Ethnic Differences in Hypertension Incidence Among Middle-Aged and Older Adults
The Multi-Ethnic Study of Atherosclerosis

April P. Carson, George Howard, Gregory L. Burke, Steven Shea, Emily B. Levitan, Paul Muntner

Abstract—The prevalence of hypertension is higher among blacks than whites. However, inconsistent findings have been reported on the incidence of hypertension among middle-aged and older blacks and whites, and limited data are available on the incidence of hypertension among Hispanics and Asians in the United States. Therefore, this study investigated the age-specific incidence of hypertension by ethnicity for 3146 participants from the Multi-Ethnic Study of Atherosclerosis. Participants, age 45 to 84 years at baseline, were followed for a median of 4.8 years for incident hypertension, defined as systolic blood pressure ≥140 mm Hg, diastolic blood pressure ≥90 mm Hg, or the initiation of antihypertensive medications. The crude incidence rate of hypertension, per 1000 person-years, was 56.8 for whites, 84.9 for blacks, 65.7 for Hispanics, and 52.2 for Chinese. After adjustment for age, sex, and study site, the incidence rate ratio (IRR) for hypertension was increased for blacks age 45 to 54 (IRR: 2.05 [95% CI: 1.47 to 2.85]), 55 to 64 (IRR: 1.63 [95% CI: 1.20 to 2.23]), and 65 to 74 years (IRR: 1.67 [95% CI: 1.21 to 2.30]) compared with whites but not for those 75 to 84 years of age (IRR: 0.97 [95% CI: 0.56 to 1.66]). Additional adjustment for health characteristics attenuated these associations. Hispanic participants also had a higher incidence of hypertension compared with whites; however, hypertension incidence did not differ for Chinese and white participants. In summary, hypertension incidence was higher for blacks compared with whites between 45 and 74 years of age but not after age 75 years. Public health prevention programs tailored to middle-aged and older adults are needed to eliminate ethnic disparities in incident hypertension. (Hypertension. 2011;57:1101-1107.)

Key Words: hypertension ■ race/ethnicity ■ epidemiology ■ incidence

Hypertension affects approximately one third of adults in the United States and is a major risk factor for cardiovascular disease morbidity and mortality.1 The prevalence of hypertension increases with age and is higher among blacks compared with whites and Hispanics at all ages.2,3 Previous data suggest that blacks have higher blood pressure levels than whites beginning in childhood.4,5 In addition, studies of young adults have consistently found a higher incidence of hypertension among blacks compared with whites.6,7 However, inconsistent data have been reported on incident hypertension for blacks compared with whites in middle-aged and older adulthood. In the National Health and Nutrition Examination Survey I Follow-Up Study, the incidence of hypertension over 9.5 years of follow-up was similar among black and white participants aged ≥55 years at baseline.7 A study of adults ages 30 to 54 years at baseline also reported a similar incidence of hypertension among blacks and whites over a 7-year follow-up period.8 Conversely, in a study of adults ages 45 to 64 years at baseline, blacks had a higher incidence of hypertension compared with whites over 3 years of follow-up.9

Data investigating hypertension among other ethnicities are limited, with previous studies primarily assessing prevalent hypertension. Several studies have reported a similar prevalence of hypertension among Hispanics and whites;2,10,11 whereas others have reported a lower hypertension prevalence for Hispanics compared with whites.12,13 Also, Asians have been reported to have a similar prevalence of hypertension as whites.14 However, in some studies, a lower prevalence of hypertension has been reported for Chinese and Japanese ethnic groups compared with whites.15,16 Little information is available for incident hypertension among Hispanics and Asians in the United States. In the San Antonio Heart Study, the overall incidence of hypertension was similar among Mexican-Americans and non-Hispanic whites over 8 years of follow-up.17 However, in analyses stratified by age, the incidence of hypertension in the oldest age group, 55 to 64 years, was higher among Mexican-Americans compared with non-Hispanic whites for both men and women.17

Given the limited published data, it remains unclear whether ethnic disparities in the incidence of hypertension are...
present among middle-aged and older adults in the United States. Therefore, we analyzed data on the incidence of hypertension among blacks, Chinese, Hispanic, and white participants from the Multi-Ethnic Study of Atherosclerosis (MESA), a population-based cohort study of men and women ages 45 to 84 years at baseline from 6 communities in the United States.

Methods

Study Design and Population
MESA is a prospective, population-based cohort study designed to investigate the characteristics of subclinical atherosclerosis and the risk factors for progression of subclinical disease to clinical cardiovascular disease among multiple ethnic groups. The study recruited 6814 men and women, ages 45 to 84 years at baseline without a history of clinical cardiovascular disease, from 6 communities in the United States: Baltimore, Maryland; Chicago, Illinois; Forsyth County, North Carolina; Los Angeles County, California; New York, New York; and St Paul, Minnesota. Participants completed a baseline examination in 2000–2002 and subsequent examinations in 2002–2004 (examination 2), 2004–2005 (examination 3), and 2005–2007 (examination 4). Between examinations, participants were contacted to ascertain the occurrence of any medical events or changes in health status. The study design and objectives have been published previously. The study was approved by the institutional review board at each participating site, and participants provided written informed consent.

For the current analysis, participants with prevalent hypertension at baseline (n=3507), defined as systolic blood pressure (SBP) ≥140 mm Hg, diastolic blood pressure (DBP) ≥90 mm Hg, current antihypertensive medication use, or a self-reported previous diagnosis of hypertension were excluded. Also, participants without blood pressure measurements at baseline (n=1) and those who did not attend a MESA follow-up examination (n=160) were excluded, resulting in a sample size of 3146 participants for these analyses.

Ascertainment of Ethnicity
Participants self-reported ethnicity as white, blacks, Asian (primarily of Chinese descent), or Hispanic based on questions adapted from the 2000 US Census. Approximately 38% of the recruited participants were white, 28% black, 12% Chinese, and 22% Hispanic. White participants were recruited from all of the study sites. Black participants were recruited from all of the study sites except St Paul. Chinese participants were recruited from Chicago and Los Angeles. Hispanic participants were recruited from St Paul, New York, and Los Angeles.

Ascertainment of Incident Hypertension
SBP and DBP were measured at each MESA examination following standardized protocols. Briefly, after resting for 5 minutes in the seated position, blood pressure was measured 3 times at 2-minute intervals using an appropriate-sized cuff and an automated oscillometric device (Dinamap Monitor Pro 100, GE Healthcare, Milwaukee, WI), with the average of the second and third measurements used to determine SBP and DBP. In addition, MESA participants were asked to bring all medication to each examination, where drug names and doses were abstracted from medication bottles. Incident hypertension was defined as the first study visit, subsequent to baseline, at which the participant had SBP ≥140 mm Hg and/or DBP ≥90 mm Hg and/or had initiated treatment with antihypertensive medications.

Ascertainment of Covariates
Information on sociodemographic factors (age, sex, and education), and lifestyle factors (alcohol consumption and smoking status) was collected at the baseline examination using standardized questionnaires. Body mass index was calculated as weight in kilograms divided by height in meters squared. Depressive symptoms were assessed using self-reported responses to the 20-item Center for Epidemiologic Studies Depression Scale, with higher scores indicative of more depressive symptoms. Dietary information was obtained from a self-administered 120-item block food frequency questionnaire that was modified to include ethnic- and geographic-specific foods and used to obtain sodium/potassium (Na/K) intake adjusted for total energy intake. Participants fasted for 12 hours before each MESA examination for the collection of fasting blood samples. Diabetes mellitus was defined as fasting glucose ≥126 mg/dL, or use of hypoglycemic medication. Estimated glomerular filtration rate was calculated using the Modification of Diet in Renal Disease equation. Parental history of hypertension at examination 2 was self-reported and used in these analyses because it was not collected at baseline.

Statistical Analyses
Baseline characteristics of MESA participants were calculated overall and by ethnicity using means or frequencies, as appropriate. The crude incidence rates of hypertension were calculated among whites, blacks, Chinese, and Hispanics, separately. Follow-up time for participants who developed hypertension was calculated as the number of years between their baseline examination and the first examination when incident hypertension criteria were fulfilled. Follow-up time for participants who did not develop hypertension was calculated as the number of years between their baseline examination and examination 4 or the last study examination completed for those who did not attend examination 4 (ie, examination 2 for 82 participants and examination 3 for 107 participants). Crude incidence rates were also calculated for each ethnic group stratified by baseline age (45 to 54, 55 to 64, 65 to 74, and 75 to 84 years).

Poisson regression models were used to calculate incidence rate ratios (IRRs) for hypertension for blacks, Chinese, and Hispanics, separately, versus whites. An initial model included adjustment for age (continuous), sex, and MESA study site. The next model included additional adjustment for education (less than high school, high school graduate, or greater than high school), body mass index (continuous), smoking status (current, former, or never), alcohol consumption (current, former, or never), Center for Epidemiologic Studies Depression score, quintile of Na/K ratio, diabetes mellitus, estimated glomerular filtration rate <60 mL/min per 1.73 m², and parental history of hypertension (both parents, 1 parent, or none). The final model included additional adjustment for baseline SBP and DBP modeled as continuous variables. In the multivariable models, 311 participants were excluded for missing covariate values, primarily Na/K information (n=256). Effect modification by age, sex, and education were evaluated, with age being the only statistically significant effect modifier using an a priori cutpoint of P<0.10. Therefore, age-stratified (45 to 54, 55 to 64, 65 to 74, and 75 to 84 years) IRRs were calculated adjusting for the variables used in the previous models. Poisson regression models including linear, quadratic, and cubic age terms and sex were used to obtain age-specific IRRs for hypertension comparing blacks, Chinese, and Hispanic participants, separately, with whites. Also, the practical incidence estimators macro approach was used to obtain the lifetime risk (cumulative incidence through age 85 years) of hypertension, by ethnicity, adjusting for the competing risk of death. All of the statistical analyses were conducted using SAS 9.2 (SAS Institute, Cary, NC).

Results
Participant sociodemographic and health characteristics at baseline are presented, overall and by ethnicity, in Table 1. The mean age of participants was 58.6 years, 52.1% of the participants were women, and the ethnicity of participants included in these analyses was 43% white, 20% black, 14% Chinese, and 23% Hispanic. A higher proportion of Chinese and Hispanic participants reported less than a high school education. Blacks had the highest proportion of current smokers (22.2%) whereas white participants had the highest...
Table 1. Baseline Participant Characteristics, Overall and by Ethnicity, the Multi-Ethnic Study of Atherosclerosis (2000–2002)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total (n=3146)</th>
<th>White (n=1358)</th>
<th>Black (n=630)</th>
<th>Chinese (n=424)</th>
<th>Hispanic (n=734)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (SD), y</td>
<td>58.6 (9.7)</td>
<td>59.6 (9.8)</td>
<td>57.9 (9.7)</td>
<td>58.8 (9.5)</td>
<td>57.5 (9.6)</td>
</tr>
<tr>
<td>Women, n (%)</td>
<td>1638 (51.2)</td>
<td>720 (53.0)</td>
<td>338 (53.7)</td>
<td>218 (51.4)</td>
<td>362 (49.3)</td>
</tr>
<tr>
<td>Less than high school education, n (%)</td>
<td>453 (14.4)</td>
<td>40 (3.0)</td>
<td>49 (7.8)</td>
<td>89 (21.0)</td>
<td>275 (37.5)</td>
</tr>
<tr>
<td>Current smoker, n (%)</td>
<td>465 (14.8)</td>
<td>175 (12.9)</td>
<td>140 (22.2)</td>
<td>25 (5.9)</td>
<td>125 (17.0)</td>
</tr>
<tr>
<td>Current alcohol consumption, n (%)</td>
<td>1903 (60.5)</td>
<td>1022 (75.3)</td>
<td>357 (56.7)</td>
<td>140 (33.0)</td>
<td>384 (52.3)</td>
</tr>
<tr>
<td>Mean BMI (SD), kg/m²</td>
<td>27.3 (5.1)</td>
<td>26.7 (4.6)</td>
<td>29.1 (5.7)</td>
<td>23.5 (3.1)</td>
<td>28.9 (5.0)</td>
</tr>
</tbody>
</table>

Table 2. Incidence Rates and Adjusted Incidence Rate Ratios (95% CI) for Hypertension

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Crude Incidence Rate per 1000 Person-Years</th>
<th>Adjusted Incidence Rate Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
</tr>
<tr>
<td>White</td>
<td>56.8</td>
<td>1.00 (reference)</td>
</tr>
<tr>
<td>Black</td>
<td>84.9</td>
<td>1.65 (1.39 to 1.96)</td>
</tr>
<tr>
<td>Chinese</td>
<td>52.2</td>
<td>1.05 (0.81 to 1.35)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>65.7</td>
<td>1.29 (1.06 to 1.57)</td>
</tr>
</tbody>
</table>

Model 1 was adjusted for age, sex, and Multi-Ethnic Study of Atherosclerosis site. Model 2 adjusted for variables in model 1 plus education, body mass index, smoking status, alcohol consumption, depressive symptoms, Na/K ratio, diabetes mellitus, estimated glomerular filtration rate <60 mL/min per 1.73 m², and parental history of hypertension. Model 3 adjusted for variables in models 1 and 2 plus baseline systolic blood pressure and diastolic blood pressure.
adjustment for age, sex, and MESA study site. Adjustment for baseline SBP and DBP attenuated these associations. Similarly, blacks ages 55 to 64 years and 65 to 74 years had higher IRRs for hypertension compared with whites after adjustment for age, sex, and MESA study site that were attenuated after additional multivariable adjustment, including baseline SBP and DBP. In contrast, in the group aged 75 to 84 years, the age-, sex-, and MESA study site–adjusted IRRs for blacks and Hispanics were similar to white participants. Chinese participants in the group aged 75 to 84 years had the highest incidence of hypertension, but this was not statistically significant compared with whites.

The estimated lifetime risk of hypertension, conditional on being free of hypertension at age 45 years, is presented by ethnicity in Figure 2. The lifetime risk of hypertension increased for all ethnicities with age. At all ages, blacks were more likely to be hypertensive than participants of other ethnic groups. For a 45-year-old adult without hypertension, 

Figure 1. Age-specific incidence rate ratios for hypertension for black, Chinese, and Hispanic participants compared with white participants. Models include adjustment for sex. Solid lines represent incidence rate ratios, and dashed lines represent 95% CIs.

Table 3. Incidence Rates and Adjusted Incidence Rate Ratios (95% CI) for Hypertension by Ethnicity and Age Group

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>No. of Participants</th>
<th>Crude Incidence Rate per 1000 Person-Years</th>
<th>Adjusted Incidence Rate Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Model 1</td>
</tr>
<tr>
<td>Age 45 to 54 y</td>
<td></td>
<td></td>
<td>Model 1</td>
</tr>
<tr>
<td>White</td>
<td>508</td>
<td>32.7</td>
<td>1.00 (reference)</td>
</tr>
<tr>
<td>Black</td>
<td>287</td>
<td>64.7</td>
<td>2.05 (1.47 to 2.85)</td>
</tr>
<tr>
<td>Chinese</td>
<td>166</td>
<td>28.6</td>
<td>0.99 (0.58 to 1.68)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>335</td>
<td>43.7</td>
<td>1.30 (0.91 to 1.88)</td>
</tr>
<tr>
<td>Age 55 to 64 y</td>
<td></td>
<td></td>
<td>Model 1</td>
</tr>
<tr>
<td>White</td>
<td>409</td>
<td>59.1</td>
<td>1.00 (reference)</td>
</tr>
<tr>
<td>Black</td>
<td>177</td>
<td>91.1</td>
<td>1.63 (1.20 to 2.23)</td>
</tr>
<tr>
<td>Chinese</td>
<td>130</td>
<td>57.7</td>
<td>1.07 (0.69 to 1.64)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>217</td>
<td>67.3</td>
<td>1.18 (0.83 to 1.68)</td>
</tr>
<tr>
<td>Age 65 to 74 y</td>
<td></td>
<td></td>
<td>Model 1</td>
</tr>
<tr>
<td>White</td>
<td>320</td>
<td>73.6</td>
<td>1.00 (reference)</td>
</tr>
<tr>
<td>Black</td>
<td>120</td>
<td>117.6</td>
<td>1.67 (1.21 to 2.30)</td>
</tr>
<tr>
<td>Chinese</td>
<td>100</td>
<td>68.9</td>
<td>0.95 (0.60 to 1.51)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>132</td>
<td>102.5</td>
<td>1.44 (0.99 to 2.11)</td>
</tr>
<tr>
<td>Age 75 to 84 y</td>
<td></td>
<td></td>
<td>Model 1</td>
</tr>
<tr>
<td>White</td>
<td>121</td>
<td>113.4</td>
<td>1.00 (reference)</td>
</tr>
<tr>
<td>Black</td>
<td>46</td>
<td>109.8</td>
<td>0.97 (0.56 to 1.66)</td>
</tr>
<tr>
<td>Chinese</td>
<td>28</td>
<td>131.1</td>
<td>1.40 (0.72 to 2.73)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>50</td>
<td>125.9</td>
<td>1.27 (0.73 to 2.02)</td>
</tr>
</tbody>
</table>

Model 1 was adjusted for age, sex, and Multi-Ethnic Study of Atherosclerosis site. Model 2 adjusted for variables in model 1 plus education, body mass index, smoking status, alcohol consumption, depressive symptoms, Na/K ratio, diabetes mellitus, estimated glomerular filtration rate < 60 mL/min per 1.73 m², and parental history of hypertension. Model 3 adjusted for variables in models 1 and 2 plus baseline systolic blood pressure and diastolic blood pressure.
percentages were the incidences of hypertension among black men and women compared with whites over a 10-year follow-up period. In baseline, blacks had a higher incidence of hypertension compared with white adults at all ages has been well established, but less is known about the incidence of hypertension in middle-aged and older adulthood, highlighting the importance of concerted prevention efforts throughout adulthood.

A higher prevalence of hypertension among blacks compared with white adults at all ages has been well established, but less is known about the incidence of hypertension. Several studies among young adults have reported higher hypertension incidence rates for blacks compared with whites in middle age but similar at older ages. Although the lifetime risk of hypertension increased with advancing age for all ethnicities, it was highest for blacks and Hispanics throughout middle-aged and older adulthood, highlighting the importance of concerted prevention efforts throughout adulthood.

In this multiethnic study of middle-aged and older adults, the incidence of hypertension was higher for blacks compared with whites between 45 to 74 years of age but similar in these 2 groups after age 75 years. The incidence of hypertension was also higher among Hispanics than whites in middle age but similar at older ages. Although the lifetime risk of hypertension increased with advancing age for all ethnicities, it was highest for blacks and Hispanics throughout middle-aged and older adulthood, highlighting the importance of concerted prevention efforts throughout adulthood.

In the Bogalusa Heart Study, blacks had an increased risk of hypertension compared with whites after 15 years of follow-up from childhood to young adulthood. In the Coronary Artery Risk Development in Young Adults Study, a prospective cohort study of adults age 18 to 30 years at baseline, blacks had a higher incidence of hypertension compared with whites over a 10-year follow-up period. In addition, in the National Health and Nutrition Examination Survey I Epidemiological Follow-Up Study, blacks had a higher incidence of hypertension than whites over 9.5 years of follow-up, with differences by age. At ages 25 to 34 years, the incidences of hypertension among black men and women (27.3% and 23.6%, respectively) were >2 times higher than white men and women (11.9% and 8.1%, respectively). Similar differences were also noted for the 35- to 54-year age group; however, hypertension incidence rates were similar among blacks and whites at ages ≥55 years.

In a secondary analysis of clinical trial participants ages 30 to 54 years at baseline who were followed for 7 years, the incidence of hypertension was similar for blacks and whites. Although the current study did not include participants <45 years of age, blacks in the youngest age category (45 to 54 years) had a higher incidence of hypertension compared with whites. The contrasting findings among this age group may be because of several factors, including the study populations investigated and the hypertension definitions used. In the current study, the incidence of hypertension was similar for blacks and whites.8 In the Atherosclerosis Risk in Communities Study, a prospective cohort study of adults ages 45 to 64 years at baseline, blacks had a higher overall incidence of hypertension compared with whites over 3 years of follow-up. The Atherosclerosis Risk in Communities Study used the same definition of hypertension as applied in the current study, and the higher incidence of hypertension for blacks compared with whites was present overall and within age strata (<50 years and ≥50 years) after 6 years of follow-up.

Data from some studies have indicated that Hispanics have a similar or lower prevalence of hypertension compared with whites, although a higher prevalence among Hispanics has also been reported. However, few studies have investigated incident hypertension. In the San Antonio Heart Study, the overall incidence of hypertension was similar among Mexican-Americans and non-Hispanic whites in crude and multivariable analyses. In age-specific analyses, the incidence of hypertension was higher among Mexican-Americans compared with non-Hispanic whites at ages 55 to 64 years. In contrast, Hispanics had a similar incidence of hypertension in age-specific analyses compared with whites in the San Luis Valley Diabetes Study of adults ages 20 to 74 years. In the current study, Hispanics had a higher incidence of hypertension and a higher lifetime risk for hypertension compared with whites.

The incidence of hypertension has not been well investigated among Asians in the United States, although prevalence data suggest that Asians have a similar or lower prevalence of hypertension compared with whites. In the current study, the incidence of hypertension was similar for Chinese participants and whites overall and at age <75 years. At age 75 to 84 years, Chinese participants had the highest crude incidence rate of hypertension of the 4 ethnic groups studied. After multivariable adjustment, Chinese participants had an increased risk of hypertension compared with whites, al-
though this association was not statistically significant and there was a limited sample size for this age group.

This study has several potential limitations. MESA was limited to adults ≥45 years of age, and a high percentage of participants had prevalent hypertension at the baseline examination. Although a greater proportion of blacks were excluded with prevalent hypertension at baseline, the incidence rate for hypertension was higher for blacks compared with whites at ages 45 to 74 years, and the lifetime risk for hypertension was higher among blacks through age 85 years. Also, the sample size was limited to fully investigate age-stratified associations. Additional studies with larger sample sizes are needed to evaluate ethnic differences in hypertension incidence, particularly at older ages. Lastly, acculturation factors (eg, birthplace, years in the United States) among Hispanic and Chinese participants were not investigated in the current study. Previous studies have reported differences in hypertension prevalence by birth place among Hispanics30,33 and Asians,34 so the findings from the current study may not be generalizable to Hispanic and Asian subgroups.

**Perspectives**

The findings from this study have public health implications for the prevention of cardiovascular morbidity and mortality. One of the Healthy People 2020 objectives is to reduce the proportion of adults with hypertension,35 and the American Heart Association’s 2020 goal is to increase cardiovascular health by focusing on the prevention of cardiovascular risk factors, particularly hypertension and prehypertension.36 The ethnic differences in hypertension incidence present for middle and older age adults suggest the need for developing and tailoring prevention programs for blacks and Hispanics. Lifestyle modifications can be effective in reducing blood pressure57,58 and may be one component in multifaceted population-wide and high-risk group approaches for the prevention of hypertension. The findings from this study suggest that ethnic differences in hypertension incidence occur in middle and older adulthood, and efforts to prevent incident hypertension are needed across the age spectrum. The lifetime risk for hypertension was >90% among blacks and Hispanics, underscoring the need for comprehensive prevention efforts. Additional research is needed to address the mediating factors associated with ethnic differences in incident hypertension and to develop approaches to eliminate this disparity.

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**Disclosures**

None.

**References**


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