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Trends in prevalence, awareness, treatment, and control of hypertension among Chinese adults 1991–2009

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Keywords

Hypertension; China; Prevalence; Awareness; Control; Trend

Hypertension is the main risk factor for cardiovascular disease (CVD), accounting for nearly 45% of global CVD morbidity and mortality [1]. Based on previous national survey data in China, the prevalence of hypertension in adults has increased from 5% in 1959 to 11.3% in 1991 and 18% in 2002 [2–4]. Although many studies have suggested that the control of hypertension is an effective strategy to prevent CVD [5], only a small percentage of hypertensive patients achieved the goal of systolic and diastolic blood pressure (SBP/DBP) < 140/90 mm Hg. The control rate of hypertension in China was only 3% in 1991 and 5% in 2002 [3,4].

Recently, three studies from China have investigated the prevalence, awareness, treatment, and control of hypertension in three urban populations [6], and two rural populations [7,8].

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Conflict of interest statement

No conflicts of interest to declare.

Author Contribution

Bo Xi and Weihong Tang designed the study. Bo Xi and Yajun Liang drafted the manuscript. Bo Xi, Yajun Liang and Yuehua Hu performed the data analysis. Weihong Tang and Kathleen H. Reilly made critical revisions.

Recent trends in hypertension prevalence and control in China on a national level, however, are still unknown.

The China Health and Nutrition Survey (CHNS) is a large-scale, national and successive cross-sectional survey that was designed to explore how the health and nutritional status of the Chinese population has been affected by social and economic changes [9]. A multistage, random cluster process was used to draw study sample from nine provinces (Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi and Guizhou). Participants aged 18 years and older were included in the analysis. Information on age, gender, region (the urban and rural regions were clarified according to their characteristics of economy and social development using data from the China National Bureau of Statistics and China Ministry of Health Statistics), body mass index (BMI), and BP measurements were collected. A total of 8426, 7905, 8509, 9469, 8847, 8980 and 8503 participants were included in the analyses across the seven study periods (1991, 1993, 1997, 2000, 2004, 2006, 2009). Gender distributions across the seven survey periods were homogeneous ($P=0.49$).

BP was measured by trained examiners using a mercury sphygmomanometer according to a standard protocol [10]. The three BP values were measured on one visit, and the last two of three readings were averaged as the BP values in this study. Prevalent pre-hypertension was defined as SBP/DBP of 120/80 to 140/90 mm Hg and hypertension was defined as SBP/DBP $\geq$ 140/90 mm Hg or on antihypertensive medications [10]. The same criteria were used for both diabetic and nondiabetic participants [11]. Awareness of hypertension was determined as self-reported diagnosis of hypertension by a physician or other healthcare professional. Treatment of hypertension was defined as self-report use of antihypertensive medications. Treated participants were considered to have their hypertension controlled if their SBP/DBP was less than 140/90 mm Hg. Trends in BP values and the estimated percentages (prevalence, awareness, treatment, and control of hypertension) from 1991 to 2009 were assessed with a multiple linear regression (continuous outcomes) or logistical regression (dichotomous outcomes) model [12] with the adjustment for gender, age, region, and BMI. Since age distributions in the seven study periods varied, the estimated percentages were age-standardized to the China Census population in 2000. A p value <0.05 was considered statistically significant. The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology [13].

Overall, both mean SBP and DBP values increased significantly across seven study visits (Table 1). Mean SBP values increased by 5.4 mm Hg and mean DBP increased by 4.1 mm Hg. Similar significant trends were observed in all subgroups defined by age, sex and region groups (all $p<0.05$), except for the group older than 60 years ($p>0.05$). Notably, mean SBP and DBP values increased more rapidly among subjects aged 40–59 years and among those living in rural regions.

The prevalence of pre-hypertension and hypertension changed significantly from 29.4% and 14.5%, respectively, in 1991, to 38.7% and 21.4%, respectively, in 2009 (both $p<0.001$), with an absolute increase of 9.3% and 6.9% (Table 2). Similar significant trends were observed in each subgroup defined by age, sex or region (all $p<0.05$). The prevalence of hypertension increased more rapidly among subjects who were older than 40 years, men, and those who lived in rural regions (Table 2).

The awareness and treatment of hypertension decreased significantly from 22.4% and 12.0% respectively, in 1991, to 13.0% and 9.6%, respectively, in 1997 (all $p<0.05$). However, there was no clear trend in the BP control rates among hypertensive patients and among those

treated over time (both $p>0.05$) (Table 3). During the periods of 1997–2009, the awareness, treatment, and control of hypertension in all hypertensive patients and those treated increased significantly from 13.0%, 9.6%, 1.7% and 17.4% in 1997, respectively, to 26.1%, 22.8%, 6.1%, and 33.1% in 2009 (all $p<0.05$). In stratified analysis, during the periods of 1997–2009, the rates of awareness, treatment, and control of hypertension in all hypertensive patients and in those treated increased more rapidly in those aged 60 years or older. In addition, the rates of hypertension control in all hypertensive patients and in those treated increased more rapidly in urban regions (Table 3).

To our knowledge, although three regional studies have been published [6–8], we firstly reported the recent trends in prevalence, awareness, treatment and control of hypertension among the partially representative Chinese adults from 1991 to 2009, based on the CHNS. The upward trend in mean SBP and DBP values and prevalence of hypertension was observed among Chinese adults from 1991 to 2009, which might be due to decreases in physical activity [14], increases in sedentary behavior, high fat diet, salt intake [15] and obesity [16]. In contrast, the United States National Health and Nutrition Examination Survey (NHNES) conducted for a similar period (1988–2008) showed that the prevalence of hypertension increased from 1988 to 2000, with little change between 2000 and 2008[17]. Better public health education and preventive measures from the government and health professionals might explain the increases in the awareness, treatment and control rates between 1997 and 2009. Similarly, the NHNES in the United States also demonstrated an increase in awareness, treatment and control of hypertension between 1988 and 2008[18].

Two limitations are noted. First, BP measurement at a single visit usually overestimates hypertension prevalence and underestimates control rate. Second, risk factors such as diabetes, hyperlipidemia, smoking, and family history of hypertension and data on treatment medications and prevalence of essential versus non-essential hypertension were unavailable presently.

The overall prevalence of hypertension increased significantly in China between 1991 and 2009. The overall awareness, treatment, and control of hypertension (in hypertensive individuals) increased over time, but are still unacceptably low. Our results suggest an urgent need for a national hypertension education program to improve the prevention, detection, treatment, and control of hypertension in China, with the ultimate goal to lower hypertension-related morbidity and mortality.

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Table 1

Trends in mean SBP and DBP values (mm Hg) among Chinese Adults: the CHNS 1991–2009

Age, y	1991			1993			1997			2000			2004			2006			2009			<i>P</i> _{trend} ^a
	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)	N	Mean(SE)				
SBP																						
Total	8426	114.7 (0.2)	7905	115.1 (0.2)	8509	117.6 (0.2)	9469	118.0 (0.2)	8847	119.5 (0.2)	8980	118.5 (0.2)	8503	120.1 (0.2)	<0.001							
Age, y																						
18–39	4517	108.7 (0.2)	3953	109.7 (0.2)	3788	112.1 (0.2)	3869	112.4 (0.2)	2841	114.1 (0.2)	2551	113.4 (0.2)	2202	113.8 (0.3)	<0.001							
40–59	2657	117.3 (0.4)	2712	117.2 (0.3)	3192	119.7 (0.3)	3796	120.7 (0.3)	3962	122.2 (0.3)	4175	121.4 (0.3)	3868	124.1 (0.3)	<0.001							
60	1252	132.1 (0.7)	1240	131.0 (0.7)	1529	133.4 (0.6)	1804	133.6 (0.5)	2044	134.1 (0.5)	2254	131.9 (0.4)	2433	135.4 (0.4)	0.421							
Sexes																						
Men	3987	116.8 (0.3)	3742	117.1 (0.3)	4111	119.4 (0.3)	4508	120.0 (0.2)	4195	121.7 (0.3)	4218	121.0 (0.3)	4007	122.3 (0.3)	<0.001							
Women	4439	112.8 (0.3)	4163	113.3 (0.3)	4398	115.7 (0.3)	4961	116.0 (0.3)	4652	117.3 (0.3)	4762	116.3 (0.3)	4496	118.0 (0.3)	<0.001							
Regions																						
Urban	2817	115.4 (0.4)	2422	115.7 (0.4)	2880	116.9 (0.3)	3209	117.4 (0.3)	3070	119.2 (0.3)	3041	118.3 (0.3)	2743	118.9 (0.3)	0.028							
Rural	5609	114.2 (0.2)	5483	114.7 (0.2)	5629	117.7 (0.2)	6260	118.2 (0.2)	5777	119.4 (0.2)	5939	118.6 (0.2)	5760	120.5 (0.3)	<0.001							
DBP																						
Total	8426	74.3 (0.1)	7905	75.4 (0.1)	8509	76.5 (0.1)	9469	76.9 (0.1)	8847	77.7 (0.1)	8980	77.6 (0.1)	8503	78.4 (0.1)	<0.001							
Age, y																						
18–39	4517	71.4 (0.1)	3953	72.8 (0.1)	3788	74.0 (0.1)	3869	74.4 (0.2)	2841	75.6 (0.2)	2551	75.4 (0.2)	2202	75.6 (0.2)	<0.001							
40–59	2657	76.5 (0.2)	2712	77.4 (0.2)	3192	78.2 (0.2)	3796	79.1 (0.2)	3962	79.8 (0.2)	4175	79.8 (0.2)	3868	81.4 (0.2)	<0.001							
60	1252	80.6 (0.4)	1240	81.2 (0.4)	1529	82.4 (0.3)	1804	81.9 (0.3)	2044	81.2 (0.3)	2254	81.4 (0.3)	2433	82.2 (0.2)	0.121							
Sexes																						
Men	3987	75.8 (0.2)	3742	76.9 (0.2)	4111	77.9 (0.2)	4508	78.5 (0.2)	4195	79.4 (0.2)	4218	79.5 (0.2)	4007	80.4 (0.2)	<0.001							
Women	4439	72.9 (0.2)	4163	74.0 (0.2)	4398	75.1 (0.2)	4961	75.4 (0.2)	4652	76.1 (0.2)	4762	75.8 (0.2)	4496	76.4 (0.2)	<0.001							
Regions																						
Urban	2817	74.7 (0.2)	2422	76.2 (0.2)	2880	76.7 (0.2)	3209	76.9 (0.2)	3070	77.7 (0.2)	3041	77.7 (0.2)	2743	78.4 (0.2)	<0.001							
Rural	5609	74.0 (0.1)	5483	75.0 (0.1)	5629	76.4 (0.1)	6260	76.9 (0.1)	5777	77.7 (0.2)	5939	77.5 (0.1)	5760	78.4 (0.2)	<0.001							

The mean SBP and DBP values were age-standardized to the China 2000 Census population

^aTime trends in mean SBP and DBP from 1991 to 2009 were assessed by multiple linear regression analysis with gender, age, region, and BMI adjustment.

Table 2

Trends in prevalence of pre-hypertension and hypertension among Chinese Adults: the CHNS 1991–2009

Age, y	1991			1993			1997			2000			2004			2006			2009			<i>P</i> _{trend} ^a
	N	% (SE)		N	% (SE)		N	% (SE)		N	% (SE)		N	% (SE)		N	% (SE)		N	% (SE)		
Pre-hypertension																						
Total	8426	29.4 (0.5)		7905	33.2 (0.5)		8509	36.6 (0.5)		9469	38.2 (0.5)		8847	40.6 (0.5)		8980	41.0 (0.5)		8503	38.7 (0.5)		<0.001
Age, y																						
18–39	4517	26.8 (0.7)		3953	31.2 (0.7)		3788	36.2 (0.8)		3869	37.3 (0.8)		2841	41.7 (0.9)		2551	41.4 (1.0)		2202	37.8 (1.0)		<0.001
40–59	2657	33.6 (0.9)		2712	37.4 (0.9)		3192	39.0 (0.9)		3796	41.5 (0.8)		3962	42.6 (0.8)		4175	43.7 (0.8)		3868	42.8 (0.8)		<0.001
60	1252	30.3 (1.3)		1240	32.4 (1.3)		1529	33.0 (1.2)		1804	34.1 (1.1)		2044	32.0 (1.0)		2254	33.8 (1.0)		2433	33.5 (1.0)		<0.001
Sexes																						
Men	3987	34.2 (0.8)		3742	39.1 (0.8)		4111	41.2 (0.8)		4508	44.5 (0.7)		4195	47.1 (0.8)		4218	47.8 (0.8)		4007	44.4 (0.8)		<0.001
Women	4439	25.2 (0.7)		4163	28.1 (0.7)		4398	32.3 (0.7)		4961	32.3 (0.7)		4652	34.6 (0.7)		4762	34.9 (0.7)		4496	33.5 (0.7)		<0.001
Regions																						
Urban	2817	29.3 (0.9)		2422	33.6 (1.0)		2880	35.6 (0.9)		3209	38.5 (0.9)		3070	39.0 (0.9)		3041	41.0 (0.9)		2743	38.3 (0.9)		<0.001
Rural	5609	29.6 (0.6)		5483	33.2 (0.6)		5629	37.1 (0.6)		6260	38.1 (0.6)		5777	41.4 (0.6)		5939	41.0 (0.6)		5760	38.9 (0.6)		<0.001
Hypertension																						
Total	8426	14.5 (0.4)		7905	15.5 (0.4)		8509	17.9 (0.4)		9469	18.2 (0.4)		8847	19.1 (0.4)		8980	17.8 (0.4)		8503	21.4 (0.4)		<0.001
Age, y																						
18–39	4517	4.6 (0.3)		3953	6.0 (0.4)		3788	7.2 (0.4)		3869	7.4 (0.4)		2841	8.2 (0.5)		2551	7.2 (0.5)		2202	8.6 (0.6)		<0.001
40–59	2657	18.2 (0.7)		2712	18.8 (0.7)		3192	21.9 (0.7)		3796	23.0 (0.7)		3962	24.4 (0.7)		4175	23.3 (0.7)		3868	29.3 (0.7)		<0.001
60	1252	43.9 (1.4)		1240	44.8 (1.4)		1529	49.4 (1.3)		1804	48.4 (1.2)		2044	49.0 (1.1)		2254	46.4 (1.1)		2433	53.0 (1.0)		0.014
Sexes																						
Men	3987	16.0 (0.6)		3742	16.9 (0.6)		4111	20.0 (0.6)		4508	20.3 (0.6)		4195	21.7 (0.6)		4218	20.4 (0.6)		4007	24.5 (0.7)		<0.001
Women	4439	13.1 (0.5)		4163	14.3 (0.5)		4398	15.8 (0.5)		4961	16.2 (0.5)		4652	16.8 (0.5)		4762	15.5 (0.5)		4496	18.7 (0.6)		<0.001
Regions																						
Urban	2817	16.4 (0.7)		2422	17.8 (0.8)		2880	18.0 (0.7)		3209	18.6 (0.7)		3070	19.7 (0.7)		3041	17.7 (0.7)		2743	20.5 (0.8)		0.019
Rural	5609	13.2 (0.5)		5483	14.3 (0.5)		5629	17.5 (0.5)		6260	17.7 (0.5)		5777	18.5 (0.5)		5939	17.7 (0.5)		5760	21.6 (0.5)		<0.001

Prevalent pre-hypertension was defined as SBP/DBP of 120/80 to 140/90 mm Hg and hypertension was defined as SBP/DBP 140/90 mm Hg or on antihypertensive medications
Prevalence were age-standardized to the China 2000 Census population

^aTime trends in pre-hypertension and hypertension from 1991 to 2009 were assessed by multiple logistical regression analysis with gender, age, region, and BMI adjustment.

Table 3
Trends in awareness, treatment, and control among Chinese hypertensive adults: the CHNS 1991–2009

Age, y	1991	1993	1997	2000	2004	2006	2009	P_{trend}^a	P_{trend}^b
	%(SE)	%(SE)	%(SE)	%(SE)	%(SE)	%(SE)	%(SE)		
Awareness									
Total	22.4 (1.3)	18.6 (1.1)	13.0 (0.8)	19.5 (0.9)	21.5 (0.9)	25.6 (0.9)	26.1 (0.9)	<0.001	<0.001
Age, y									
18–39	15.0 (2.7)	7.1 (1.8)	4.4 (1.2)	8.5 (1.7)	8.6 (1.8)	12.1 (2.4)	11.6 (2.3)	<0.001	<0.001
40–59	30.5 (2.2)	30.0 (2.1)	20.3 (1.5)	29.9 (1.6)	34.1 (1.5)	37.7 (1.6)	38.7 (1.4)	<0.001	<0.001
60	33.3 (2.2)	37.4 (2.2)	29.7 (1.7)	38.7 (1.7)	43.5 (1.6)	51.3 (1.6)	54.3 (1.4)	0.002	0.002
Sexes									
Men	17.6 (1.6)	16.7 (1.5)	11.0 (1.0)	16.4 (1.1)	18.1 (1.1)	24.3 (1.3)	24.3 (1.2)	<0.001	<0.001
Women	29.7 (2.0)	20.7 (1.7)	16.1 (1.3)	23.0 (1.4)	26.3 (1.4)	26.3 (1.3)	27.9 (1.2)	<0.001	<0.001
Regions									
Urban	24.0 (2.0)	23.3 (1.9)	17.7 (1.5)	20.7 (1.5)	24.1 (1.5)	30.0 (1.6)	30.2 (1.5)	0.001	<0.001
Rural	20.8 (1.6)	15.4 (1.4)	10.1 (0.9)	18.3 (1.1)	19.5 (1.1)	22.8 (1.1)	23.6 (1.0)	<0.001	<0.001
Treatment									
Total	12.0 (1.0)	10.1 (0.9)	9.6 (0.7)	13.6 (0.8)	16.6 (0.8)	19.0 (0.8)	22.8 (0.8)	0.027	<0.001
Age, y									
18–39	7.3 (1.9)	3.4 (1.2)	3.7 (1.1)	4.9 (1.3)	5.6 (1.5)	7.1 (1.9)	10.5 (2.2)	0.073	0.052
40–59	17.1 (1.8)	15.3 (1.7)	14.1 (1.3)	21.0 (1.4)	26.9 (1.4)	28.8 (1.5)	32.3 (1.4)	0.025	<0.001
60	19.3 (1.8)	24.1 (1.9)	22.6 (1.5)	30.5 (1.6)	36.2 (1.5)	43.3 (1.5)	49.0 (1.4)	0.812	<0.001
Sexes									
Men	8.8 (1.2)	9.1 (1.2)	8.1 (0.9)	10.9 (1.0)	13.4 (1.0)	17.2 (1.1)	20.6 (1.1)	0.468	<0.001
Women	17.0 (1.7)	11.2 (1.3)	12.1 (1.2)	16.6 (1.2)	20.9 (1.3)	20.6 (1.2)	25.4 (1.2)	0.014	<0.001
Regions									
Urban	14.6 (1.6)	14.6 (1.6)	14.1 (1.4)	15.4 (1.3)	19.5 (1.4)	22.2 (1.5)	28.0 (1.5)	0.318	<0.001
Rural	10.1 (1.2)	7.2 (1.0)	7.1 (0.8)	12.0 (0.9)	14.4 (1.0)	16.8 (1.0)	19.8 (1.0)	0.038	<0.001
Control Among hypertensive patients									
Total	3.0 (0.5)	2.6 (0.5)	1.7 (0.3)	3.3 (0.4)	4.6 (0.4)	4.5 (0.4)	6.1 (0.5)	0.775	<0.001
Age, y									

Age, y	1991	1993	1997	2000	2004	2006	2009	P_{trend}^a	P_{trend}^b
	% (SE)	% (SE)	% (SE)	% (SE)	% (SE)	% (SE)	% (SE)		
18–39	2.9 (1.3)	2.1 (1.0)	0.4 (0.4)	1.7 (0.8)	1.7 (0.8)	1.1 (0.8)	3.2 (1.3)	0.043	0.093
40–59	3.3 (0.9)	3.0 (0.8)	3.1 (0.7)	4.8 (0.7)	7.4 (0.8)	7.9 (0.9)	8.3 (0.8)	0.819	<0.001
60	2.4 (0.7)	3.8 (0.9)	3.7 (0.7)	6.1 (0.8)	9.3 (0.9)	10.1 (0.9)	12.0 (0.9)	0.372	<0.001
Sexes									
Men	2.3 (0.6)	2.4 (0.6)	1.5 (0.4)	2.4 (0.5)	3.8 (0.6)	4.1 (0.6)	5.4 (0.6)	0.987	<0.001
Women	4.0 (0.9)	3.1 (0.7)	2.1 (0.5)	4.6 (0.7)	6.0 (0.7)	4.5 (0.6)	7.0 (0.7)	0.653	<0.001
Regions									
Urban	3.2 (0.8)	3.4 (0.8)	2.3 (0.6)	4.4 (0.7)	5.4 (0.8)	6.1 (0.8)	9.5 (1.0)	0.753	<0.001
Rural	2.7 (0.7)	2.3 (0.6)	1.3 (0.4)	2.6 (0.5)	3.8 (0.5)	3.5 (0.5)	4.4 (0.5)	0.542	<0.001
Among those treated									
Total	29.7 (3.2)	42.6 (3.4)	17.4 (2.4)	29.7 (2.1)	32.8 (1.9)	21.4 (1.5)	33.1 (1.6)	0.211	0.008
Age, y									
18–39	40.0 (12.6)	62.5 (17.1)	12.5 (11.7)	35.7 (12.8)	36.4 (14.5)	16.7 (10.8)	37.5 (12.1)	0.349	0.247
40–59	19.5 (4.4)	19.7 (4.6)	25.6 (4.8)	23.5 (3.2)	29.0 (2.9)	28.5 (2.8)	28.8 (2.6)	0.275	0.317
60	12.7 (3.3)	16.4 (3.3)	18.1 (3.2)	20.2 (2.5)	27.0 (2.4)	24.2 (2.1)	25.9 (1.8)	0.269	0.014
Sexes									
Men	35.4 (5.4)	28.6 (4.7)	12.6 (3.1)	23.3 (3.1)	27.9 (2.8)	23.6 (2.4)	30.9 (2.3)	0.267	0.295
Women	26.0 (4.0)	47.6 (4.9)	19.9 (3.6)	37.7 (3.0)	35.2 (2.6)	12.1 (1.6)	39.8 (2.2)	0.504	0.006
Regions									
Urban	24.5 (4.1)	34.1 (4.4)	19.7 (3.5)	27.1 (3.0)	27.7 (2.6)	27.5 (2.4)	47.3 (2.4)	0.304	0.026
Rural	34.4 (5.0)	65.8 (4.9)	12.5 (3.1)	28.7 (3.0)	34.8 (2.8)	17.9 (2.0)	26.6 (2.0)	0.450	0.109

Definitions of awareness, treatment, and control among Chinese hypertensive adults were presented in the Methods section.

Proportions were age-standardized to the China 2000 Census population

^aTime trends in estimated percentages from 1991 to 1997 were assessed by multiple logistical regression analysis with gender, age, region, and BMI adjustment.

^bTime trends in estimated percentages from 1997 to 2009 were assessed by multiple logistical regression analysis with gender, age, region, and BMI adjustment.