

Spring 5-11-2018

Lifetime Risk of Atrial Fibrillation by Race and Socioeconomic Status: The Atherosclerosis Risk in Communities (ARIC) Study

Liping Mou

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ABSTRACT

Lifetime risk of atrial fibrillation by race and socioeconomic status: The Atherosclerosis

Risk in Communities (ARIC) study

Atrial fibrillation (AF) is a common cardiac arrhythmia, affecting 2.7-6.1 million people in the US. The lifetime risk of AF has been previously reported in whites, but not in African Americans. Lifetime risk of AF by socioeconomic status has not been investigated before. This study investigated the lifetime risk of AF in African Americans and in individuals with different socioeconomic status. The analysis included 15,343 whites and African Americans in the Atherosclerosis Risk in Communities (ARIC) study who were followed for an average of 21 years. For analysis, total family income was categorized as <\$25,000, \$25,000-\$49,999, and \geq \$50,000, and education as < high school graduate, high school graduate, and at least some college. Incident AF was ascertained from study electrocardiograms, hospital discharge records, and death certificates. Lifetime risk of AF was estimated by a modified Kaplan-Meier method. 2760 AF cases were identified during follow-up. Lifetime risk of AF was 36% (95% CI: 32-38%) in white men, 30% (26-32%) in white women, 21% (13-24%) in African American men, and 22% (16-25%) in African American women. Regardless of race and sex, incidence rates of AF decreased from the lowest to highest categories of income and education. In contrast, lifetime risk of AF increased in individuals with higher income and education in most sex-race groups. Cumulative incidence of AF was lower in those with higher income and education compared to their low socioeconomic status counterparts through earlier life but was reversed after age 85. The study concluded that lifetime risk of AF in the ARIC cohort was approximately 33% among whites and 20% among African Americans. Socioeconomic status was inversely associated with cumulative incidence of AF before the last decades of life.

Lifetime risk of atrial fibrillation by race and socioeconomic status: The Atherosclerosis Risk in
Communities (ARIC) study

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A Thesis Submitted to the Graduate Faculty of Georgia State University in Partial Fulfillment
of the Requirements for the Degree
MASTER OF PUBLIC HEALTH

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Author's Statement

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INTRODUCTION

Background

Atrial fibrillation (AF) affects 2.7-6.1 million people in the United States. This number is expected to increase as the population ages.¹ It is estimated that by 2030 there will be 12.1 million AF cases in the US.⁴¹ AF is associated with significant morbidity, mortality, and poor quality of life, as it can lead to blood clots and increase the risk of heart failure (HF), myocardial infarction (MI),³ and stroke.⁴ Risk factors for AF include high blood pressure, obesity, diabetes, smoking, and heavy drinking.⁴²

AF constitutes a significant public health burden. Annual cost of AF in the US is approximately \$6 billion, and people who have AF spend an additional \$8,705 per year on medical costs compared to people without AF.^{1,2}

Findings from the Framingham Heart Study in 2004 indicated that one in four individuals would develop AF during their lifetime,⁵ with recent estimates in the same cohort suggesting that lifetime risk of AF is greater 30%.⁶ Lifetime risk quantifies the absolute risk of developing a disease of interest before death. It is calculated as the adjusted cumulative incidence of the disease, taking the competing risks of death into account.⁵ Estimates of the lifetime risk of developing AF are an easy way to communicate future risk to individuals.⁵ However, the recent Framingham estimates, though taking into account recent upward trends in the incidence of AF,⁷ may not be generalizable to non-white populations because its participants are from a predominantly white population of European origin. Since African Americans and other ethnic and racial groups have lower risk of AF compared to whites,^{8,9} contemporary estimates of lifetime risk of AF in more diverse populations are needed.

Socioeconomic and racial health disparities exist in the US,¹⁰ which influences health outcomes, including the management and care of cardiovascular diseases.¹¹ A previous analysis of the US-based Atherosclerosis Risk in Communities (ARIC) study cohort showed that lower income in the overall population and lower education level among women were associated with increased risk of AF.¹² To date, however, no study has explored the lifetime risk of AF by socioeconomic status (SES).

Therefore, to address these gaps, data from over 25 years of follow-up among 15,343 participants in the ARIC study was used to provide estimates of lifetime risk of AF by race and SES. These estimates can provide a more precise picture of the current and future public health burden of AF in the growingly diverse US populations.

Research Questions

What is the AF incidence in whites, African Americans, and individuals with distinguished SES in ARIC cohort? What is the lifetime risk of AF in ARIC cohort? What is the lifetime risk of AF in African Americans? What are lifetime risks of AF in groups of different SES?

LITERATURE REVIEW

Lifetime risk of AF

A well-cited paper ⁵ from the Framingham Heart Study in 2004 reported that the lifetime risk for developing AF is 25% for men and women aged 40 years and older. The study included 3999 men and 4726 women followed from 1968 to 1999. The lifetime risk of AF was estimated to the age of 95. The study showed that from the index age of 40, the lifetime risk of AF was 26% [95% confidence interval (CI), 24% - 27%] for men and 23% (21% - 24%) for women, but it did not change significantly with the increase of the index ages. At the age of 80, the lifetime risk of AF was 23% (20% - 24%) in men and 22% (19% - 23%) in women. Recently, another analysis ⁶ from the same cohort of Framingham Heart Study shows that the lifetime risk of AF is 37% after the age of 55 and 22% (95% CI, 15% - 29%) among individuals with low risks and 48% (95% CI, 41% - 55%) with high risks. This recent analysis found a higher lifetime risk of AF than that reported in 2004 from the same cohort. In Europe, a prospective cohort study conducted in Sweden ²⁰ found that the lifetime risk of AF was 23% among the male participants who were followed from the age of 50 to 98 years. The study indicated that among the cohort of 855 men born in 1913, 185 developed AF before the age of 98. Another large European population-based study ²¹ demonstrated that the lifetime risk of AF was 24% in men and 22% in women at the age of 55. This study assessed 6808 participants followed for an average of 6.9 years.

Prevalence and incidence of AF

Studies have shown the AF prevalence and incidence in the white population. A study ⁷ of the Framingham Heart Study investigated the 50-year trends of incidence and prevalence of AF by dividing time into 10-year groups (1958-67, 1968-77, 1978-87, 1988-97, and 1998-2007) in

the analyses. It found that from 1958 to 2007 the age-adjusted prevalence of AF increased from 20.4 to 96.2 cases per 1000 person-years in men and from 13.7 to 49.4 cases per 1000 person-years in women and the age-adjusted incidence increased from 3.7 to 13.4 and 2.5 to 8.6 new cases per 1000 person-years in men and women, respectively. The prevalence of AF diagnosed by electrocardiograph (ECG) increased from 12.6 in 1958-67 to 25.7 in 1998-2007 per 1000 person-years in men and from 8.1 to 11.8 in women, while the incidence of AF diagnosed by ECG remained unchanged during the same period. The Sweden study of 855 men ²⁰ reveals that the prevalence of AF was 0.4% among men aged 50 years, 1.9% by the age of 60, 4.6% by 70, 12.5% by 80, and 15.7% by 90 years old, clearly indicating the prevalence was increasing as people age. Another prospective European study found that the overall prevalence was 5.5% (0.7% in the age of 55-59 years and 17.8% in individuals \geq 85 years) and that the incidence was 1.1 per 1000 person-years in the age of 55-59 and 20.7 per 1000 person-years in the age \geq 80 years. The study also found that men had higher prevalence and incidence than women.

Other studies also revealed the AF prevalence and incidence in diverse populations. ^{8,9} An analysis ⁸ of the Atherosclerosis Risk in Communities (ARIC) study found that the crude incidence rates of AF were 6.7, 4.0, 3.9, and 3.0 per 1000 person-years in white men, white women, African American men, and African American women, respectively. The risk of AF in African Americans was lowered 41% (95% CI, 8% - 62%), compared with whites. Another multi-ethnic study ⁹ included 6721 participants followed by a mean period of 7.3 years. The study showed that the AF incidence in Hispanics, Non-Hispanic Blacks, and Chinese was significantly lower than that in Non-Hispanic Whites. An investigation on the US emergency room visit and the hospital admission ²² revealed that from 1993 to 2004 there were 2.7 million emergency room visits due to AF in the US and the visit rate was increased from 0.6 to 1.2 per

1000 people during this period. The number of visits was increased 88% over the span of 12 years. Another analysis²⁴ on patients with pacemakers indicated that the prevalence of AF in African Americans was 21%, 95% (CI, 20%-23%) and was significantly lower than whites (26%, 95% CI, 25%-26%).

Health disparity and AF

Studies consistently show the existence of health disparity in the US. African Americans have greater risks of cardiovascular diseases, such as hypertension and hyperlipidemia, obesity, and diabetes¹⁰. An analysis¹² of ARIC study confirmed that low family income (< \$25K per year) is associated with increased AF risk (hazard ratio 1.45, 95% CI, 1.27 – 1.67), compared with high income (\geq \$50k per year). It also found much higher AF risk (hazard ratio 1.88, 95% CI, 1.55 – 2.28) in women of low education status than those with high educational level. In addition, another ARIC study found that the rates of stroke, heart failure, coronary heart disease (CHD), and mortality were higher in African Americans diagnosed with AF, compared with their white counterparts. The observed rate differences were distinct among African Americans and whites. Heart failure and CHD were found to be 1.5 – 2 folds higher in African Americans than whites. Approximately 56% (95% CI, 48% - 64%) mortality rate difference was observed in whites with AF and those without AF. For African Americans with AF and without AF, the difference was 106% (95% CI, 86% - 126%). Moreover, another retrospective study on patients with AF³² concluded that the all-cause mortality is associated with SES. The study used the SES score determined by household income, the value of house unit, occupation, and education as a predictor of mortality, and found that the AF patients with low SES scores had significantly higher mortalities than their SES counterparts.

METHODS

Study population

The basic design of ARIC has been described by other authors.^{8, 13} Briefly, the Atherosclerosis Risk in Communities (ARIC) study is a prospective cohort study for the investigation of risk factors for cardiovascular diseases.^{8, 13} During 1987 to 1989, 15,792 participants (55% women, 27% African Americans) 45 to 64 years old were enrolled in the study. The participants were sampled from 4 US communities: Washington County, MD; the northwest suburbs of Minneapolis, MN; Jackson, MS; and Forsyth County, NC. The racial composition of the cohort reflected the underlying populations, except in Jackson, MS, where only African Americans were sampled. Baseline information was collected by a phone interview and a clinical examination. Subsequently, participants were examined 3 times at roughly 3-year intervals until 1998, with a fifth examination taking place in 2011-2013. During follow-up, participants were contacted annually by phone to gather information on hospital admission and verify vital status. The response rates on the triennial exams and the annual phone interview were 93%, 86%, 80%, and >90%, respectively. For this analysis, we included follow-up information through December 31, 2014. The ARIC study has been approved by the Institutional Review Boards at the participating institutions. All the participants signed a written informed consent.

Among the 15,792 participants, the following was excluded from the analysis: 48 with self-reported race of non-white or non-African American and 55 African Americans in the study centers of MN and MD because of the small sample sizes; 37 with AF or atrial flutter diagnosed by ECG at the baseline visit; and 310 whose ECG was missing or unreadable at the baseline visit. In total, 15,343 participants were included as the study population. For the analysis by total

family income and education, 893 whose income information was missing and 24 whose education information missing were excluded, respectively, in the corresponding analysis.

Incidence of AF events

The ascertainment method for AF has been reported previously.^{8, 12} In brief, AF was identified by three sources: ECGs from follow-up exams, hospital discharge records, and death certificates. ECGs during follow-up exams were done with MAC PC personal Cardiographs. All ECGs were transmitted to the ARIC ECG reading center for coding, interpretation, and storage. A trained cardiologist visually read recordings of ECGs automatically coded as AF for the certainty of the diagnosis. Also, hospitalization information was obtained during the annual follow-up interview and from surveillance of local hospitals. In ARIC, a trained abstractor accessed the hospital discharge records and recorded all the diagnoses according to International Classification of Diseases, Ninth Revision Clinical Modification (ICD-9-CM). AF was defined if codes 427.31 or 427.32 were present in the absence of procedure codes for open heart surgery. Finally, information on death from any cause was collected by calling participant's proxy, or from obituaries, hospital records, death certificates, or vital statistics from the National Death Index.¹⁴ Cases of AF were identified from death certificates if ICD-10 code I48 or ICD-9 code 427.3 were listed as one of the causes of death. The validity of this approach for AF event identification, with a positive predictive value of approximately 90%, has been demonstrated previously.⁸

The incidence date of AF was defined as the first occurrence of AF in an ECG during follow-up exam, a hospital discharge record, or death certificate.⁸

Assessment of SES and covariates

The total family income and individual education level were self-reported during the baseline visit conducted by ARIC researchers. For the analysis, the total family income was categorized into three groups: < \$25,000 per year; \$25,000 to < \$50,000 per year; and \geq \$50,000 per year. In subgroup analysis related to African Americans, the last two groups were combined into one as \geq \$25,000 per year due to the small number of African American participants with reported income \geq \$50,000. Education level was also categorized into three groups: Basic – less than high school; Intermediate – high school or equivalent; and High– completed at least some college education.

Risk factors for cardiovascular disease were measured at baseline. Smoking status was self-reported. Participant's height was measured without wearing shoes, and weight wearing light clothing. Blood pressure was measured three times at each visit after a 5-minute rest and in sitting position. The average of the last two measurements was used for the study. Blood pressure \geq 140/90 mmHg or taking medications for hypertension was defined as hypertension. As it has been used in other studies, fasting blood glucose \geq 126 mg/dl, non-fasting blood glucose \geq 200 mg/dl, current treatment for diabetes, or self-reported physician-diagnosis of diabetes was defined as diabetes mellitus.¹⁵ Self-reported history of myocardial infarction (MI) or electrocardiographic evidence of prior MI was characterized as prevalent MI.¹⁵ Prevalent heart failure (HF) was identified using the Gothenburg criteria, or treatment of HF in the past two weeks at baseline.^{15, 17}

To study the association of short-time risk of AF with lifetime risk, the individual predicted 5-year risk of AF was calculated based on a previously described predictive risk model.¹⁸ The model includes the following variables: age (years divided by 5), race (white or African American), height (10 cm), weight (15 kg), systolic (20 mmHg) and diastolic blood

pressure (10 mmHg), smoking status (current), the presence of treatment of hypertension with medications (yes), diabetes (yes), HF (yes), and history of MI (yes). It can be calculated as

$$1 - 0.9718412736^{\exp(\Sigma\beta X - 12.5815600)}.^{18}$$

Statistical analysis

Participants' characteristics at baseline are presented as percentages for the categorized variables and mean (standard deviation) for the continuous and stratified by race.

Age-specific rates of AF by 10-year group for age 45-54, and 5-year groups starting at age 55 through age 92 (oldest attained age) were computed. Incidence rates were calculated dividing the number of new cases in an age-specific group by the corresponding person-years of follow-up. Person-years of follow-up were defined from the date of visit 1 to the first diagnosis of AF, death, loss of follow-up, or December 31, 2014, whichever occurred first. The crude incidence rate was calculated as the total number of AF events divided by total person-years of follow-up. Rates were age-standardized using the age-specific distribution of person-years in the entire cohort as the standard population.

The modified Kaplan-Meier method was used to account for the competing risk of death by calculating the lifetime risk of AF (cumulative incidence through oldest attained age in the cohort), as reported previously.¹⁹ In the computation of cumulative incidence adjusted for competing risk, the survival analysis was performed by taking death into account as the event of interest together with AF but not censored. Survival free of AF and being alive was a more appropriate condition than being free of AF but not alive when death was censored. Lifetime risk through age 92 (oldest age at which an AF event occurred in the cohort) starting at the index age 45, 55, 65, and 75 was calculated. The separate calculations by race, sex, total family income, education level, and predicted 5-year AF risk according to quartiles of the CHARGE-AF score

were conducted. This later analysis was performed to estimate lifetime risk of AF across categories of short-term (5-year) AF risk.

SAS 9.4 (SAS Inc., Cary, NC) was used for the analysis.

RESULTS

Characteristics of participants at baseline

There were 15,343 participants aged 45-64 years and without AF at baseline. Table 1 shows participants' characteristics by race and sex, while Table 2 reports characteristics by race, family income, and education. African Americans had the higher prevalence of cardiovascular events than whites, while white men had higher predicted 5-year risk of AF than other groups. As shown in Table 2, among both whites and African Americans, the lower income groups had a higher proportion of women (63% in whites and 67% in African Americans) compared to the other income groups, and those in the lowest categories of income and education had more adverse cardiovascular risk factors: higher systolic blood pressure (SBP) and higher prevalence of hypertension, diabetes, HF, and MI, and smoking. Overall, higher income and education were correlated with more favorable cardiovascular profile, and across categories of income and education, whites had a lower prevalence of cardiovascular risk factors than African Americans.

AF incidence and lifetime risk by race and sex

The average follow-up period was 21 (+7SD) years. During the 1987 – 2014, follow-up period, 2,790 new cases of AF (2,270 in whites and 520 in African Americans) were identified. Incidence rates of AF rose with age across all gender and race groups, whites showing a higher rate (9.1 per 1,000 person-years) than African Americans (6.8 per 1,000 person-years) overall. Table 3 presents the age-, race-, and sex-specific incidence rates of AF per 1,000 person-years from 1987 to 2014. Age-standardized rates were highest (11.3 per 1,000 person-years) among white men (WM) and lowest (6.1 per 1,000 person-years) among African American women (AAW). Compared to WM, the rate ratios (RR) and 95% confidence interval (CI) of AF in

AAW, African American men (AAM), and white women (WW) were 0.54 (0.47, 0.61), 0.71 (0.62, 0.83), and 0.64 (0.59, 0.70), respectively.

The lifetime risk of AF at the age 45 to 92 in whites was 33% and in African Americans 21%, or approximately 1 in 3 and 1 in 5, respectively. Lifetime risk was 36% in WM, 30% in WW, 21% in AAM, and 22% in AAW. Table 4 displays the lifetime risk by race and sex at the index age of 45, 55, 65, and 75. The lifetime risk of AF remained almost constant from index age 45 to 65, with slightly smaller values after index age 75. Figure 1 shows the cumulative incidence of AF from age 45 to 92 by race and sex.

AF incidence and lifetime risk by income and education

Table 5 shows the age-, race-, income-, and education-specific AF incidence rates per 1,000 person-years from 1987 to 2014. Overall, regardless of race and sex, AF incidence rates decreased as income and education increase. Compared to those with the lowest income, individuals in the highest income category had age-standardized relative rate reduction of 24% (WM), 30% (WW), 20% (AAM), and 27% (AAW). Corresponding values for high education versus low education were 21%, 43%, 29%, and 37% in WM, WW, AAM, and AAW, respectively.

Table 6 provides lifetime risk of AF by race, sex, income, and education conditional on survival free of AF from index age 45 to 75. In contrast to the clear association of higher income and education with lower rates of AF, lifetime risk of AF was higher in those with higher income and education. The only exception was estimates among WW, in which those with higher income and education had lower lifetime risk of AF than their more socioeconomically disadvantaged counterparts. Figure 2 presents the cumulative incidence of AF from age 45 to 92 by income and education in WM, WW, AAM, and AAW. The figure shows that earlier in life,

cumulative incidence of AF is lower among those with higher income and education, but that trend is reversed after the age of 80 years. The only exception was WW who experienced lower AF cumulative incidence from the lowest to the highest categories of income and education during their entire lifetime.

Lifetime risk of AF by predicted AF risk

With the purpose of estimating long-term risk of AF across categories of short-term predicted AF risk, an estimate of the lifetime risk of AF by quartiles of the predicted 5-year AF risk was calculated from the predictive model at baseline (see methods for variables included in the predictive model). Lifetime risk across quartiles of predicted 5-year risk at baseline was 11% for those with predicted risk $\leq 0.4\%$, 25% for predicted risk $> 0.4\%$ and $\leq 0.8\%$, 29% for predicted risk $> 0.8\%$ and $\leq 1.5\%$, and 37% for those with predicted risk $> 1.5\%$, as shown in Table 7. Figure 3 presents the cumulative incidence of AF by quartiles of predicted 5-year risk of AF during age 45-92. The cumulative incidence positively increased with the predicted risk. The individuals having the highest predicted risk of AF showed more dramatic increase of cumulative incidence from age 45 to 92 compared to their counterparts who possessed lower predicted risk of AF.

DISCUSSION AND CONCLUSION

In this analysis of 15,343 men and women followed for an average of 21 years, estimated lifetime risk of developing AF was approximately 1 in 3 among whites and 1 in 5 among African Americans. The higher rates of AF with old age, among whites, and in individuals with lower socioeconomic status was observed. In contrast, the lifetime risk of AF was lower in individuals with low versus high socioeconomic status in most race-sex groups, possibly due to longer survival among the socioeconomically advantaged. Even among those with the lowest short-term predicted risk of AF, lifetime risk was considerable (>10%).

The current results complement those from an earlier analysis of the ARIC cohort with follow-up through 2004 (compared to 2014 in the present analysis).⁸ The overall results from the two analyses are consistent, showing higher incidence rates of AF in whites than in African Americans, in men than in women, and exponential rate increases with age. However, because of more incident AF cases in the older cohort due to the extended follow-up, the crude incidence rates of AF increased from 6.7 to 11.5 per 1,000 person-years in white men, from 4.0 to 7.5 in white women, from 3.9 to 7.2 in African American men, and from 3.0 to 5.7 in African American women, compared with the previous ARIC report.⁸

AF incidence rates in white men and white women in the ARIC cohort are comparable to the rates reported in a recent analysis of the Framingham Heart Study,⁷ reflecting the general occurrence of AF in the white population in the US. Also, it was found that AF lifetime risk is around 1 in 3 in whites (36% in white men and 30% in white women) after the age of 45 years, which is higher than the lifetime risks reported in a previous analysis of the Framingham Heart Study,⁵ the Swedish Study of Men Born in 1913,²⁰ and the Dutch Rotterdam Study,²¹ but similar to a recent report from the Framingham Heart Study. The increased AF lifetime risk may

partially be attributed to enhanced surveillance for and awareness of AF in the community.⁷ Of note, follow-up in the older Framingham Heart Study and Rotterdam Study publications ended before the year 2000.^{5,21} Also, differences in AF risk factors and lifestyles across cohorts might explain the differences. For example, the prevalence of diabetes and MI in the ARIC cohort was higher than that in the Rotterdam Study.²¹ Differences in the lifetime risk of AF between the current ARIC report and the recent Framingham Heart Study⁶ can be explained by dissimilarities in the ascertainment of AF, which rely mostly in hospitalizations in ARIC, while the Framingham Heart Study had access to outpatient medical records.

Multiple studies have demonstrated that African Americans have lower incidence of AF than whites. In an earlier analysis of the ARIC study, it was found that AF rates in African Americans were 41% lower compared to whites after an average 15-year follow-up.⁸ The same results have been found in different cohorts.^{22–28} Complementing previous studies, I now show that African Americans have lower lifetime risk of AF than whites, despite higher prevalence of AF risk factors. However, notwithstanding their lower lifetime risk, still 1 in 5 African Americans in ARIC were estimated to develop AF during their lifetime, certainly not a trivial figure. It was also found that unlike whites, African American women had a slightly increased lifetime risk compared to African American men. The reason might be that African American women could live longer to very old age to have more chance of developing AF than African American men. In fact, African American women have lower all-cause mortality and longer life expectancy than African American men.²⁹

Prior research has reported higher rates of cardiovascular disease, including AF, among those with lower SES.^{30–34} As expected, I found that age-standardized incidence rates of AF decreased in a dose-response fashion with higher income and education, regardless of race and

sex. The findings here are consistent with a previous ARIC report that specifically focused on examining the association between SES and AF incidence.¹²

In contrast to the inverse association of SES with AF rates, I found that AF lifetime risk increased with income in WM, AAM, and AAW, and with education in WM and AAM. In this analysis, it was found that cumulative incidence of AF was generally lower earlier in life among those with higher income but increased substantially in the last decade of life among those with higher SES. Consistent with my findings, a prior study showed that the association between mortality risk and SES was attenuated in older people.³⁴ One potential explanation for this observation is the impact of mortality as a competing risk disproportionately affecting the socioeconomically disadvantaged groups. As shown in this analysis, ARIC participants in the lowest ranks of income and education had the highest prevalence of cardiovascular risk factors. Consequently, mortality would be higher in people with low income and education compared to others and, therefore, fewer people in low income and education would survive to old age to have a chance to develop AF. This may result in more AF in people with high income and education at the very late stage of life. In summary, estimates of lifetime risk of AF across SES groups may be problematic because it could mask actual socioeconomic disparities in the incidence of the arrhythmia.

The findings have significant implications for public health. The observation that 1 in 3 whites and 1 in 5 African Americans will develop AF during their lifetime underscore the high burden of AF in the community. The increased number of AF patients has brought about an increased demand for anticoagulation treatment for stroke prevention,³⁵ and highlights the need for more randomized trials to evaluate strategies to reduce risk of ischemic events associated with AF.³⁶ The impact of AF is exacerbated by the increased risk of stroke, HF, and mortality in

persons affected by AF.^{37–40} Hence, novel prevention approaches for AF and its complications are urgently needed overall and specifically in low SES individuals and other vulnerable groups, such as African Americans, who experience more AF-related adverse clinical outcomes.¹⁴

Strengths and limitations

This study is the first to report the lifetime risk of AF in African Americans. It takes advantage of the data available in the ARIC cohort, one of the longest follow-up studies in a large biracial population in the US. In addition to the diverse population, the large number of AF events, and the extended follow-up, other strengths include the excellent cohort retention and the careful methodology for ascertainment of cardiovascular events and mortality.

There are certain limitations in the study. More importantly, ascertainment of AF is likely to be incomplete since asymptomatic cases and those exclusively managed in the outpatient settings were missing. False negatives of AF possibly existed because the cardiologist was not visually examining the negative ECGs. Also, AF can be intermittent, and therefore may not be detected with a standard 10-second ECG and hospitalizations. In addition, the information on education and total family income was self-reported and collected only at baseline. Although the individual education status might not change after baseline, the total family income of some participants could change during the > 20 years of follow-up. While the total family income of other participants remained constant, this change might affect the result of the analysis. Moreover, the impact of education and income in the ARIC study reflects the experience of a cohort born between the 1920s to early 1940s, which may be different from those of later cohorts.

Conclusions

Lifetime risk of AF in a contemporary cohort is approximately 36% among whites, higher than previously reported, and 25% among African Americans. These results contribute to clarify

the public health impact of AF and can be used to raise awareness of this common condition among the population. The findings also emphasize the importance of developing programs on screening and prevention of AF in low SES populations.

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Table 1. Baseline characteristics of participants, Atherosclerosis Risk in Communities Study, 1987-1989

	White men	White women	African American men	African American women
N	5332	5948	1539	2524
Incidence AF cases	1263	1009	212	309
Age, years	55 (6)	54 (6)	54 (6)	53 (6)
%	35	39	10	16
Height, cm	176 (7)	162 (6)	176 (7)	163 (6)
Weight, kg	85 (14)	70 (15)	85 (17)	82 (18)
BMI	27 (4)	27 (6)	28 (5)	31 (7)
SBP, mmHg, mean	120 (16)	117 (18)	130 (22)	128 (22)
DBP, mmHg, mean	73 (10)	70 (10)	82 (13)	78 (12)
Smoking, %	25	25	38	25
Antihypertension therapy, %	20	20	34	45
Prevalence of diabetes, %	10	8	18	21
Prevalence of HF, %	3	5	5	9
Prior MI, %	7	1	5	3
Predictive 5-year risk, %	0.02 (0.02)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Estimated glomerular filtration rate	97 (13)	101 (12)	107 (19)	110 (20)

Values correspond to means (standard deviations) or percentages. HF: Heart failure. MI: myocardial infarction. CHARGE-AF score: Predicted 5-year risk of AF

Table 2. Baseline Characteristics of participants by race, family income, and education, Atherosclerosis Risk in Communities Study, 1987 - 1989

	Whites (n=11,280)					
	Total Family Income			Education Levels		
	<\$25K	\$25K-<\$50K	≥\$50K	Basic	Median	High
N	2874	4569	3337	1844	4890	4046
% of total	26.7	42.4	31	17.1	45.4	37.5
AF cases	683	917	58	491	1007	768
Age, years	57(6)	54(6)	53(5)	56(5)	54(6)	54(6)
% of female	62	51	46	50	59	46
Height (women), cm	161(6)	162(6)	163(6)	160(6)	162(6)	163(6)
Height (men), cm	174(7)	176(7)	178(6)	174 (6)	176(7)	178(6)
Weight, kg	76(16)	78 (16)	78 (16)	78 (16)	76(16)	78(16)
BMI	28(5)	27(5)	26(4)	28(5)	27(5)	27(4)
SBP, mmHg	122(18)	119 (17)	116 (16)	122 (18)	119(17)	117(16)
DBP, mmHg	71(10)	72(10)	72(10)	71(10)	72(10)	72(10)
Smoking, %	30	25	20	35	26	19
AT, %	26	20	15	26	21	16
P. of diabetes, %	14	9	6	15	9	7
P. of HF, %	6	3	2	6	4	3
Prior MI, %	6	4	3	8	4	3
	African-Americans (n=4,063)					
	<\$25K	≥\$25K		Basic	Median	High
N	2598	1055		1529	1035	1089
% of total	71.1	28.9		41.9	28.3	29.8
AF cases	366	26		258	142	119
Age, years	54(6)	52(5)		55 (6)	53 (6)	52 (6)
% of female	67	52		60	65	63
Height (women), cm	163(6)	164(6)		163 (6)	163 (6)	164 (6)
Height (men), cm	176(7)	177(7)		176 (7)	176 (7)	177 (7)
Weight, kg	83(18)	83(16)		84 (18)	83 (17)	82 (17)
BMI	30(6)	29(5)		30(7)	30(6)	29(6)
SBP, mmHg	131(22)	125(19)		132 (22)	128 (23)	126 (19)
DBP, mmHg	80(12)	79(12)		80 (13)	79 (13)	79 (12)
Smoking, %	32	25		34	29	25
AT, %	44	34		46	38	36
P. of diabetes, %	23	13		25	19	15
P. of HF, %	9	3		10	7	4
Prior MI, %	4	2		5	4	2

Values corresponding to mean (standard deviation) or percentages.

AT: antihypertension therapy. P.: prevalence. HF: heart failure. MI: myocardial infarction.

Basic – did not complete high school; Median – completed high school or equivalent; High – completed at least some college education.

Table 3. Age-, race-, and sex-specific incidence rates of AF per 1000 person-years, Atherosclerosis Risk in Communities Study, 1987-2014

Age group	White men			White women			African American men			African American women		
	N. AF	Person-Years	IR	N. AF	Person-years	IR	N. AF	Person-years	IR	N. AF	Person-years	IR
45-54	25	13355	1.9	9	17483	0.5	4	4681	0.7	4	8397	0.5
55-59	66	16223	4.1	30	19809	1.5	11	4817	2.3	13	8781	1.5
60-64	132	21855	6.0	84	25581	3.3	23	5983	3.8	31	10641	2.9
65-69	220	22324	9.9	169	26341	6.4	42	5952	7.1	56	10606	5.3
70-74	279	18143	15.4	241	22001	11.0	51	4481	11.4	74	8449	8.8
75-79	267	11198	23.8	224	13808	16.2	47	2378	19.8	68	4692	14.5
80-84	198	5118	38.7	178	6605	26.9	24	943	25.5	40	2107	19.0
85-89	73	1255	58.2	73	1904	38.4	10	233	42.9	21	557	37.7
Crude rate	1262	109514	11.5	1008	133602	7.5	212	29478	7.2	308	54250	5.7
Age-adjusted rate			11.3			7.3			8.1			6.1
RR (95%CI)*	1 (Ref.)			0.64 (0.59, 0.70)			0.71 (0.62, 0.83)			0.54 (0.47, 0.61)		

IR: Incidence rate (per 1000 person-years). *Age-standardized rate ratio and 95% confidence interval

Table 4. Estimates (95% confidence intervals) of race- and sex-specific lifetime risk of AF conditional on survival free of AF to age 45, 55, 65, or 75, Atherosclerosis Risk in Communities study, 1987-2014.

Survival free of AF	White men	White women	African American men	African American women
age 45	36 (32, 38)	30 (26, 32)	21 (13, 24)	22 (16, 25)
age 55	36 (32, 38)	30 (27, 32)	21 (13, 24)	22 (16, 25)
age 65	35 (31, 37)	30 (26, 32)	22 (14, 26)	23 (17, 26)
age 75	32 (28, 35)	26 (23, 29)	21 (12, 26)	21 (15, 26)

Lifetime risk (%) is up to age 92.

Table 5. Age-, race-, sex-, income-, and education-specific incidence rates of AF per 1000 person-years, Atherosclerosis Risk in Communities Study, 1987-2014

Age group	White men			White women			African American men			African American women		
	<\$25K	\$25K-<\$50K	≥\$50K	<\$25K	\$25K-<\$50K	≥\$50K	<\$25K	≥\$25K	<\$25	≥\$25K	<\$25	≥\$25K
45-54	1.3	2.1	1.6	0.9	0.7	0.2	0.9	0.8	0.6	0.3		
55-59	6.9	4.2	2.6	1.5	2.1	0.8	1.3	3.3	2.1	0.3		
60-64	7.1	6.0	5.7	2.7	3.4	3.4	5.1	2.5	3.8	1.1		
65-69	14.8	9.5	7.2	10.0	5.9	3.7	7.1	7.0	5.2	5.5		
70-74	19.3	14.6	14.8	12.4	10.4	9.7	13.4	9.1	9.1	8.1		
75-79	27.3	24.1	22.2	19.3	16.0	14.2	24.1	14.3	16.7	9.0		
80-84	30.6	41.5	41.0	31.8	23.6	23.4	28.1	21.4	22.4	9.1		
85-89	78.9	43.3	61.2	38.3	40.3	38.4	31.5	67.1	30.6	70.7		
Rate*	13.7	11.1	10.4	8.7	7.1	6.0	8.9	7.2	6.7	4.9		
RR (95%CI)**	1 (Ref.)	0.81 (0.70, 0.94)	0.76 (0.65, 0.88)	1 (Ref.)	0.82 (0.71, 0.94)	0.70 (0.59, 0.83)	1 (Ref.)	0.80 (0.60, 1.07)	1 (Ref.)	0.73 (0.56, 0.96)		
Age group	Basic	Median	High	Basic	Median	High	Basic	Median	High	Basic	Median	High
45-54	2.2	1.2	2.4	1.6	0.6	0.1	0.7	0.7	1.1	0.4	0.4	0.6
55-59	4.1	5	3.2	3.0	1.4	1.2	1.1	3.8	2.3	1.0	1.9	1.7
60-64	6.5	6.2	5.7	4.9	3.2	2.7	4.1	7.2	1.0	4.9	2.8	0.6
65-69	12.7	11.1	7.7	11.0	6.1	4.7	7.8	9.6	4.2	7.8	4.2	3.3
70-74	15.9	16.9	13.9	15.1	10.6	9.6	11.5	13.1	10.1	10.0	10.0	5.7
75-79	25.7	26.3	20.9	25.0	15.5	12.7	25.9	15.3	13.7	15.3	11.2	16.5
80-84	41.7	35.9	38.7	27.7	26.7	27.0	30.0	18.5	23.1	22.7	19.4	12.2
85-89	65.2	62.1	51.4	51.5	39.5	28.2	45.8	19.2	60.0	41.8	29.8	39.7
Rate*	12.5	12.1	10.2	10.6	7.1	6.0	8.9	8.7	6.3	7.4	5.7	4.7
RR (95%CI)***	1 (Ref.)	0.96 (0.83, 1.12)	0.81 (0.70, 0.94)	1 (Ref.)	0.67 (0.57, 0.78)	0.57 (0.48, 0.68)	1 (Ref.)	0.97 (0.70, 1.35)	0.71 (0.5, 1.00)	1 (Ref.)	0.77 (0.59, 1.00)	0.63 (0.48, 0.84)

Basic – did not complete high school; Median – completed high school or equivalent; High – completed at least some college education.

* Age-adjusted rate.

** Age-standardized rate ratio and 95% confidence interval. Group of < \$25K as reference.

*** Age-standardized rate ratio and 95% confidence interval. Group of Basic as reference.

Table 6. Estimates (95% confidence intervals) of race-, sex, income-, and education-specific lifetime risk of AF conditional on survival free of AF to age 45, 55, 65, and 75, Atherosclerosis Risk in Communities study, 1987-2014

Survival free of AF	White men			White women			African American men		African American women			
	<\$25K	\$25K - <\$50K	≥\$50K	<\$25K	\$25K - <\$50K	≥\$50K	<\$25K	≥\$25K	<\$25K	≥\$25K		
age 45	33 (26, 37)	35 (30, 38)	40 (32, 45)	31 (26, 34)	28 (24, 31)	28 (20, 34)	19 (10, 22)	25 (6, 31)	21 (15, 24)	26 (2, 37)		
age 55	34 (27, 38)	34 (29, 37)	40 (32, 45)	31 (26, 34)	29 (24, 32)	28 (20, 35)	19 (11, 23)	25 (6, 32)	22 (16, 25)	26 (3, 38)		
age 65	33 (26, 37)	33 (28, 36)	39 (31, 45)	32 (27, 35)	28 (23, 31)	28 (19, 34)	21 (12, 25)	25 (6, 33)	22 (16, 25)	28 (4, 40)		
age 75	30 (22, 35)	30 (24, 34)	37 (28, 44)	29 (23, 33)	24 (19, 28)	25 (15, 32)	21 (11, 26)	24 (4, 34)	21 (15, 26)	26 (1, 41)		
Survival free of AF	Basic	Median	High	Basic	Median	High	Basic	Median	High	Basic	Median	High
age 45	34 (26, 38)	37 (31, 40)	36 (30, 39)	35 (28, 40)	29 (25, 32)	27 (21, 30)	19 (10, 23)	21 (3, 27)	24 (1, 33)	23 (14, 27)	20 (9, 26)	19 (10, 25)
age 55	33 (25, 37)	37 (31, 40)	35 (30, 39)	34.6 (27, 39)	29 (25, 32)	27 (21, 31)	20 (11, 24)	21 (3, 27)	24 (0, 33)	23 (14, 27)	22 (10, 28)	19 (10, 25)
age 65	33 (25, 37)	36 (30, 39)	34 (28, 38)	35 (28, 40)	29 (24, 32)	26 (21, 31)	22 (13, 27)	20 (1, 27)	25 (1, 35)	24 (15, 29)	22 (10, 28)	20 (10, 26)
age 75	32 (23, 38)	33 (26, 37)	32 (25, 36)	31 (23, 37)	26 (21, 29)	23 (17, 28)	24 (13, 30)	16 (0, 26)	24 (0, 38)	23 (13, 29)	20 (7, 28)	19 (9, 26)

Basic – did not complete high school; Median – completed high school or equivalent; High – completed at least some college education.

Table 7. Estimates (95% confidence intervals) of lifetime risk of AF conditional on survival free of AF to age 45, 55, 65, or 75 by quartiles of 5-year predicted risk, Atherosclerosis Risk in Communities Study, 1987-2014

Survival free of AF	Q1 Predicted risk \leq 0.4%	Q2 0.4% < Predicted risk \leq 0.8%	Q3 0.8% < Predicted risk \leq 1.5%	Q4 Predicted risk > 1.5%
age 45	11 (8, 13)	25 (12, 33)	29 (25, 32)	37 (32, 43)
age 55	11 (8, 13)	25 (12, 33)	29 (25, 31)	35 (32, 37)
age 65	10 (7, 12)	24 (11, 33)	28 (25, 31)	34 (31, 36)
age 75	5 (2, 8)	22 (8, 33)	25 (21, 28)	31 (28, 33)

Figure 1. Race- and sex-specific cumulative incidence of AF, Atherosclerosis Risk in Communities Study, 1987-2014.

Lifetime risk is cumulative risk through 92 years of age.

AAM: African American men; AAW: African American women; WM: white men; WW: white women

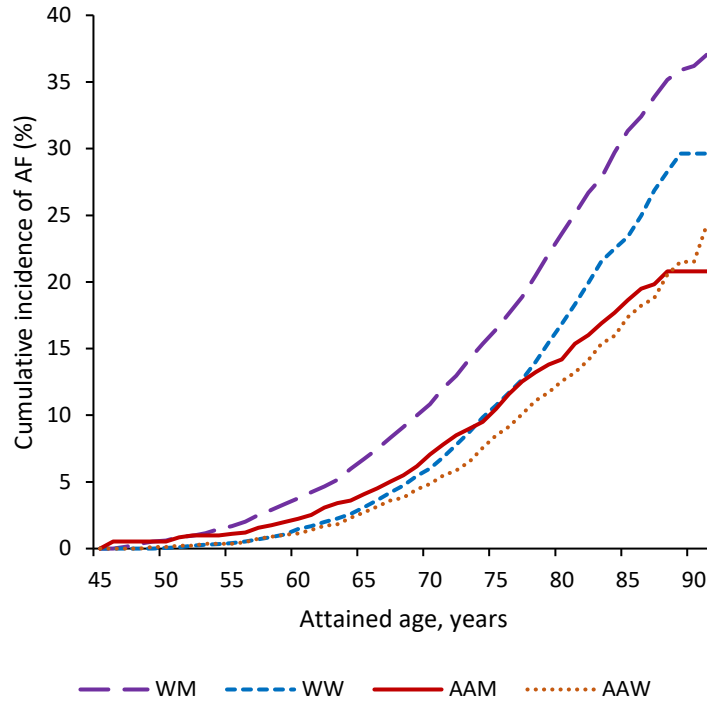


Figure 2. Cumulative incidence of AF from age 45 to 92 by income, education, race and sex, Atherosclerosis Risk in Communities Study, 1987-2014.

A: By income categories in whites. B: By income categories in African Americans. C: By education categories in whites. D: By education categories in African Americans.

AAM: African American men. AAW: African American women. WM: white men. WW: white women.

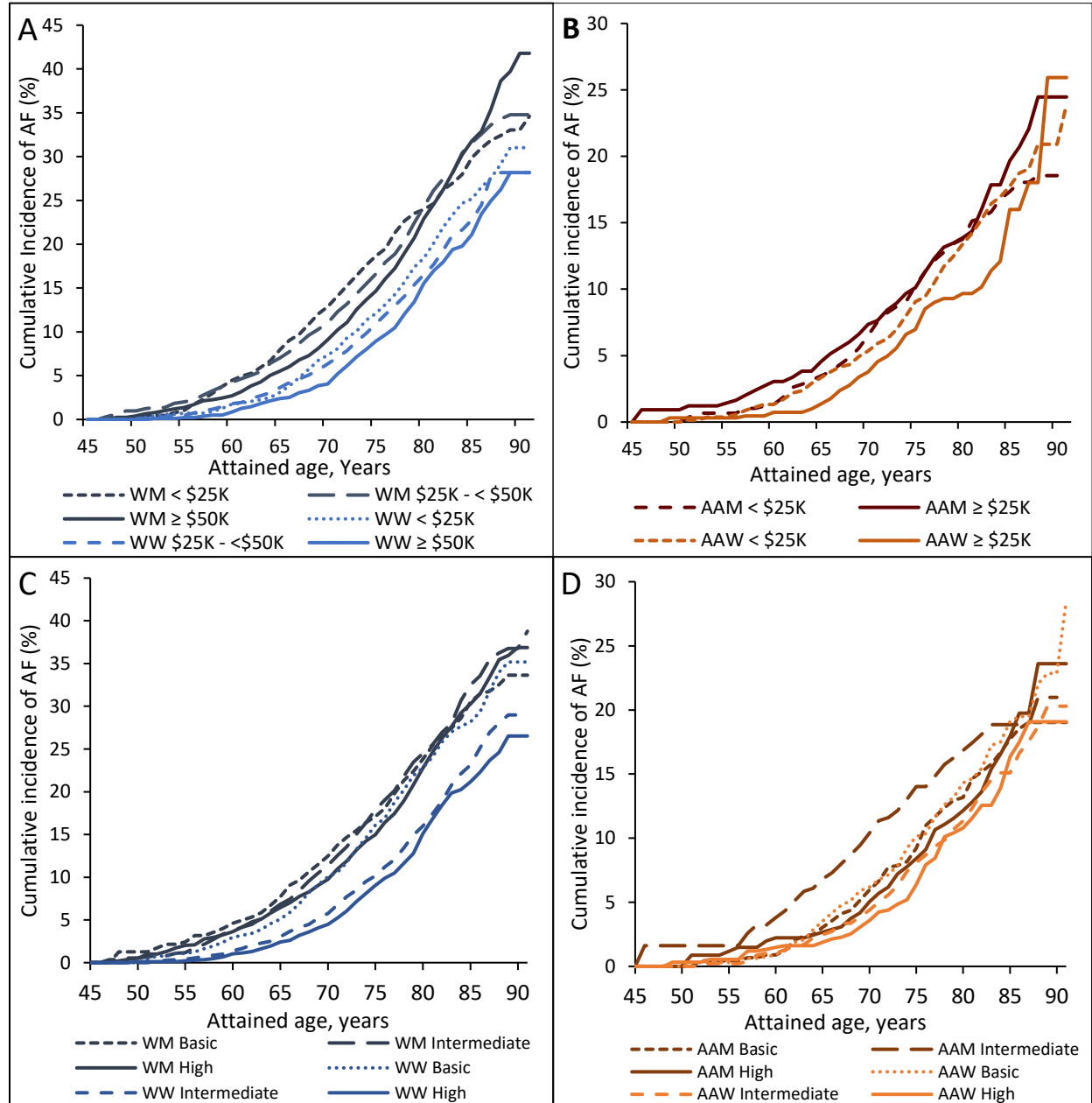


Figure 3. Cumulative incidence of AF from age 45 to 92 by quartiles of predicted 5-year risk of AF, Atherosclerosis Risk in Communities Study, 1987-2014.

Q1: predicted risk $\leq 0.4\%$. Q2: $0.4\% < \text{predicted risk} \leq 0.8\%$. Q3: $0.8\% < \text{predicted risk} \leq 1.5\%$. Q4: predicted risk $> 1.5\%$.

