Prevalence and Risk Factors of Prehypertension Among Chinese Adults

Dahai Yu, MS,* Jianfeng Huang, MD,* Dongsheng Hu, MD, PhD,† Jichun Chen, MS,* Jie Cao, MS,* Jianxin Li, MD,* and Dongfeng Gu, MD, PhD*

INTRODUCTION

In 2003, the Seventh Joint National Committee on the Prevention, Detection, Evaluation and Treatment of Hypertension (JNC-7) introduced prehypertension as a new category defined as systolic blood pressure (SBP) of 120 to 139 mmHg or diastolic BP (DBP) of 80 to 89 mmHg in adults aged 18 years or older.1,2 The purpose of defining prehypertension was to emphasize the risk associated with BP in this range and to focus clinical and public health attention on prevention. According to the JNC-7, individuals with prehypertension are at higher risk of developing clinical hypertension than those with lower BP levels.2 The increased risk of such patients developing clinical hypertension has been confirmed in recent reports.3–5 Moreover, prehypertension is associated with increased incidence of cardiovascular disease.6–8 Despite the importance of this new BP category, few studies to date have assessed prehypertension in the adult Chinese population. We aimed to assess the prevalence of prehypertension among Chinese adults and to illustrate the important risk factors associated with prehypertension.

METHODS

Study Population

The International Collaborative Study of Cardiovascular Disease in Asia (InterASIA) was a cross-sectional study of cardiovascular disease risk factors among residents of China and Thailand aged 35 to 74 years.9 A detailed description of the study’s methods have been described elsewhere.9,10 A nationally representative sample of Chinese residents were sampled during 2000 to 2001 by the 4-stage stratified sampling method. A total of 19,012 people were selected and invited to participate in the survey. A total of 15,838 people (7684 men and 8154 women) completed the study. The overall response rate was 83.3% and was similar between men and women and urban and rural residents. Of these participants, 15,540 (7526 men and 8154 women) completed the study. The overall response rate was 83.3% and was similar between men and women and urban and rural residents. Of these participants, 15,540 (7526 men and 8014 women) were 35 to 74 years old.11,12 All analyses were restricted to data for survey participants without a history of myocardial infarction, stroke, or congestive heart failure. Data for participants lacking data for height, weight, total cholesterol, high-density lipoprotein cholesterol (HDL-cholesterol), low-density lipoprotein cholesterol (LDL-cholesterol), triglycerides, glucose, or blood pressure were also excluded, so the population analyzed was 14,770 Chinese adults (7133 men and 7637 women). The analysis reported in this article is restricted to 10,748 adults (5050 men and 5698 women).
women) aged 35 to 74 years after excluding participants with hypertension or treated hypertension.

**Data Collection**

Data were collected in examination centers at local health stations or community clinics in the participants’ residential area. During the visits, trained research staff administered a standard questionnaire in Chinese. They obtained information on demographic characteristics, including age, sex, education, and occupation. The interview included questions related to the diagnosis and treatment of hypertension.

**Blood Pressure Measurement**

BP was measured by trained physicians or nurses with the patient sitting after having rested for at least 5 minutes. Participants were advised to avoid alcohol, cigarette smoking, coffee/tea, and exercise for at least 30 minutes before BP measurement. Three BP measurements were obtained from each participant according to a common protocol adapted from procedures recommended by the American Heart Association. A standard mercury sphygmomanometer was used, and 1 of 4 cuff sizes (pediatric, regular adult, large, or thigh) was chosen on the basis of the circumference of the participant’s arm.

**Height and Weight Measurement**

Body weight and height were measured by trained observers after a standard protocol. Weight was recorded by use of a certified double-balance-beam scale placed on a firm, level surface. Height was measured with use of a Frankfort plane positioned at a 90-degree angle against a wall-mounted metal tape. Waist circumference (WC) was measured at 1 cm above the navel under minimal respiration and hip circumference at the level of maximum extension of the buttocks. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared according to the World Health Organization (WHO) classification. Ratio of waist to hip (WHR) was calculated as WC divided by hip circumference. Overweight based on BMI and central obesity based on WC were defined by WHO classification and Asian-Pacific guidelines (Overweight is defined as BMI ≥ 25 kg/m². Central obesity is defined as circumference ≥ 90 cm in men and ≥ 80 cm in women).

**Laboratory Measurements**

A blood specimen was collected after overnight fasting into a vacuum tube containing sodium fluoride for measurement of serum glucose and lipid profiles. Blood specimens were processed at the examination center and shipped by air to a central clinical laboratory in Beijing, where the specimens were stored at –70°C for later use. Plasma glucose and lipid levels were measured by use of a modified hexokinase enzymatic method (HITACHI automatic clinical analyzer, Model 7060, Japan). Total and HDL cholesterol and serum triglycerides were analyzed enzymatically with commercially available reagents. Lipid measurements were standardized according to the criteria of the Centers for Disease Control and Prevention—National Heart, Lung, and Blood Institute Lipid Standardization Program. For participants with a triglyceride level of 400 mg/dl or higher, a second blood sample was collected and triglycerides were measured to exclude lipid contamination.

**TABLE 1. Characteristics of Normotensive and Prehypertensive Chinese Men and Women Aged 35 to 74 Years, 2000–2001**

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
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<th>Men</th>
<th>Women</th>
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<tbody>
<tr>
<td></td>
<td>Normotension</td>
<td>Prehypertension</td>
<td>P*</td>
<td>Normotension</td>
<td>Prehypertension</td>
<td>P*</td>
</tr>
<tr>
<td></td>
<td>(n = 3766)</td>
<td>(n = 1284)</td>
<td></td>
<td>(n = 4720)</td>
<td>(n = 978)</td>
<td></td>
</tr>
<tr>
<td>High school education (%)</td>
<td>20.93 (0.66)</td>
<td>25.56 (1.64)</td>
<td>0.0079</td>
<td>15.37 (0.44)</td>
<td>13.37 (1.28)</td>
<td>0.1704</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
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<tr>
<td>Professional (%)</td>
<td>17.52 (0.67)</td>
<td>20.24 (1.60)</td>
<td>0.2716</td>
<td>11.62 (0.42)</td>
<td>8.89 (1.11)</td>
<td>0.0007</td>
</tr>
<tr>
<td>Laborer (%)</td>
<td>78.81 (0.76)</td>
<td>77.01 (1.71)</td>
<td></td>
<td>83.95 (0.55)</td>
<td>88.50 (1.25)</td>
<td></td>
</tr>
<tr>
<td>Other (%)</td>
<td>3.51 (0.45)</td>
<td>2.64 (0.71)</td>
<td></td>
<td>4.26 (0.38)</td>
<td>2.02 (0.47)</td>
<td></td>
</tr>
<tr>
<td>Urban residence (%)</td>
<td>19.51 (0.29)</td>
<td>17.60 (1.03)</td>
<td>0.148</td>
<td>21.23 (0.25)</td>
<td>16.87 (1.19)</td>
<td>0.0034</td>
</tr>
<tr>
<td>Northern residence (%)</td>
<td>35.65 (0.51)</td>
<td>38.25 (1.91)</td>
<td>0.2671</td>
<td>37.62 (0.44)</td>
<td>46.92 (2.38)</td>
<td>0.0006</td>
</tr>
<tr>
<td>Using cholesterol-lowering medications (%)</td>
<td>0.3 (0.1)</td>
<td>1.0 (0.4)</td>
<td>&lt;0.0001</td>
<td>0.4 (0.1)</td>
<td>0.6 (0.3)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>DM (%)</td>
<td>4.0 (0.4)</td>
<td>5.4 (0.8)</td>
<td>&lt;0.0001</td>
<td>3.3 (0.3)</td>
<td>5.1 (0.9)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.29 (0.06)</td>
<td>23.30 (1.60)</td>
<td>&lt;0.0001</td>
<td>22.72 (0.06)</td>
<td>24.28 (1.40)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>77.31 (0.17)</td>
<td>80.23 (1.30)</td>
<td>&lt;0.0001</td>
<td>74.98 (0.16)</td>
<td>78.70 (0.37)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>WHR</td>
<td>0.85 (0.001)</td>
<td>0.86 (0.002)</td>
<td>&lt;0.0001</td>
<td>0.82 (0.001)</td>
<td>0.83 (0.002)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>113.98 (0.21)</td>
<td>127.71 (0.21)</td>
<td>&lt;0.0001</td>
<td>112.25 (0.20)</td>
<td>127.82 (0.25)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>73.23 (0.14)</td>
<td>83.94 (0.11)</td>
<td>&lt;0.0001</td>
<td>71.61 (0.13)</td>
<td>83.50 (0.12)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>TG (mg/dl)</td>
<td>117.84 (1.54)</td>
<td>140.96 (4.08)</td>
<td>&lt;0.0001</td>
<td>116.90 (1.37)</td>
<td>131.95 (4.20)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>TC (mg/dl)</td>
<td>178.30 (0.74)</td>
<td>187.20 (1.21)</td>
<td>&lt;0.0001</td>
<td>182.85 (0.69)</td>
<td>190.00 (1.58)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>HDL-C (mg/dl)</td>
<td>51.03 (0.28)</td>
<td>51.45 (0.51)</td>
<td>0.3511</td>
<td>53.37 (0.24)</td>
<td>51.83 (0.46)</td>
<td>0.0006</td>
</tr>
<tr>
<td>LDLC-C (mg/dl)</td>
<td>103.71 (0.64)</td>
<td>107.56 (1.08)</td>
<td>0.0002</td>
<td>106.10 (0.61)</td>
<td>111.79 (1.53)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fasting glucose (mg/dl)</td>
<td>96.14 (0.51)</td>
<td>98.70 (0.72)</td>
<td>0.0006</td>
<td>96.25 (0.43)</td>
<td>98.51 (0.76)</td>
<td>0.0052</td>
</tr>
</tbody>
</table>

Values are expressed as means (standard error) or percentage (standard error). Values are adjusted for weight and age. BMI, body mass index; WHR, waist-to-hip ratio; WC, waist circumference; DM, diabetes mellitus; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglyceride; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol. *P < 0.05 between normotensive and prehypertensive subjects.
level below 4.5 mmol/L, LDL cholesterol levels were calculated from the Friedewald equation:\(^{17}\):

\[
\text{LDL cholesterol} = \frac{(\text{total cholesterol}) - (\text{HDL cholesterol} - \text{triglycerides})}{5}.
\]

The Institutional Review Boards both at Fuwai Hospital of the Chinese Academy of Medical Science and Tulane University Health Sciences Center approved the InterASIA study. Informed consent was obtained from each participant before data collection.

**Statistical Methods**

The size of the InterASIA sample was selected to meet generally recommended requirements for precision in a complex survey. All calculations were weighted to represent the total Chinese adult population aged 35 to 74 years. The weights were calculated on the basis of the 2000 China Population Census and the InterASIA sampling scheme and took into account several features of the survey, including oversampling for specific age or geographic subgroups, nonresponse, and other demographic or geographic differences between the sample and the total populations. Standard errors were calculated by a technique appropriate to the complex survey design, which used 20 strata to account for each province and urban/rural area. Differences in demographic and anthropometric characteristics between prehypertensive and normotensive groups were analyzed by one-way ANOVA and chi-square test. The chi-square test was also used for the comparison of prevalence rates between or among groups. Logistic regression analyses were used to test significant determinants of prehypertension status, with prehypertension as a dichotomous variable. The stepwise regression was employed in models. The model fit statistics like AIC was used as a criterion to select covariates. Statistical analyses involved use of SAS (version 9.1.3; SAS Institute, Cary, NC). \(P < 0.05\) was considered statistically significant.

**RESULTS**

**Characteristics of Study Participants**

Characteristics of the study participants are shown in Table 1. Women with prehypertension were more likely to live in urban and northern China than women with normotension; whereas, men with prehypertension were likely to be more highly educated than those with normotension. Furthermore, individuals with prehypertension were more likely to accept cholesterol-lowering therapy compared with normotensive participants, prehypertensive individuals had higher prevalence of diabetes. Men and women with prehypertension had higher BMI, WC, and WHR, as well as triglyceride, total cholesterol, LDL-cholesterol, and fasting plasma glucose levels than their normotensive counterparts.

**Age-specific Prevalence of Prehypertension**

The age-standardized prevalence of prehypertension is shown in Table 2. The age-standardized prevalence of prehypertension was 21.9% in the Chinese adult population. The age-standardized prevalence of prehypertension was higher among men compared to their counterparts among women (25.7% versus 18.0%; \(P < 0.0001\)). The age-standardized prevalence of prehypertension was similar between men and women living in urban and their counterparts in rural areas (27.2% versus 25.4%, \(P = 0.3057\) for men and 17.1% versus 18.3%, \(P = 0.1414\) for women). The age-standardized prevalence of prehypertension was higher among men and women living in northern compared to their counterparts in southern China (28.3% versus 24.2%, \(P = 0.0061\) for men and 21.7% versus 15.5%, \(P < 0.0001\) for women).

**Prevalence of Prehypertension Among Overweight and Central Obese Adults**

The prevalence of prehypertension was higher for overweight than normal-weight men (38.4% versus 22.5%,...
Risk Factors Associated With Prehypertension

Multivariate analyses of men and women separately showed similar risk factors associated with prehypertension: urban versus rural residence, northern versus southern residence, BMI, WC, and total cholesterol level (per SD increase) (Table 3). Prehypertension was less likely among individuals living in urban areas but more likely among northern residents and those with high levels of BMI, WC, and total cholesterol.

Odds Ratios for Overweight and Central Obesity Associated With Prehypertension

The association between obesity and prehypertension was quantified by use of odds ratios computed separately for men and women with 2 independent multiple logistic regression models adjusted for 2 different sets of covariables (Fig. 2). Overall, overweight or central obesity was associated with increased odds of prehypertension among men and women, especially overweight individuals and especially overweight women. In model 1, the adjusted odds ratios for overweight and central obesity compared with their normal weight counterparts were 2.14 (95% CI, 1.78 to 2.59) and 1.91 (1.52 to 2.39), respectively, for men and 2.22 (1.90 to 2.78) and 1.91 (1.52 to 2.39), respectively, for women. Similar findings were also found in model 2 with increasing values for adjusted covariables; the adjusted odds ratios were 2.01 (95% CI, 1.64 to 2.47) and 1.663 (1.32 to 2.10), respectively, for men and 2.02 (1.65 to 2.48) and 1.91 (1.58 to 2.32), respectively, for women.

DISCUSSION

We examined the prevalence and its risk factors of prehypertension in the general Chinese adult population by a large and nationally representative sample. Furthermore, these results document regional difference in prevalence of prehypertension; higher prevalence was found in northern compared with southern China. Moreover, results emphasized that overweight and central obesity were important risk factors for prehypertension in Chinese adult population.

To allow for international comparisons, all study measurements in InterASIA were obtained by trained staff using a standard protocol. A vigorous quality assurance program was used to ensure the quality of the data collection over the entire study period. In the United States, the prevalence of prehypertension in an adult population 18 years and older is 31%. We found that the total prevalence of prehypertension in Chinese adult population aged 35 to 74 years to be 21.9%, which is lower than the prevalence in above American adult population. As well, consistent with the American adult findings, prehypertension was greater in Chinese adult men than in women (25.7% versus 18.0%) but not as prevalent as in American men and women (41% versus 23%). The age-specific prevalence of prehypertension across 4 age groups was higher in men than in women, a finding similar to that for the American adult population.

In the United States, the prevalence of prehypertension tends to increase steadily from 18 to 60 years; thereafter, it begins to decline. In the current study, the prevalence increases until age 55 years among Chinese adults, at which point it begins to decline.

Strikingly, the prevalence of prehypertension was higher in northern than southern China (24.9% versus 20.0%), and this difference was even greater for women (21.7% versus 15.5%), especially those aged 45 to 64 years. Moreover, compared with southern residence, northern residence was an independent risk factor for Chinese adults. As well, this geographic pattern of prehypertension in China is consistent with the regional pattern in the United States.
with the “salt hypothesis,” which proposes that a high intake of dietary salt in the north increases the risk of increased blood pressure.19,20 Indeed, several epidemiological studies have documented that dietary salt intake is higher in northern than southern China. Both observational epidemiology studies and clinical trials have documented that high dietary sodium intake increases BP.21 Unfortunately, data on dietary sodium intake was not collected in the current study. Furthermore genetic contributions to the regional differences in prehypertension should be examined.

Although we found the prevalence of prehypertension similar between urban and rural residents, after adjusting for some covariables, multivariate analysis revealed a significant negative association between urban residence and prehypertension. Although national guidelines require BP to be measured during all outpatient visits, BP is often not checked, especially in rural China. Lack of organized efforts for health promotion and education in rural China contributes to this situation.22 Previous studies have found awareness lower among rural than urban residents.12,22,23 These urban-rural differences are likely due to an inadequate supply of medications and less health education in rural China.12 Much more efforts for the detection and treatment of high BP must be complemented by equally energetic approaches directed at primary prevention of prehypertension in rural as well as urban areas in China.

Previous studies have reported an association between overweight and prehypertension,18,24–28 as we found. Central obese and especially overweight individuals had a higher prevalence of prehypertension than those with normal weight. Moreover, both overweight and central obesity are associated with prehypertension. Recent evidence indicates that overweight is on the increase in many developing countries, including China.10,29 Another analysis of the InterASIA study revealed that 31.1% of the Chinese adult population aged 35 to 74 years was overweight, and the prevalence of central obesity was 13.9%.10 This increasing trend of overweight may lead to greater prevalence of prehypertension and, subsequently, hypertension. JNC-7 recommends lifestyle modifications such as weight loss, physical activity, and adoption of a healthy diet for all people with prehypertension.30 According to our results, if BMI decreased 1 SD (3.23 kg/m² for men and 3.50 kg/m² for women) the risk of prehypertension would decrease 1.36-fold for men and 1.49-fold for women. Targeting prehypertensive subjects early and encouraging lifestyle modifications may result in important long-term benefits, especially in resource-poor

### TABLE 3. Adjusted Odds Ratios (95% Confidence Intervals) of Variables Associated With Prehypertension in Chinese Adult Men and Women

<table>
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<th>Women</th>
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<tr>
<td></td>
<td>Multivariate Model 1</td>
<td>Multivariate Model 2</td>
</tr>
<tr>
<td>Urban residence</td>
<td>0.85 (0.43 to 0.94)</td>
<td>0.84 (0.52 to 0.97)</td>
</tr>
<tr>
<td>North residence</td>
<td>1.27 (1.07 to 1.50)</td>
<td>1.15 (1.08 to 1.35)</td>
</tr>
<tr>
<td>BMI</td>
<td>1.42 (1.30 to 1.56)</td>
<td>1.36 (1.12 to 1.51)</td>
</tr>
<tr>
<td>WC</td>
<td>1.40 (1.29 to 1.53)</td>
<td>1.32 (1.07 to 1.62)</td>
</tr>
<tr>
<td>TC</td>
<td>1.29 (1.18 to 1.40)</td>
<td>1.24 (1.13 to 1.38)</td>
</tr>
</tbody>
</table>

All variables are weighted. Variables included in multivariate model 1 are adjusted for age, education, and occupation. Variables included in multivariate model 2 are adjusted for all variables in model 1 and for fasting glucose, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol levels. For model 2, each of the 5 variables (urban versus rural residence, north versus south residence, BMI, WC, TC) was entered into the model in a stepwise fashion adjusting for the other 4 variables. The significant level was 0.05 for entering into the models. Stepwise regression is employed in the models. The odds ratios for BMI, WC, and TC are all computed as per standard deviation increase.

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**FIGURE 2.** Adjusted odds ratios of prehypertension associated with obesity status in Chinese men (M) and women (W) by multivariate models.
settings where the control of hypertension is a serious problem. Furthermore, the implementation of lifestyle-change programs such as promoting healthy body weight, physical activity, especially among younger age groups, and reduced salt intake through community organizations, government, businesses, and schools may have a profound positive effect on preventing clinical hypertension in China.

The aggregation of multiple risks such as obesity, elevated BP, and hyperlipidemia has been found to increase the development of cardiovascular diseases. We found not only a significant association between BMI and prehypertension status but also a relation between prehypertension and above-optimal levels of cholesterol, especially total cholesterol. Prehypertension seems to coexist with the risk factors we mention above, and thus it may be an important clinical entity that requires medical attention.

In conclusion, our results indicate that prehypertension is very common in the general Chinese adult population and is related to overweight, central obesity, and dyslipidemia, which points to the health benefits of a multifaceted lifestyle modification, including weight control and regular physical activity. More efforts implementing national wide programs of prevention and control of hypertension and overweight, especially in rural and northern China, are needed to reduce the societal burden of hypertension in China.

REFERENCES