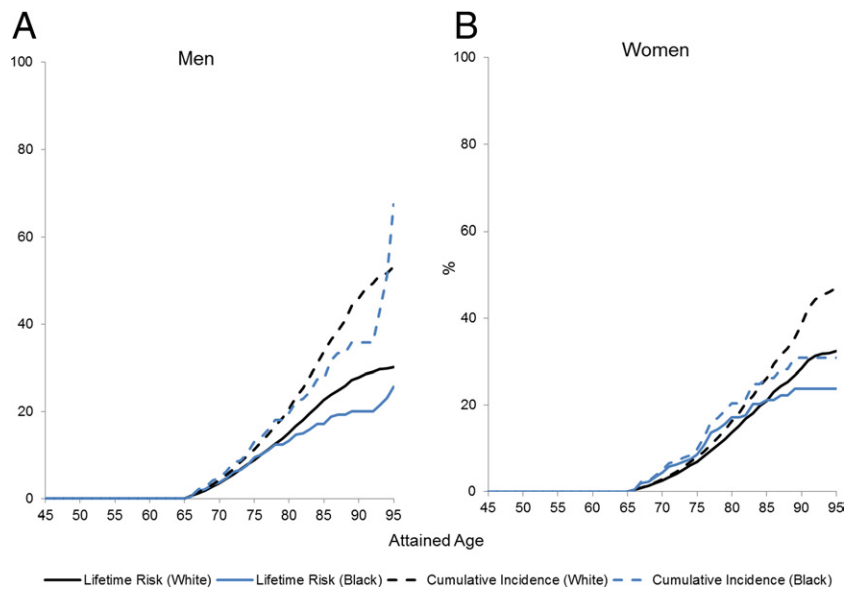

Figure 2 Lifetime and Unadjusted Risks for HF

Lifetime risks (LR) are compared with unadjusted risks for heart failure (HF) at an index age of 45 years by sex–race group in the CHA (Chicago Heart Association Detection in Industry Project) cohort: **(A)** men; **(B)** women. The difference between lifetime risk estimate and unadjusted cumulative incidence (Kaplan-Meier estimate) is an estimate of the competing risk for each sex–race group.

Table 4 Continued

Women					
White			Black		
75	85	95	75	85	95
6.2 (5.7–6.7)	18.9 (17.9–19.9)	28.7 (27.3–30.2)	8.3 (5.7–10.9)	20.0 (15.1–24.9)	22.7* (16.7–28.6)
4.5 (4.0–5.1)	18.4 (17.3–19.5)	28.3 (26.8–29.9)	6.7 (2.7–10.7)	19.3 (12.8–25.7)	22.0* (14.7–29.2)
10.6 (8.8–12.4)	—	—	19.9 (16.4–23.4)	—	—
10.4 (8.6–12.2)	—	—	20.1 (16.5–23.8)	—	—
4.9 (3.3–6.5)	14.5 (12.5–16.5)	29.9 (26.8–33.0)	8.9 (4.6–13.1)	20.3 (15.1–25.4)	36.3 (28.8–43.8)
—	10.7 (9.2–12.2	28.1 (24.9–31.3)	—	12.5 (8.4–16.6)	30.5 (22.7–38.4)

Values are mean (95% confidence interval). Cumulative risk was adjusted for competing risk of death and antecedent myocardial infarction. *Limited to 90-year follow-up.
Abbreviations as in Table 1.

REFERENCES

1. Roger VL, Go AS, Lloyd-Jones DM, et al. Heart disease and stroke statistics—2012 update: a report from the American Heart Association. Circulation 2012;125:e2–220.
2. Levy D, Kenchaiah S, Larson MG, et al. Long-term trends in the incidence of and survival with heart failure. N Engl J Med 2002;347:1397–402.
3. Roger VL, Weston SA, Redfield MM, et al. Trends in heart failure incidence and survival in a community-based population. JAMA 2004;292:344–50.
4. Curtis LH, Whellan DJ, Hammill BG, et al. Incidence and prevalence of heart failure in elderly persons, 1994–2003. Arch Intern Med 2008;168:418–24.
5. Baker DW. Prevention of heart failure. J Card Fail 2002;8:333–46.
6. He J, Ogden LG, Bazzano LA, Vupputuri S, Loria C, Whelton PK. Risk factors for congestive heart failure in US men and women: NHANES I epidemiologic follow-up study. Arch Intern Med 2001;161:996–1002.
7. Lee DS, Massaro JM, Wang TJ, et al. Antecedent blood pressure, body mass index, and the risk of incident heart failure in later life. Hypertension 2007;50:869–76.
8. Gottdiener JS, Arnold AM, Aurigemma GP, et al. Predictors of congestive heart failure in the elderly: the Cardiovascular Health Study. J Am Coll Cardiol 2000;35:1628–37.
9. Lloyd-Jones DM, Larson MG, Leip EP, et al. Lifetime risk for developing congestive heart failure: the Framingham Heart Study. Circulation 2002;106:3068–72.
10. Bleumink GS, Knetsch AM, Sturkenboom MC, et al. Quantifying the heart failure epidemic: prevalence, incidence rate, lifetime risk and prognosis of heart failure: the Rotterdam Study. Eur Heart J 2004;25:1614–9.
11. Kannel WB, D'Agostino RB, Silbershatz H, Belanger AJ, Wilson PW, Levy D. Profile for estimating risk of heart failure. Arch Intern Med 1999;159:1197–204.
12. Remme WJ, Swedberg K. Guidelines for the diagnosis and treatment of chronic heart failure. Eur Heart J 2001;22:1527–60.
13. Loehr LR, Rosamond WD, Chang PP, Folsom AR, Chambless LE. Heart failure incidence and survival (from the Atherosclerosis Risk in Communities study). Am J Cardiol 2008;101:1016–22.
14. Bahrami H, Kronmal R, Bluemke DA, et al. Differences in the incidence of congestive heart failure by ethnicity: the Multi-Ethnic Study of Atherosclerosis. Arch Intern Med 2008;168:2138–45.
15. Avery CL, Loehr LR, Baggett C, et al. The population burden of heart failure attributable to modifiable risk factors: the ARIC (Atherosclerosis Risk in Communities) study. J Am Coll Cardiol 2012;60:1640–6.
16. Blackman DK, Bennett EM, Miller DS. Trends in self-reported use of mammograms (1989–1997) and Papanicolaou tests (1991–1997)—Behavioral Risk Factor Surveillance System. MMWR CDC Surveill Summ 1999;48:1–22.
17. Visser LE, Bleumink GS, Trienekens PH, Vulto AG, Hofman A, Stricker BH. The risk of overanticoagulation in patients with heart failure on coumarin anticoagulants. Br J Haematol 2004;127:85–9.
18. Stamler J, Dyer AR, Shekelle RB, Neaton J, Stamler R. Relationship of baseline major risk factors to coronary and all-cause mortality, and to longevity: findings from long-term follow-up of Chicago cohorts. Cardiology 1993;82:191–222.
19. The ARIC investigators. The Atherosclerosis Risk in Communities (ARIC) study: design and objectives. Am J Epidemiol 1989;129:687–702.
20. Fried LP, Borhani NO, Enright P, et al. The Cardiovascular Health Study: design and rationale. Ann Epidemiol 1991;1:263–76.
21. Berry JD, Dyer A, Cai X, et al. Lifetime risks for cardiovascular disease. New Engl J Med 2012;366:312–9.
22. National Center for Health Statistics. Health, United States, 1995. Hyattsville, MD: Public Health Service, 1996.
23. Campbell VA, Crews JE, Moriarty DG, Zack MM, Blackman DK. Surveillance for sensory impairment, activity limitation, and health-related quality of life among older adults—United States, 1993–1997. MMWR CDC Surveill Summ 1999;48:131–56.
24. Vasan RS, Beiser A, Seshadri S, et al. Residual lifetime risk for developing hypertension in middle-aged women and men: the Framingham Heart Study. JAMA 2002;287:1003–10.
25. Beiser A, D'Agostino RB Sr., Seshadri S, Sullivan LM, Wolf PA. Computing estimates of incidence, including lifetime risk: Alzheimer's disease in the Framingham Study. The Practical Incidence Estimators (PIE) macro. Stat Med 2000;19:1495–522.
26. Bibbins-Domingo K, Pletcher MJ, Lin F, et al. Racial differences in incident heart failure among young adults. N Engl J Med 2009;360:1179–90.
27. Kung HC, Hoyert DL, Xu J, Murphy SL. Deaths: final data for 2005. Natl Vital Stat Rep 2008;56:1–120.
28. McKee PA, Castelli WP, McNamara PM, Kannel WB. The natural history of congestive heart failure: the Framingham study. N Engl J Med 1971;285:1441–6.
29. Lloyd-Jones DM, Leip EP, Larson MG, et al. Prediction of lifetime risk for cardiovascular disease by risk factor burden at 50 years of age. Circulation 2006;113:791–8.

Key Words: epidemiology ■ heart failure ■ lifetime risk.

APPENDIX

For expanded information on estimating lifetime risk of HF, please see the online version of this paper.