

Original Contribution

Alcohol Consumption in Young Adults and Incident Hypertension: 20-Year Follow-up From the Coronary Artery Risk Development in Young Adults Study

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The relation between alcohol consumption and incident hypertension is unclear, and most observational studies have not accounted for socioeconomic factors. This study examined the association between alcohol consumption in a diverse group of young adults and incident hypertension over 20 years. Participants ($n = 4,711$) were from the Coronary Artery Risk Development in Young Adults Study cohort, recruited in 1985 (aged 18–30 years) from Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California. The 20-year incidence of hypertension for never, former, light, moderate, and at-risk drinkers was 25.1%, 31.8%, 20.9%, 22.2%, and 18.8%, respectively ($P < 0.001$). Race, gender, age, family history of hypertension, body mass index, income, education, and difficulty paying for basics and medical care were associated with hypertension. Adjustment using Cox proportional hazard models revealed no association between baseline alcohol consumption and incident hypertension, except among European-American women in whom any current alcohol consumption was associated with lower risk of incident hypertension. The lack of association between alcohol and hypertension in the majority of this socioeconomically diverse cohort is not definitive. Future studies should include social factors, such as income and education, and consider additional characteristics that may modify or confound associations between alcohol and blood pressure.

African continental ancestry group; alcohol drinking; cohort studies; European continental ancestry group; hypertension; incidence

Abbreviations: ARIC, Atherosclerosis Risk in Community; CARDIA, Coronary Artery Risk Development in Young Adults; CI, confidence interval; HR, hazard ratio; NIAAA, National Institute on Alcohol Abuse and Alcoholism.

In observational studies, moderate alcohol consumption has been associated with lower incidence of cardiovascular diseases such as coronary artery disease, stroke, heart failure, and peripheral vascular disease (1–13). The relation between alcohol consumption and hypertension, which affects 30% of US adults and accounts for 38 million outpatient visits and 23,000 deaths annually (14), is less clear (15, 16). Observational studies provide inconsistent results, reporting that moderate alcohol consumption is 1) associated with decreased incident hypertension (17–19), 2) associated with increased incident hypertension (19–21), or 3) not associated with hypertension at all (22, 23). The relations may differ by race or gender, with some studies sug-

gesting that alcohol consumption is linearly related to incident hypertension in one race or gender but not others in the same cohort (24–26). A fairly consistent finding is that heavy drinking (usually defined as >2 drinks/day) is associated with increased blood pressure and incident hypertension (19, 26–28).

Long-term randomized controlled trials of alcohol consumption may be inappropriate or impractical, which leaves careful observation to examine the association between alcohol consumption and incident hypertension. Previous observational studies that have demonstrated an association between alcohol consumption and incident hypertension were conducted in relatively homogeneous cohorts and/or

did not take socioeconomic factors into account (18, 20–22, 25). The Coronary Artery Risk Development in Young Adults (CARDIA) Study is a longitudinal cohort of African-American and European-American men and women designed to recruit individuals with a wide range of incomes and education from 4 urban areas. In this diverse cohort, we examined the relation between baseline alcohol use and incident hypertension over 20 years of follow-up, accounting for traditional risk factors as well as demographic and socioeconomic factors.

MATERIALS AND METHODS

Study population

The CARDIA Study is a longitudinal study of coronary artery disease risk factors in 5,115 young African-American and European-American men and women. Participants, aged 18–30 years, were recruited in 1985–1986 from 4 urban centers (Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California). With informed consent of the participants and approval of institutional review boards at each site, the participants have undergone 7 examinations including baseline and years 2, 5, 7, 10, 15, and 20 with retention rates of 90%, 86%, 81%, 79%, 74%, and 72% of the surviving cohort, respectively. At each examination, participants underwent measurements of height, weight, and blood pressure, and they answered an extensive battery of behavioral and psychosocial questions. Further details on the study design, recruitment, and procedures have been previously published (29, 30). For this analysis, we included the 4,711 participants who did not have hypertension (as defined below) at the baseline assessment examination, answered the baseline alcohol question, and had blood pressure measured at least once in follow-up.

Alcohol consumption

At each CARDIA Study examination, participants were asked, “Did you drink any alcoholic beverages in the past year?” and, with the use of visual aids to demonstrate a typical drink, were asked 3 follow-up questions to assess the number of drinks of wine, beer, and liquor typically consumed in a week. Assuming that 1 drink of beer, wine, or liquor contains 16.7 mL, 17.0 mL, or 19.2 mL of ethanol, respectively (per CARDIA Study protocol), we estimated total ethanol consumption/week in milliliters of ethanol. The result was divided by 17.2 mL of ethanol/average drink to estimate the usual number of standard drinks/week. We used this combined alcohol variable, because there were not sufficient numbers of individuals, especially women, to conduct the analyses stratified by type of alcohol.

We used National Institute on Alcohol Abuse and Alcoholism (NIAAA) suggested drinking categories as the main independent variable in our analyses. These drinking categories are as follows: never drinkers (had never drunk alcohol at baseline), former drinkers (no alcohol in previous year but had drunk in the past), light drinkers (<7 drinks/week for men and <4 drinks/week for women), moderate drinkers (7–14 drinks/week for men and 4–7 drinks/week for

women), and at-risk drinkers (>14 drinks/week for men and >7 drinks/week for women). The at-risk drinking category represents a threshold defined by the NIAAA (31) and corresponds to a level at which health and mortality risks tend to be elevated (32) even when abuse/dependence is not present. We are unable to assess alcohol abuse, because the CARDIA Study examination did not include questions regarding consequences relating to alcohol (e.g., legal issues, job loss, and so on).

Hypertension

At each examination, after a 5-minute rest, blood pressure was measured on the seated participant's right arm using a Hawksley random zero sphygmomanometer (W. A. Baum Company, Copiague, New York). Three measurements were taken at 1-minute intervals. Systolic and diastolic pressures were recorded as phase I and phase V Korotkoff sounds. The average of the second and third measurements was the pressure of record. We defined hypertension, consistent with the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7), as systolic blood pressure ≥ 140 mm Hg, diastolic blood pressure ≥ 90 mm Hg, or taking antihypertensive medication at that examination (33). We defined incident hypertension at the first follow-up examination at which a participant met at least 1 of the above 3 criteria.

Covariates

To adjust for potential confounding, we included traditional risk factors associated with developing hypertension as well as socioeconomic variables. We included age, gender, race, baseline body mass index (normal weight, <25 kg/m²; overweight, $25\text{--}<30$ kg/m²; or obese, ≥ 30 kg/m²), physical activity (low, moderate, or high based on tertiles of activity) (34), smoking status (never, past, or current smokers), and family history of hypertension. Socioeconomic variables included the highest educational attainment (< high school, high school or graduate equivalency degree, some college, college graduate, or graduate degree); household income (<\$16,000, \$16,000–\$24,999, \$25,000–\$49,999, \$50,000–\$74,999, \$75,000–\$99,999, or \geq \$100,000); difficulty paying for basics such as food and heating (categorized into very hard, hard, or somewhat hard vs. not very hard); and difficulty paying for medical care (categorized into very hard, hard, or somewhat hard vs. not very hard). We used socioeconomic variables from the year 20 examination, because many participants were college age at baseline when income and education variables do not truly represent a person's socioeconomic status (35).

Statistical analyses

Analyses to estimate the incidence of hypertension included 4,711 individuals after excluding 1 participant without baseline blood pressure measurement, 198 participants with hypertension at baseline, 188 participants without at least 1 follow-up blood pressure measurement, and 17 participants without reported baseline alcohol consumption.

We performed bivariate analyses to examine associations between baseline alcohol consumption and incident hypertension, as well as associations between potential confounders and incident hypertension. Covariates were included in the multivariable models based on the finding of a significant association (2-sided $P < 0.05$) with hypertension in bivariate analyses. We used Cox proportional hazards with incident hypertension as “failure” to assess the association between incident hypertension and categories of alcohol consumption, with never drinkers as referent. We constructed a series of models starting with an unadjusted model, then adding traditional risk factors (age, gender, race, body mass index, physical activity score, smoking status, and family history of hypertension), and then adding socioeconomic factors (education, income, and difficulty paying for basics and medical care). To examine whether potential associations between alcohol and hypertension differed among race-sex groups, we also conducted race-sex-stratified analyses.

RESULTS

The study sample of 4,711 included 2,362 African-American participants (50.1%) and 2,596 (55.1%) women. There were fewer women in higher alcohol consumption categories (Table 1). A large proportion (78.6%) of never drinkers were African American, and most moderate (58.3%) and at-risk (63.2%) drinkers were European American. Generally, exercise and smoking increased with increased drinking. Obesity and family history of hypertension tended to decrease with increased drinking status. Light and moderate drinkers had the highest proportions of college and graduate degrees and the lowest proportions of people with annual incomes of less than \$50,000 and difficulty paying for basics and medical care. Baseline data stratified by gender are available in Web Table 1. (This information is described in the first of 3 supplementary tables; each is referred to as “Web table” in the text and is posted on the *Journal's* website (<http://aje.oxfordjournals.org/>).) Few men (15%) and fewer women (3.2%) drank more than 2 glasses of alcohol per day. The type of alcohol consumed per day is available online in Web Table 2.

More African-American than European-American participants developed hypertension (Table 2). Participants who developed hypertension, on average, were older, had higher body mass indexes, smoked more, exercised less, had a family history of hypertension, had lower educational attainment, had less annual household income, and had more difficulty paying for basics and medical care. Former drinkers (those who had drunk in the past but not in the previous 12 months) had the highest incident hypertension, 31.8%, and at-risk drinkers had the lowest incident hypertension, 18.8%. The proportion of individuals developing hypertension according to the amount and type of alcohol consumed (beer, wine, or liquor) is available online in Web Table 2.

In the overall unadjusted Cox proportional hazards model, compared with never drinking, light drinking and at-risk drinking were associated with lower risk of incident

hypertension (hazard ratios (HRs) = 0.79 (95% confidence interval (CI): 0.64, 0.98) and 0.74 (95% CI: 0.56, 0.97), respectively). There were no significant associations between alcohol consumption and hypertension in men. African-American women who were former drinkers had a higher risk of incident hypertension (HR = 2.03, 95% CI: 1.36, 3.04), and European-American women who were at-risk drinkers had a lower risk of incident hypertension (HR = 0.33, 95% CI: 0.15, 0.75). In multivariable models, baseline alcohol consumption was not associated with incident hypertension overall, in men or African-American women. European-American women who reported current drinking, at any level, were at lower risk of incident hypertension (Table 3). Traditional risk factors, specifically older age, male gender, African-American race, family history of hypertension, and body mass index, were associated with incident hypertension. Household income, difficulty paying for basics, and difficulty paying for medical care were not associated with incident hypertension in any group. However, lower educational attainment in European Americans was associated with increased risk of incident hypertension compared with those who obtained graduate degrees. This differed in African-American men, among whom lower educational attainment was associated with lower risk of incident hypertension compared with men who obtained graduate degrees. The risk of incident hypertension did not differ across categories of educational attainment for African-American women (Web Table 3).

Kaplan-Meier estimates of time to incident hypertension (Figure 1) show that there is no difference in the association between drinking categories and incident hypertension ($P = 0.09$).

DISCUSSION

In the CARDIA Study cohort, we found in unadjusted analysis that light and at-risk alcohol consumption at ages 18–30 years was associated with lower incident hypertension over the next 20 years compared with never drinkers. In multivariate analysis, alcohol was not associated with 20-year incident hypertension, overall; only in European-American women was the risk of incident hypertension lower in drinkers compared with never drinkers.

Our findings confirm reports that light to moderate alcohol consumption is associated with lower risk of hypertension in European-American women. In both the Nurses' Health Study II and the Women's Health Study, composed predominantly of European-American women, lower risk of hypertension was associated with drinking light to moderate amounts of alcohol. However, our findings differ from those of these 2 cohorts regarding higher rates of alcohol consumption. In the Nurses' Health Study II and the Women's Health Study, women with greater alcohol intake had a higher risk of hypertension (18, 36). In the CARDIA Study, European-American women with NIAAA-defined at-risk drinking had the lowest risk of developing hypertension. Regarding the other race-sex groups, our findings also differ, in some respects, from those of previous studies. In the Physicians'

Table 1. Baseline Characteristics of CARDIA Study Participants by Baseline Alcohol Consumption,^a 1985–1986

| | Never | Former | Light | Moderate | At Risk | Total |
|--|------------|------------|--------------|------------|------------|------------|
| <i>Categorical variables</i> | | | | | | |
| No. (% of total cohort) | 379 (8.1) | 264 (5.6) | 2,792 (59.3) | 659 (14.0) | 617 (13.1) | 4,711 |
| Women, % | 67.3 | 57.6 | 57.4 | 43.4 | 48.6 | 55.1 |
| African American, % | 78.6 | 53.0 | 50.9 | 41.7 | 36.8 | 50.1 |
| Body mass index, % | | | | | | |
| Normal weight | 62.4 | 56.1 | 67.7 | 65.7 | 67.5 | 66.3 |
| Overweight | 19.2 | 26.7 | 21.8 | 24.3 | 24.1 | 22.5 |
| Obese | 18.4 | 17.2 | 10.5 | 10.0 | 8.5 | 11.2 |
| Physical activity, % | | | | | | |
| Low | 67.7 | 65.5 | 59.2 | 51.8 | 49.1 | 57.9 |
| Moderate | 21.4 | 26.5 | 27.3 | 30.5 | 30.3 | 27.6 |
| High | 10.9 | 8.0 | 13.5 | 17.8 | 20.6 | 14.5 |
| Smoking status, % | | | | | | |
| Never | 84.1 | 59.2 | 60.9 | 43.8 | 31.8 | 56.5 |
| Current | 11.4 | 19.5 | 26.8 | 38.3 | 52.2 | 30.0 |
| Past | 4.5 | 21.4 | 12.4 | 18.0 | 16.0 | 13.5 |
| Family history of hypertension, % | 67.6 | 66.7 | 62.4 | 59.0 | 60.5 | 62.3 |
| Education, % ^b | | | | | | |
| <High school | 2.7 | 4.1 | 2.2 | 4.4 | 5.4 | 3.1 |
| High school | 47.0 | 39.2 | 34.2 | 35.1 | 36.7 | 36.0 |
| Some college | 13.4 | 14.6 | 12.3 | 9.6 | 12.0 | 12.1 |
| College graduate | 24.1 | 22.2 | 31.0 | 30.5 | 29.3 | 29.7 |
| Graduate degree | 13.0 | 19.9 | 20.3 | 20.5 | 16.6 | 19.3 |
| Household income, % ^b | | | | | | |
| <\$16,000 | 15.3 | 13.0 | 8.5 | 9.7 | 13.1 | 10.0 |
| \$16,000–\$24,999 | 5.7 | 5.7 | 4.9 | 5.3 | 6.4 | 5.2 |
| \$25,000–\$49,999 | 27.1 | 24.3 | 18.8 | 16.5 | 20.4 | 19.6 |
| \$50,000–\$74,999 | 17.6 | 22.6 | 20.3 | 17.1 | 16.1 | 19.2 |
| \$75,000–\$99,999 | 17.2 | 14.7 | 17.0 | 16.2 | 10.3 | 15.9 |
| ≥\$100,000 | 17.2 | 19.8 | 30.5 | 35.2 | 33.7 | 30.0 |
| Difficulty paying for the following, % | | | | | | |
| Basics | 32.5 | 27.5 | 23.4 | 24.0 | 27.6 | 24.9 |
| Medical care | 31.5 | 30.3 | 25.9 | 25.6 | 29.5 | 27.0 |
| <i>Continuous variables</i> | | | | | | |
| Age, years (mean (SD)) | 22.8 (3.8) | 25.5 (3.6) | 24.7 (3.7) | 25.4 (3.3) | 25.4 (3.3) | 24.8 (3.7) |
| Body mass index, kg/m ² (mean (SD)) | 24.8 (5.7) | 25.7 (6.0) | 24.3 (4.9) | 24.3 (4.4) | 24.0 (4.2) | 24.4 (4.9) |

Abbreviations: CARDIA, Coronary Artery Risk Development in Young Adults; SD, standard deviation.

^a National Institute on Alcohol Abuse and Alcoholism drinking categories: never drinkers (had never drunk alcohol); former drinkers (no alcohol in previous year but had drunk in the past); light drinkers (<7 drinks/week for men and <4 drinks/week for women); moderate drinkers (7–14 drinks/week for men and 4–7 drinks/week for women); and at-risk drinkers (>14 drinks/week for men and >7 drinks/week for women).

^b At year 20.

Health Study, the predominantly European-American men also had higher risk of hypertension if they drank more than 5 drinks per week, and there was no association with incident hypertension in men who drank less (36). In the CARDIA

Study, the association with higher levels of drinking was not present. Different from the participants with relatively high socioeconomic status in the Nurses' Health Study II, Women's Health Study, and Physicians' Health Study,

Table 2. Baseline Characteristics of 4,711 CARDIA Study Participants by Incident Hypertension Over 20 Years, 1985–2006

| | Total No. | Developed Hypertension, % | Did Not Develop Hypertension, % | P Value ^a |
|--|------------|---------------------------|---------------------------------|----------------------|
| <i>Categorical variables</i> | | | | |
| No. | 4,711 | 21.7 | 78.3 | |
| Women | 2,596 | 21.2 | 78.8 | 0.35 |
| African American | 2,362 | 29.3 | 70.7 | <0.0001 |
| Physical activity | | | | <0.0001 |
| Low | 2,726 | 24.0 | 76.0 | |
| Moderate | 1,300 | 19.2 | 80.9 | |
| High | 684 | 17.7 | 82.3 | |
| Smoking status | | | | 0.03 |
| None | 2,643 | 22.0 | 78.0 | |
| Past | 631 | 17.8 | 82.3 | |
| Current | 1,406 | 23.0 | 77.0 | |
| Family history of hypertension | 2,277 | 27.9 | 72.1 | <0.0001 |
| Education ^b | | | | <0.0001 |
| <High school | 98 | 36.7 | 63.3 | |
| High school | 1,156 | 31.9 | 68.1 | |
| Some college | 388 | 33.5 | 66.5 | |
| College graduate | 954 | 17.3 | 82.7 | |
| Graduate degree | 619 | 17.6 | 82.4 | |
| Household income ^b | | | | <0.0001 |
| <\$16,000 | 337 | 38.3 | 61.7 | |
| \$16,000–\$24,999 | 175 | 32.6 | 67.4 | |
| \$25,000–\$49,999 | 657 | 28.8 | 71.2 | |
| \$50,000–\$74,999 | 643 | 26.4 | 73.6 | |
| \$75,000–\$99,999 | 533 | 23.8 | 76.3 | |
| ≥\$100,000 | 1,003 | 17.0 | 83.1 | |
| Difficulty paying for the following ^b | | | | |
| Basics | 845 | 33.4 | 66.6 | <0.0001 |
| Medical care | 913 | 30.1 | 69.9 | <0.0001 |
| Drinking status | | | | <0.0001 |
| Never | 379 | 25.1 | 74.9 | |
| Former | 264 | 31.8 | 68.2 | |
| Light | 2,792 | 20.9 | 79.1 | |
| Moderate | 659 | 22.2 | 77.9 | |
| At risk | 617 | 18.8 | 81.2 | |
| <i>Continuous variables</i> | | | | |
| Age, years (mean (SD)) | 24.8 (3.7) | 25.5 (3.6) | 24.6 (3.6) | <0.0001 |
| Body mass index, kg/m ² (mean (SD)) | 24.4 (4.9) | 26.6 (6.1) | 23.7 (4.3) | <0.0001 |
| Drinks per day, no. (mean (SD)) | 0.69 (1.3) | 0.66 (1.2) | 0.70 (1.3) | 0.46 |

Abbreviations: CARDIA, Coronary Artery Risk Development in Young Adults; SD, standard deviation.

^a Comparing participants who developed hypertension with those who had not.

^b At year 20.

Table 3. Hazard Ratios and 95% Confidence Intervals for 20-Year Incidence of Hypertension With Alcohol Consumption Modeled in NIAAA Categories, the CARDIA Study, 1985–2006

| Drinking Status ^a | Total | | African-American Women | | European-American Women | | African-American Men | | European-American Men | |
|------------------------------|--------------|-------------------------|------------------------|-------------------------|-------------------------|-------------------------|----------------------|-------------------------|-----------------------|-------------------------|
| | Hazard Ratio | 95% Confidence Interval | Hazard Ratio | 95% Confidence Interval | Hazard Ratio | 95% Confidence Interval | Hazard Ratio | 95% Confidence Interval | Hazard Ratio | 95% Confidence Interval |
| <i>Model 1^b</i> | | | | | | | | | | |
| Former | 1.15 | 0.83, 1.59 | 1.27 | 0.79, 2.02 | 0.59 | 0.23, 1.53 | 0.90 | 0.43, 1.90 | 2.75 | 0.80, 9.47 |
| Light | 0.82 | 0.65, 1.04 | 0.82 | 0.60, 1.12 | 0.47 | 0.23, 0.95 | 0.96 | 0.61, 1.53 | 1.46 | 0.46, 4.67 |
| Moderate | 0.83 | 0.62, 1.12 | 0.97 | 0.62, 1.50 | 0.36 | 0.14, 0.91 | 0.96 | 0.55, 1.71 | 1.46 | 0.44, 4.81 |
| At risk | 0.82 | 0.60, 1.12 | 0.72 | 0.43, 1.21 | 0.25 | 0.10, 0.65 | 1.33 | 0.76, 2.32 | 1.47 | 0.44, 4.96 |
| <i>Model 2^c</i> | | | | | | | | | | |
| Former | 1.07 | 0.74, 1.54 | 1.27 | 0.69, 2.02 | 0.59 | 0.23, 1.53 | 0.66 | 0.26, 1.66 | 2.75 | 0.80, 9.47 |
| Light | 0.77 | 0.60, 1.00 | 0.82 | 0.60, 1.12 | 0.47 | 0.23, 0.95 | 0.90 | 0.52, 1.54 | 1.46 | 0.46, 4.67 |
| Moderate | 0.82 | 0.59, 1.13 | 0.97 | 0.62, 1.50 | 0.36 | 0.14, 0.91 | 0.98 | 0.51, 1.90 | 1.46 | 0.44, 4.81 |
| At risk | 0.76 | 0.54, 1.07 | 0.72 | 0.43, 1.21 | 0.25 | 0.10, 0.65 | 1.12 | 0.57, 2.23 | 1.47 | 0.44, 4.96 |

Abbreviations: CARDIA, Coronary Artery Risk Development in Young Adults; NIAAA, National Institute on Alcohol Abuse and Alcoholism.

^a Reference category: never.

^b Model 1: adjusted for age and family history of hypertension, plus body mass index (continuous) and smoking status. Total column, also adjusted for race and gender.

^c Model 2: adjusted as in model 1 plus education, income, difficulty paying for basics, and difficulty paying for medical care.

participants in the Atherosclerosis Risk in Community (ARIC) Study were 15% African American, and 60% had a high school education or less. In the ARIC Study, alcohol consumption was not associated with incident hypertension except in African-American men, who were at higher risk of hypertension if they drank any alcohol (26). No similar association emerged in the analysis of CARDIA Study data.

Naimi et al. (37) suggest one plausible explanation for the disparate findings across studies, but our data do not shed conclusive light on this matter. Using the 2003 Behavioral Risk Factor Surveillance System survey, they identified 30 cardiovascular risk factors or confounders divided into 5

domains: demographic factors, social factors, behavioral factors, health access, and health conditions. In adjusted multivariable models, they found that 27 of 30 (90%) adverse risk factors or confounders were significantly more prevalent in nondrinkers than in moderate drinkers. In their study, being older, being nonwhite, having less education and income, lacking access to health care or preventive services, and having comorbid health conditions were all associated with being a nondrinker. The Nurses' Health Study II, the Women's Health Study, and the Physicians' Health Study controlled for traditional hypertension risk factors such as age, body mass index, and physical activity, but they did not control for social factors such as income or education. The ARIC Study adjusted for education and found no association between alcohol and hypertension.

In our CARDIA Study, education was an independent predictor of hypertension among 3 of the 4 race-sex groups. However, the introduction of 4 socioeconomic variables tied to income and education did not materially alter the pattern of associations that we found. Given discrepant associations among the major cohorts studied to date, we speculate that there remains significant risk of residual confounding, including in the CARDIA Study. Alternatively, it may be the case that any alcohol-hypertension association is modified by characteristics that differ across the cohorts assembled to date, including geographic locale, urbanicity, or unmeasured aspects of socioeconomic status.

We caution readers to be mindful of limitations to this study. The CARDIA Study cohort includes only African Americans and European Americans, so findings may not be generalizable to other racial/ethnic groups. Although the CARDIA Study cohort is the largest longitudinal cohort of young adults in the United States, it still started with only 5,115 individuals, resulting in limited power to detect

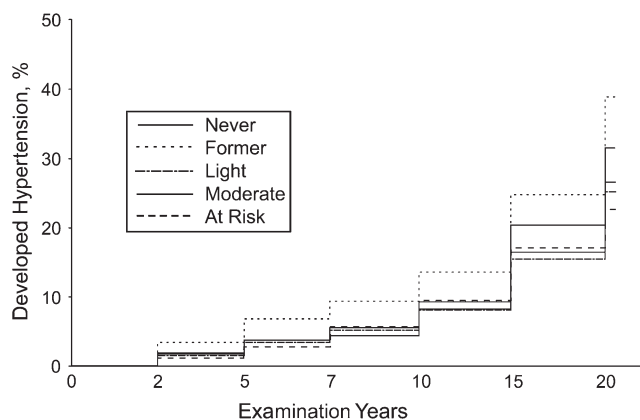


Figure 1. Kaplan-Meier estimates of time to incident hypertension by drinking category, the Coronary Artery Risk Development in Young Adults (CARDIA) Study, 1985–2006 (a longitudinal cohort of African-American and European-American men and women from Birmingham, Alabama; Chicago, Illinois; Minneapolis, Minnesota; and Oakland, California). Two-sided $P = 0.09$.

modest but possibly clinically important differences, especially in stratified subgroup analyses. Because hypertension was based on blood pressure readings and medication from individual examination days, we may have over- or underestimated prevalent hypertension at baseline or incident hypertension during follow-up. As is the case for nearly all large longitudinal cohorts, the study relied on self-reported alcohol intake and did not include either biologic measures (which capture only recent use), indicators of alcohol abuse (e.g., alcohol-related traffic violations or job loss), or reasons that former drinkers stopped drinking. Additionally, we were not able to examine higher alcohol cutpoints, because of the small number of CARDIA Study participants, especially women, in higher drinking categories.

In the biracial and socioeconomically diverse CARDIA Study, we found that alcohol consumption was associated with lower risk of incident hypertension in European-American women only and that there was no similar association in the other race-sex groups. Our data are not definitive on the question of unmeasured confounders, but they reinforce the unsettled nature of the hypothesized association between alcohol and blood pressure. Future observational studies examining the relation between alcohol intake and health outcomes should continue to include social factors, such as income, education, and access to health care, and consider additional characteristics that may modify or confound potential associations between alcohol and blood pressure.

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