

Prevalence of Isolated Systolic and Isolated Diastolic Hypertension Subtypes in China

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Background: Isolated systolic hypertension (ISH), more so than any other hypertension subtype, increases the risk for stroke and coronary heart disease. The prevalence of ISH versus other hypertension subtypes in the general Chinese adult population is not known.

Methods: The prevalence of isolated systolic and isolated diastolic hypertension (IDH) was examined in a representative national sample of 15,540 Chinese adults aged 35 to 74 years. Three seated blood pressure (BP) measurements taken after 5 min of rest were averaged and hypertension subtypes were defined among individuals not receiving antihypertensive therapy as follows: ISH as systolic BP ≥ 140 mm Hg and diastolic BP < 90 mm Hg; IDH as systolic BP < 140 mm Hg and diastolic BP ≥ 90 mm Hg; and combined systolic/diastolic hypertension (SDH) as a systolic BP ≥ 140 mm Hg and diastolic BP ≥ 90 mm Hg.

Results: Overall, 7.6% of the Chinese adult population had ISH, 7.4% had SDH, and 4.4% had IDH. The prevalence of ISH increased with age and was more common in older women than in older men. Stage 1 hypertension was much more prevalent than stage 2 hypertension among all hypertension subtypes. The prevalence of SDH, IDH, and ISH (women, only) were higher in northern China than southern. The prevalence of ISH and SDH (women, only) were higher among rural residents versus urban residents.

Conclusions: These data document high rates of ISH in China. Given the risk of cardiovascular disease associated with ISH, our findings underscore the critical need for enhanced hypertension screening and treatment programs in China. Am J Hypertens 2004;17:955-962 © 2004 American Journal of Hypertension, Ltd.

Key Words: Isolated systolic hypertension, isolated diastolic hypertension, China, population, cross-sectional survey.

As in Western populations, cardiovascular disease is now the leading cause of death in China, with mortality projected to increase over the next decade.^{1,2} Hypertension is an important modifiable risk factor for cardiovascular disease, and its prevalence in China has increased. Data from the International Collaborative Study of Cardiovascular Disease in Asia (InterASIA) reported a hypertension prevalence of 25.8% in men and 28.6% in women for the years 2000 to 2001, which is up from 19.1% and 20.2%, respectively, in the 1991 Chinese National Hypertension Survey.^{3,4}

Although early hypertension guidelines focused on the diagnosis and treatment of elevated diastolic blood pressure (BP), isolated systolic hypertension (ISH) is now known to carry greater cardiovascular disease risk. Both observational epidemiologic and clinical trial data have demonstrated that elevated systolic BP confers significantly increased risk of stroke, coronary heart disease, and end-stage renal disease, especially in individuals ≥ 65 years of age.⁵

National data on the prevalence of isolated systolic and isolated diastolic hypertension (IDH) in China have never

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Table 1. Prevalence of stage 1 and 2 hypertension by isolated systolic hypertension (ISH), isolated diastolic hypertension (IDH), and combined systolic/diastolic hypertension subtypes in China, 2000–2001

Age (y)	Treated		Untreated SDH		Untreated IDH		Untreated ISH	
	Controlled	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 2
Men								
35–44	0.7 (0.2)	1.6 (0.3)	0.1 (0.06)	4.3 (0.5)	0.8 (0.2)	7.0 (0.6)	0.8 (0.2)	2.0 (0.3)
45–54	1.7 (0.4)	3.3 (0.5)	1.7 (0.4)	7.2 (0.7)	1.9 (0.4)	6.6 (0.7)	0.3 (0.2)	4.7 (0.7)
55–64	3.0 (0.6)	5.3 (0.7)	2.7 (0.5)	9.7 (1.0)	4.0 (0.6)	2.9 (0.5)	0.4 (0.2)	10.6 (1.1)
65–74	3.6 (0.8)	7.3 (1.2)	3.4 (0.9)	8.8 (1.2)	2.9 (0.9)	1.2 (0.5)	0.4 (0.2)	14.2 (1.6)
35–74*	1.8 (0.2)	3.5 (0.3)	1.5 (0.2)	6.7 (0.4)	2.0 (0.2)	5.4 (0.4)	0.5 (0.1)	5.9 (0.4)
Women								
35–44	0.9 (0.2)	1.1 (0.2)	0.3 (0.1)	2.3 (0.3)	0.5 (0.1)	3.0 (0.4)	0.5 (0.2)	1.9 (0.3)
45–54	3.1 (0.5)	5.1 (0.6)	1.8 (0.4)	6.1 (0.7)	1.0 (0.3)	3.1 (0.5)	0.2 (0.2)	5.4 (0.7)
55–64	4.1 (0.7)	6.1 (0.7)	4.2 (0.7)	7.9 (0.9)	1.9 (0.4)	1.7 (0.4)	0.1 (0.09)	10.2 (1.0)
65–74	5.2 (1.0)	7.5 (1.2)	4.0 (0.8)	6.6 (1.1)	1.1 (0.4)	1.0 (0.3)	0.2 (0.2)	19.3 (1.8)
35–74*	2.7 (0.2)	4.1 (0.3)	1.9 (0.20)	5.0 (0.3)	1.0 (0.1)	2.5 (0.2)	0.3 (0.1)	6.7 (0.4)
								1.5 (0.2)

Values are % (SE).

* Age-standardized.

been reported. In this study we report the prevalence of combined systolic and diastolic hypertension, IDH, and ISH in the general Chinese adult population, by age, sex, geographic region, and degree of urbanization. This information may aid in the development of targeted hypertension screening and treatment programs in China aimed at the prevention of the large and increasing burden of cardiovascular disease morbidity and mortality.

Methods

Study Population

The methods of the International Collaborative Study of Cardiovascular Disease in Asia (InterASIA) have been previously published.⁶ InterASIA used a four-stage stratified sampling method to select a nationally representative sample of the general adult population in China aged 35 to 74 years. The sample process was stratified by rural versus urban areas and North versus South, as divided by the Yangtzi River. North China consisted of the Beijing municipality as well as the Jilin, Shandong, Qinghai, and Shanxi provinces, whereas South China consisted of the Shanghai municipality as well as the Sichuan, Hubai, Fujian, and Guangxi provinces. The final stage of sampling was stratified by sex (50% men and 50% women) and by age distribution based on 1990 China census data. Only one participant was selected from each household, without replacement.

A total 19,012 individuals were randomly selected from 20 primary sampling units (street districts in urban areas, or townships in rural areas) and invited to participate. A total of 15,838 individuals completed the survey and examination, yielding a response rate of 83.3% (82.1% in men and 84.5% in women; 82.2% in urban areas and 84.4% in rural areas). Of these individuals, 298 were excluded for being outside the age range, leaving 15,540 in the range of 35 to 74 years.

Measurement of BP

Data collection was conducted in examination centers at local health stations or in community clinics in the participants' residential area in the autumn of 2000 and the spring of 2001, months during which the temperature in China is mild, so as to have negligible effects on BP measures. For a few individuals who could not attend examinations at the clinic, home visits were conducted. During examinations, a standard questionnaire including age, gender, hypertension diagnosis, and treatment information was administered by trained research staff.

Three BP measurements were obtained in the sitting position after at least 5 min of rest by trained nurses and physicians according to a common protocol adapted from American Heart Association recommendations.⁷ A standard mercury sphygmomanometer was used with one of four cuff sizes (pediatric, regular adult, large adult, or

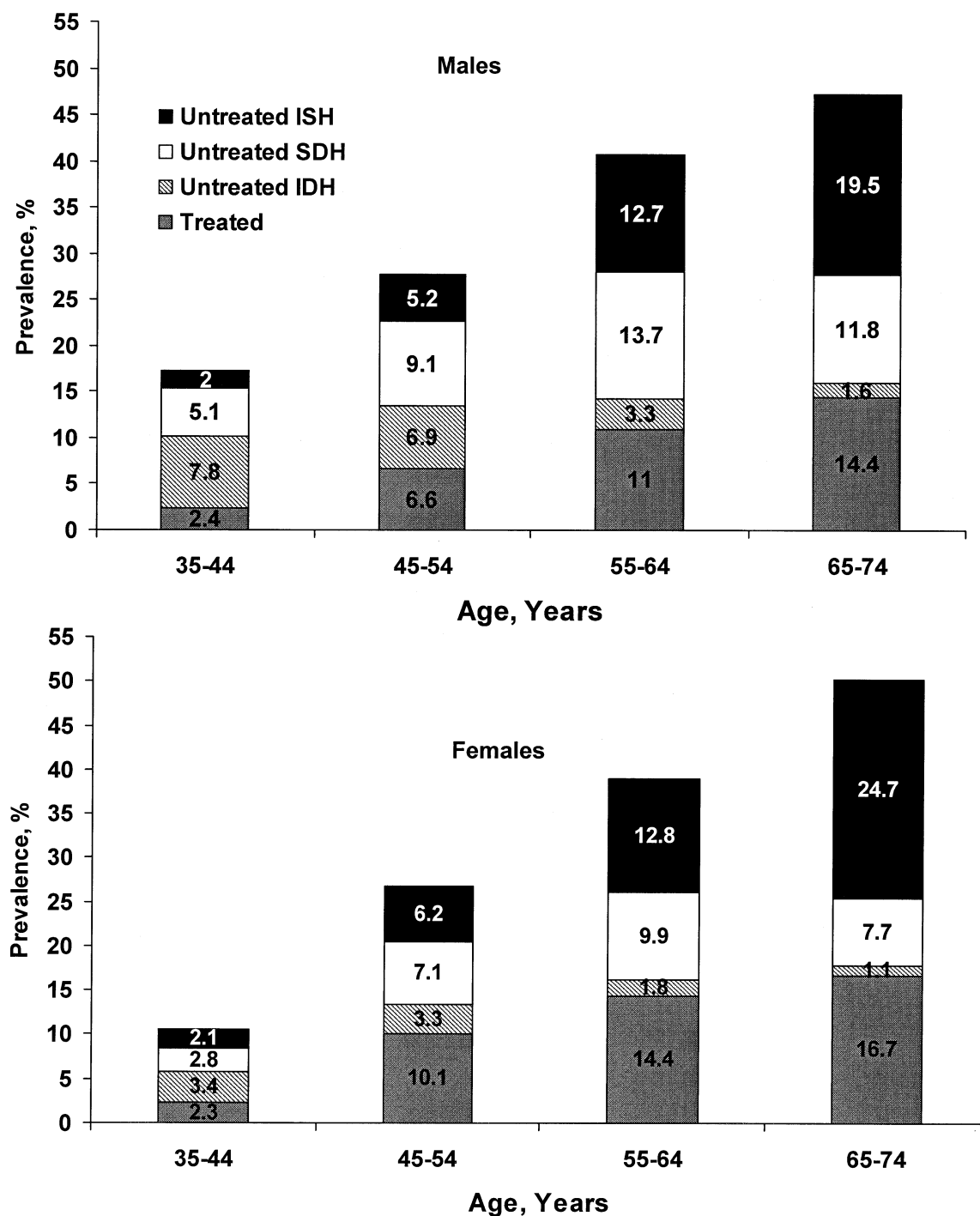


FIG. 1. Prevalence of isolated systolic and diastolic hypertension among men (**upper panel**) and women (**lower panel**) by age group. IDH = isolated diastolic hypertension; ISH = isolated systolic hypertension; SDH = combined systolic/diastolic hypertension.

thigh) based on the participant's arm circumference. Participants were advised to refrain from coffee, tea, or alcohol intake, cigarette smoking, and exercise beginning at least 30 min before their examination.

All study investigators and staff members successfully completed a training program orienting them both to the aims of the study and to the specific tools and methodologies used. At the training sessions, interviewers were

given detailed instructions on administration of the study questionnaire. All BP observers participated in a special training session on the use of the standardized BP measurement protocol. Requirements for certification as an InterASIA BP observer consisted of satisfactory performance on: a written test assessing knowledge of preparation of study participants for BP measurement, selection of appropriate cuff size, and standard BP measurement tech-

Table 2. Mean systolic blood pressure (BP) and diastolic blood pressure (DBP) levels by JNC-VII categories in China, 2000–2001

Age (y)	Normotensive		Prehypertension		Treated	
	SBP	DBP	SBP	DBP	SBP	DBP
Men						
35–44	109.1 (0.3)	71.1 (0.2)	123.7 (0.3)	81.1 (0.2)	139.2 (2.0)	94.5 (1.6)
45–54	108.8 (0.4)	71.1 (0.3)	123.7 (0.4)	81.3 (0.2)	145.6 (2.4)	95.1 (1.4)
55–64	108.9 (0.5)	69.8 (0.4)	126.8 (0.4)	78.8 (0.4)	150.8 (2.7)	90.6 (1.6)
65–74	109.1 (0.7)	67.9 (0.8)	127.8 (0.6)	77.1 (0.5)	153.5 (2.7)	84.5 (1.3)
35–74*	109.0 (0.2)	70.4 (0.2)	124.8 (0.2)	80.2 (0.1)	145.1 (1.2)	92.7 (0.8)
Women						
35–44	106.2 (0.2)	69.6 (0.2)	122.9 (0.3)	80.0 (0.2)	142.0 (2.7)	90.0 (1.7)
45–54	107.6 (0.3)	70.2 (0.3)	125.1 (0.4)	79.9 (0.3)	148.4 (2.1)	90.4 (1.1)
55–64	108.3 (0.4)	69.3 (0.4)	126.4 (0.4)	77.8 (0.4)	150.0 (1.9)	85.8 (1.1)
65–74	109.2 (0.9)	66.7 (0.9)	127.9 (0.5)	74.8 (0.7)	151.6 (2.3)	83.4 (1.2)
35–74*	107.4 (0.2)	69.3 (0.2)	124.8 (0.2)	78.9 (0.2)	146.6 (1.3)	88.5 (0.8)

JNC = Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; other abbreviations as in Table 1.

Values are mean (SE).

* Age-standardized.

niques; a standardized videotape examination; and concordant BP measurements with an instructor.

Hypertension was defined as an average systolic BP (SBP) ≥ 140 mm Hg, an average diastolic BP (DBP) ≥ 90 mm Hg, or self-reported use of antihypertensive medication within the past 2 weeks.⁸ Hypertension subtypes were defined for individuals not reporting current antihypertensive treatment as follows: combined systolic/diastolic hypertension (SDH) was defined as an average SBP ≥ 140 mm Hg and an average DBP ≥ 90 mm Hg; IDH was defined as an average SBP < 140 mm Hg and an average DBP ≥ 90 mm Hg, and ISH was defined as an average SBP ≥ 140 mm Hg and an average DBP < 90 mm Hg. Individuals reporting current antihypertensive treatment were categorized together as one group (treated) irrespective of their actual BP values. Prehypertension was defined according to the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-VI) criteria for both systolic (120 to 139 mm Hg) and diastolic (80 to 89 mm Hg) BP.⁹ Stage 1 hypertension was defined as either SBP ≥ 140 and < 160 mm Hg or DBP ≥ 90 and < 100 mm Hg. Stage 2 hypertension was defined as SBP ≥ 160 mm Hg or DBP ≥ 100 mm Hg.

The Institutional Review Board at Tulane University Health Sciences Center approved the InterASIA study. In addition, ethics committees and other relevant regulatory bodies in China approved the study. Informed consent was obtained from each participant before data collection. During the study, participants with untreated conditions were referred to their usual primary health care provider.

Statistical Analysis

The InterASIA study was designed to provide precise estimates of prevalence for all stratification groups (men, women, north, south, urban, rural) in each of the four age

groups (35 to 44 years, 45 to 54 years, 55 to 64 years, and 65 to 74 years). The InterASIA sample size was estimated to meet generally recommended requirements for precision in a complex survey.¹⁰

Prevalence and mean BP levels were weighted to represent the total Chinese population aged 35 to 74 years, representing an estimated 477 million individuals. Weights were calculated based on the 2000 China population census data 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 total China population. Age standardization was performed by the direct method using the 2000 China population aged 35 to 74 years as the standard population. Prevalence of hypertension and its subtypes was calculated for northern and southern China, for urban and rural residents, and for men and women. North/south and urban/rural differences in age-standardized prevalence were tested via logistic regression. Standard errors for all analyses were calculated by a technique appropriate to the complex survey design. Analyses were conducted using SUDAAN, version 8.0 (Research Triangle Institute, Research Triangle Park, NC).

Results

Overall, ISH was the predominant untreated hypertension subtype (7.6%), followed by SDH (7.4%) and IDH (4.4%), with 7.7% of adults reporting current antihypertensive treatment. The prevalence of ISH increased with age, whereas the prevalence of IDH decreased with age among both men and women (Table 1). The prevalence of SDH increased from 35 to 64 years in similar magnitude to ISH until the 65 to 74 year age group, in which SDH preva-

Table 2. Continued

Untreated SDH		Untreated IDH		Untreated ISH	
SBP	DBP	SBP	DBP	SBP	DBP
151.6 (1.3)	100.8 (0.8)	130.0 (0.7)	94.2 (0.4)	146.5 (1.1)	82.2 (1.1)
154.6 (1.4)	98.8 (0.6)	129.4 (0.8)	92.8 (0.4)	146.3 (0.9)	81.9 (0.9)
161.7 (1.7)	99.2 (0.8)	131.1 (1.1)	93.9 (0.7)	150.8 (1.0)	81.3 (0.5)
166.9 (3.3)	98.5 (1.4)	132.3 (2.0)	93.8 (1.3)	154.8 (2.0)	80.3 (0.7)
156.3 (0.8)	99.6 (0.4)	130.4 (0.5)	93.7 (0.3)	148.3 (0.6)	81.7 (0.5)
155.1 (1.9)	97.7 (0.8)	130.3 (0.8)	93.8 (0.6)	146.9 (1.4)	83.3 (1.0)
159.5 (1.6)	96.9 (0.6)	128.9 (1.3)	93.4 (0.6)	149.3 (1.0)	83.9 (0.5)
162.9 (2.0)	97.9 (0.8)	133.1 (1.2)	93.5 (1.0)	153.0 (1.2)	82.2 (0.5)
164.3 (2.2)	95.9 (0.7)	133.2 (2.4)	94.3 (1.5)	152.6 (0.9)	79.4 (0.7)
159.0 (1.0)	97.3 (0.4)	130.8 (0.6)	93.7 (0.4)	149.5 (0.7)	82.8 (0.4)

lence fell, whereas ISH prevalence increased dramatically, especially among women. Stage 1 hypertension was more prevalent than stage 2 hypertension among all hypertension subtypes and among treated individuals. This was consistent for all age groups and both sexes. For both SDH and IDH, the prevalence of stage 2 hypertension held constant or slightly decreased with increasing age group, whereas for ISH, the prevalence of stage 2 hypertension increased with increasing age group.

Figure 1 presents prevalence of hypertension subtypes for men and for women. IDH was the most common hypertension subtype in the age group 35 to 44 years for both men and women; SDH was the most common subtype in the age groups 45 to 54 years and 55 to 64 years for men, and in the age group 45 to 54 years for women; and ISH was the most common subtype in the age group 65 to 74 years for men and the age groups 55 to 64 years and 65 to 74 years for women. ISH was slightly more prevalent in

women than in men, whereas IDH was much more prevalent in men than in women.

Mean BP values for normotensive, prehypertensive, and treated and untreated hypertensive subjects are provided in Table 2. For all groups except those with IDH, mean SBP increased and mean DBP decreased with increasing age group among both men and women. For those with IDH, mean SBP increased slightly with increasing age group, whereas mean DBP did not increase with increasing age group.

For men, the prevalence of treated hypertension, and untreated SDH and IDH were higher in northern China than southern, whereas the prevalence of untreated ISH did not differ by region (Table 3). In addition, the prevalence of treated hypertension was higher and untreated ISH lower among urban residents compared with rural residents, whereas the prevalence of untreated SDH and IDH did not differ by degree of urbanization among men.

Table 3. Prevalence of hypertension subtypes by geographic region and urbanization in China, 2000–2001

	Treated	Untreated SDH	Untreated IDH	Untreated ISH
Men				
North	10.3 (0.7)	11.2 (0.7)	8.1 (0.6)	7.4 (0.6)
South	4.2 (0.4)	6.9 (0.5)	4.3 (0.4)	7.0 (0.5)
<i>P</i> value for difference	<.001	<.001	<.001	.671
Urban	10.0 (0.5)	9.5 (0.6)	6.4 (0.4)	6.2 (0.4)
Rural	6.0 (0.5)	8.5 (0.5)	5.8 (0.4)	7.4 (0.5)
<i>P</i> value for difference	<.001	.178	.296	.042
Women				
North	11.6 (0.7)	6.8 (0.5)	3.9 (0.5)	9.3 (0.7)
South	6.6 (0.5)	5.4 (0.5)	2.0 (0.3)	7.4 (0.5)
<i>P</i> value for difference	<.001	.054	<.001	.023
Urban	11.4 (0.5)	5.0 (0.4)	2.7 (0.3)	6.9 (0.4)
Rural	8.0 (0.5)	6.2 (0.4)	2.8 (0.3)	8.6 (0.5)
<i>P</i> value for difference	<.001	.031	.682	.008

Values are % (SE).

* Age-standardized.

For women, the prevalence of treated hypertension, and untreated IDH and ISH was higher in northern than in southern China; the prevalence of untreated SDH was slightly higher in northern than in southern China, although the difference was not statistically significant. Additionally, the prevalence of treated hypertension was higher and the prevalence of untreated SDH and ISH lower among urban compared with rural residents, whereas the prevalence of untreated IDH did not differ by degree of urbanization among women.

Discussion

These data document a high prevalence of untreated hypertension in China, with the largest proportion having ISH (7.6%), representing more than an estimated 36 million Chinese adults aged 35 to 74 years (17 million men and 19 million women). We observed that ISH was especially prevalent among those 55 years or older, with higher prevalence among older women than among older men.

Few data have been published concerning ISH prevalence among developing countries. For each age group, the prevalence of ISH in China reported here is slightly higher than that reported from a random sample of an industrializing city in South Korea.¹¹ The prevalence of ISH among those aged 35 to 44 years in Ansan-city, South Korea, was 0.71%, as compared with 2.0% among men and 2.1% among women in the current study; and among those 65 to 74 years, ISH prevalence was 12.4% in Ansan-city compared with 19.5% among men and 24.7% among women in the current study. In addition, the prevalence of ISH in China reported here is dramatically higher than that reported from a two-city study in rural Thailand, where the prevalence of ISH among those aged 30 to 65 years was 1.0%.¹² However, differences in measurement methods may impede direct comparison among studies. The higher prevalence estimates in the current study may represent increased westernization in China compared with the earlier studies in Korea and Thailand. However, as neither the Korean study nor the Thai study used a nationally representative sample, comparison with the current study is tenuous. The patterns of prevalence reported here among the Chinese population are similar to data from both the U.S. population¹³ and Korea,¹¹ which report higher prevalence of ISH with increasing age as well as higher ISH prevalence among women versus men.

Isolated systolic hypertension, more so than IDH, increases the risk of stroke, coronary heart disease, and end-stage renal disease morbidity and mortality in both Western and Asian populations.^{5,14} Additionally, ISH may be more difficult to control.¹⁵ However, the risks associated with ISH can clearly be decreased with BP lowering treatment. The Systolic Hypertension in the Elderly Program demonstrated a 36% reduction in the rates of stroke and a 32% reduction in the rates of cardiovascular disease,¹⁶ whereas the Systolic Hypertension in Europe Trial demonstrated a 42% reduction in stroke and a 26% reduc-

tion in the rates of both fatal and nonfatal cardiovascular disease with treatment of ISH.¹⁷ Treatment benefits were similarly large in the Chinese population. The Systolic Hypertension in China Trial demonstrated a 38% reduction in stroke incidence, a 58% reduction in stroke mortality, and a 37% reduction in the rates of fatal and nonfatal cardiovascular disease with treatment of ISH.¹⁸

Despite these treatment benefits, previously reported InterASIA data indicate that only 28% of Chinese hypertensive subjects are on treatment, with only 8.1% achieving BP control.³ The high prevalence of ISH noted here demonstrates the large number of Chinese adults at substantially increased risk for cardiovascular disease. Additionally, these prevalence numbers are only for untreated hypertensive subjects. If treated hypertensive subjects are included, the prevalence of ISH is much higher. These data underscore the critical need for enhanced physician education in China as to the importance of hypertension screening, the benefits of treatment on the risks associated with ISH, and the value of closely monitoring patients who are on antihypertensive treatments to ensure eventual control of their BP.

Although the prevalence of untreated ISH was high among the Chinese population, these data indicated that the majority of cases for all hypertension subtypes could be categorized as stage 1 rather than stage 2 hypertension according to the JNC-VII criteria.⁹ Our data are similar to data reported in the United States using the JNC-V criteria, where for all age groups, among both men and women, stage 1 hypertension was found to be more common than stage 2.¹⁹

Although ISH was the predominant hypertension subtype among our data, similar to that in the U.S. population,¹³ our study documents a higher prevalence of SDH among the older age groups than those reported in the United States. Franklin et al report an SDH prevalence of approximately 3% among individuals 60 to 69 years in the U.S. population,¹³ whereas our data indicate that the prevalence of SDH was 7.7% for Chinese women and 11.7% for Chinese men aged 65 to 74 years. Despite the larger prevalence of diastolic hypertension (whether alone or in combination with systolic hypertension), our data document that for every BP subtype including IDH, mean SBP values increased whereas mean DBP values decreased with increasing age group.

These data demonstrated higher prevalence of treated hypertension as well as untreated SDH, IDH, and ISH (women, only) in northern China versus southern China. Previous national surveys in China, including previously published InterASIA data have indicated higher overall hypertension prevalence in northern versus southern China.^{4,20} These data extend those findings to the specific hypertension subtypes underlying the overall hypertension prevalence.

Although data on many developing countries, including national surveys from China, have indicated a higher prevalence of hypertension among urban-dwelling residents

versus rural-dwelling residents,^{4,21-23} previously published data from the InterASIA population did not demonstrate significant urban-rural differences in the overall prevalence of hypertension.²⁰ This finding was attributed to a rapid increase in hypertension rates among rural residents between the last Chinese national survey and InterASIA, most likely resulting from an increased exposure on the part of rural residents to dietary and work-related lifestyles previously associated with urban living.²⁰ Our data stratifying overall hypertension rates by treated and untreated hypertension subtypes, however, document a higher prevalence of untreated SDH (women, only) and ISH among rural residents and a higher prevalence of treated hypertension in urban residents. The higher prevalence of untreated SDH and ISH among rural residents is likely due to the lower treatment rates in rural areas documented here.

In conclusion, the present study documents a high prevalence of ISH among Chinese adults, affecting more than an estimated 36 million individuals. Given the risks associated with ISH, these prevalence numbers indicate a sizeable population risk for coronary heart disease and stroke that is highly preventable with treatment. These data, taken in light of the low hypertension treatment and control rates,³ underscore the critical need for enhanced physician education and screening programs in China.

Appendix

Members of the InterASIA Collaborative Group

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