Global Health Journal 7 (2023) 24–33

Contents lists available at ScienceDirect

Global Health Journal

journal homepage: https://www.keaipublishing.com/en/journals/global-health-journal/

RESEARCH ARTICLE

A comparison study of prevalence, awareness, treatment and control rates of hypertension and associated factors among adults in China and the United States based on national survey data

Xiaomin Sun[a,1], Xinguang Chen[a,1], Zumin Shi[b], Alice Fang Yan[c], Zhongying Li[a], Shiqi Chen[a], Bingtong Zhao[a], Wen Peng[d], Xi Li[e], Mei Zhang[f], Limin Wang[f], Jing Wu[f,*], Youfa Wang[a,*]

[a] *Global Health Institute, School of Public Health, Xi'an Jiaotong University Health Science Center, Xi'an Jiaotong University, Xi'an, Shaanxi 710061, China*
[b] *Human Nutrition Department, College of Health Sciences, QU Health, Qatar University, Doha 2713, Qatar*
[c] *Department of Research Patient Care Service, Stanford Health Care, Palo Alto, CA 94305, USA*
[d] *Nutrition and Health Promotion Center, Department of Public Health, Medical College, Qinghai University, Xining, Qinghai 810061, China*
[e] *Department of Geriatrics, The Second Affiliated Hospital, Xi'an Jiaotong University Health Science Center, Xi'an Jiaotong University, Xi'an, Shaanxi 710061, China*
[f] *National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing 100050, China*

ARTICLE INFO

Article history:
Received 7 November 2022
Received in revised form 25 January 2023
Accepted 2 February 2023
Available online 4 February 2023

Keywords:
Hypertension
International comparison
Treatment
Obesity
Risk factors

ABSTRACT

Objective: This study compared the prevalence, awareness, treatment and control of hypertension and associated factors in China and the United States (US).
Methods: Adult data from nationally representative samples were derived from the Chronic Disease and Risk Factors Surveillance in 2010 and 2013 in China and the National Health and Nutrition Examination Survey in 2010 and 2013 in the US. Multivariable logistic and Poisson regression analysis were conducted to assess associations of the four outcomes with body weight status and behavioral factors.
Results: Age-standardized prevalence rates of hypertension was 35.7% (95% confidence interval [*CI*]: 35.4% to 36.1%) in 2010 and 29.8% (95% *CI:* 29.4% to 30.2%) in 2013 in China, and 35.3% (95% *CI:* 33.6% to 37.1%) in 2010 and 37.9% (95% *CI:* 36.0% to 39.7%) in 2013 in the US. Among hypertensive participants, the age-standardized rates of treatment were 18.4% (95% *CI:* 17.9% to 18.9%) in 2010 and 23.8% (95% *CI:* 23.1% to 24.6%) in 2013 in China and 54.5% (95% *CI:* 50.3% to 58.7%) in 2010 and 50.9% (95% *CI:* 46.5% to 55.3%) in 2013 in the US; the age-standardized hypertension control rates were 3.2% (95% *CI:* 3.0% to 3.5%) and 5.7% (95% *CI:* 5.3% to 6.0%) in 2010 and 2013 in China and 50.6% (95% *CI:* 46.2% to 55.0%) and 55.3% (95% *CI:* 50.3% to 60.3%) in the US. Obesity was significantly associated with prevalence, awareness and control rates in both countries. Different from the US, obesity was negatively associated with hypertension control in China.
Conclusion: Hypertension prevalence in China is similar to that in the US, but the control rate in China was significantly lower. Obesity was a critical risk factor for poor hypertension control in China.

1. Introduction

Hypertension is a major contributor to the increased morbidity and premature mortality worldwide.[1] In 2021, an estimated 1.28 billion adults aged 30–79 years worldwide had hypertension, and about two-thirds lived in low- and middle-income countries (LMICs).[1] Furthermore, this number is projected to increase to 416.47 million by 2030 in China.[2] Another serious worldwide challenge is that the awareness and management rates of hypertension are low in many LMICs, including China, while the situation is better in high-income countries.[3] Related comparison studies across-countries are limited, but they can offer important insights to help fight hypertension. A comparison study of China, the largest transitional country, and the US, the largest industrialized country, can offer valuable insights into hypertension management for many other countries.

Along with rapid industrialization, urbanization, and modernization, China has witnessed an increase in hypertension prevalence.[4] This is likely due to the shifts in lifestyle factors and the increase in obesity.[5]

* Corresponding authors: youfawang@xjtu.edu.cn (Youfa Wang); wujing@chinacdc.cn (Jing Wu).
[1] Joint first authors.

https://doi.org/10.1016/j.glohj.2023.02.001

To curb the increasing trend in hypertension, the Chinese Center for Disease Control and Prevention (China CDC) launched six national surveys since 2004 to examine the status of and factors related to chronic and non-communicable diseases (NCDs) with hypertension as a priority focus.[6] Findings from these surveys consistently showed high prevalence rates of hypertension (27%–34%) but low rates of awareness (26%–41%), treatment (19%–35%), and control (6%–11%).[7-9]

Previous studies shows that during 1999–2018, hypertension prevalence rates among American adults varied from 28%–32%; among those with hypertension, more than 80% were aware of their diagnosis, over 70% received treatment, and nearly half had their blood pressure under control.[10-11] Although Lu and colleagues compared hypertension related outcomes (prevalence, and the rates of awareness, treatment and control) in adults (45–75 years) using 2011–2012 data from the China Health and Retirement Longitudinal Study and the US National Health and Nutrition Examination Survey (NHANES), the sample was relatively small (12 654 participants in China and 2 607 in the US) and did not included younger participants (< 45 years) that are also at high risk for hypertension.[12] In addition, understanding changes in key outcome measures over time is of great significance for hypertension management. However, few studies have examined these issues and compared their differences between China and the US. Furthermore, studies on factors associated with these hypertension outcomes is essential for precision interventions.

Obesity prevalence in China has been increasing since the 1990s and has become a major public health problem now, with one in every two adults overweight or obese.[13] Obesity is considered as a major determinant of hypertension, accounting for 65% to 75% of primary hypertension.[14] Obesity can also negatively affect the effect of hypertension treatment and control.[15-16] However, this negative influence has not been evaluated using national data in China.

Using nationally representative data from China and the US, this study aimed to: (1) compare the rates of prevalence, awareness, treatment, and control of hypertension between China and the US; and (2) explore factors being associated with these rates. A China-US comparison study will help guide improvements in future intervention strategies in China and other LMICs.

2. Methods and materials

2.1. Data sources and study populations

The 2009–2010 (2010) and 2013–2014 (2013) data for China and the US were derived from the China Chronic Disease and Risk Factors Surveillance (CCDRFS) and the NHANES. The CCDRFS is a data collection system for cross-sectional surveys with nationally representative samples. The system is designed and implemented by the National Center for Chronic and Noncommunicable Disease Control and Prevention, the China CDC. Detailed description about CCDRFS can be found elsewhere.[17] The NHANES as a cross-sectional national survey was launched in the early 1960s and has been conducted by the US National Center for Health Statistics, the US Centers for Disease Control and Prevention. Detailed description of the NHANES can be found elsewhere.[18]

To ensure homogeneity of the study samples, participants were limited to those who were aged ≥ 20 with complete data. Participants who were pregnant (0 in China and 133 in US), or with missing data on key variables such as age, sex, and measured blood pressure (3 668 for the CCDRFS and 1 624 for the NHANES) were excluded, yielding a final sample of 270 779 for China data (94 741 in 2010 and176 038 in 2013) and 10 230 for US data (5 311 in 2010 and 4 919 in 2013). A flow-chart detailing the sample selection is presented in Fig. 1.

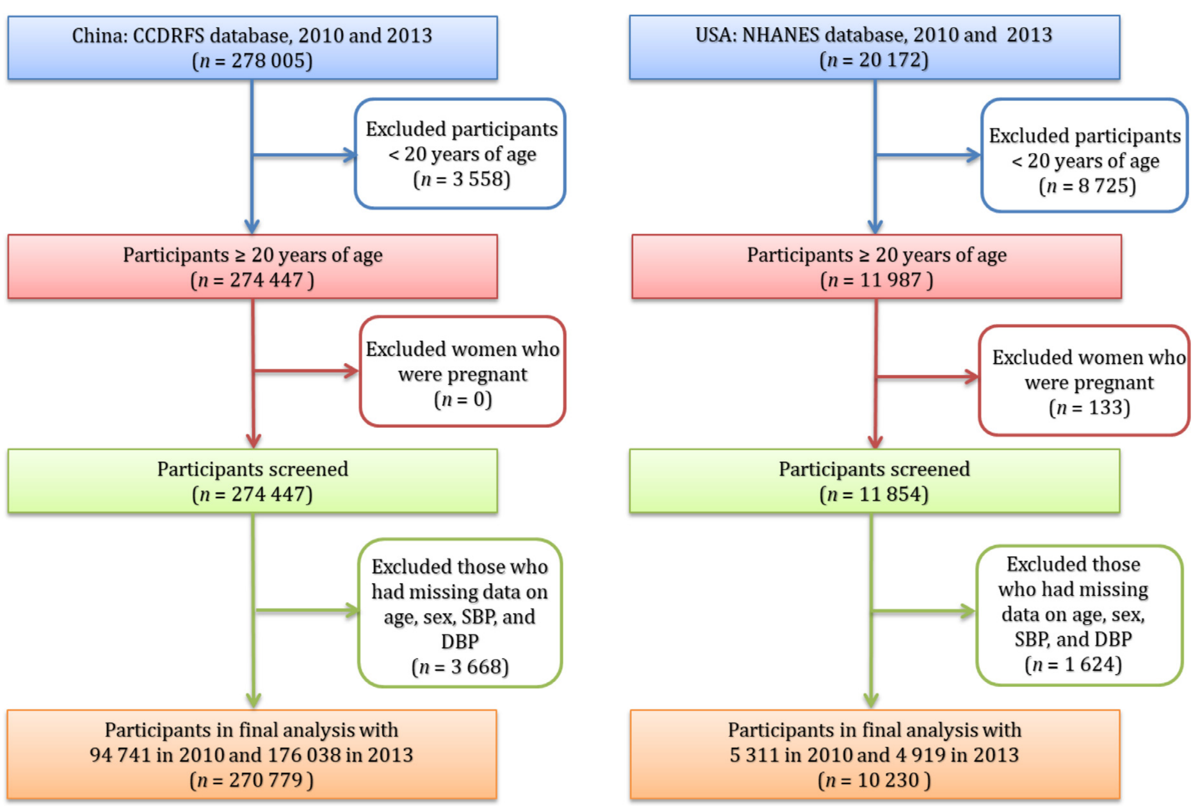

Fig. 1. Flow diagram of study sample sizes.
CCDRFS: The China Chronic Disease and Risk Factors Surveillance; NHANES: US National Health and Nutrition Examination Survey; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

The CCDRFS was approved by the Chinese Center for Disease Control and Prevention ethical review committee and other participating institutions, and NHANES was approved by the National Center for Health Statistics Ethics Review Board. Participants were recruited through written informed consent in both CCDRFS and NHANES.

2.2. Outcome variables

Hypertension: In the CCDRFS, after 5 min rest three consecutive measures of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were assessed using the Omron digital blood pressure monitor (Omron, Dalian, China) with 60 s between each measure. The same protocol was used in the NHANES with blood pressures measured using the mercury sphygmomanometer (W.A. Baum, Copiague, NY).[10] Our primary outcomes were prevalence of hypertension, proportion of people with hypertension who were aware of their disease (awareness), proportion of those taking medication for hypertension (treatment), and proportion of those whose blood pressure was controlled (control).

Based on both the measured BP and survey data, participants were classified as hypertensive if they: (1) responded positively to either of the two survey questions, or (2) the measured mean BP met the WHO criteria (SBP ≥ 140 mmHg or DBP ≥ 90 mmHg).[19]

Both CCDRFS and NHANES collected data to assess the awareness, treatment, and control of hypertension among participants with hypertension: (1) Hypertension awareness was defined based on the response of a participant to the question: "Have you ever been told by a doctor or health professional that you had hypertension, also called high blood pressure?" Participants were coded as 0 (unaware) if they responded negatively to the question, including never measured blood pressure; otherwise, 1 (aware). (2) Hypertension treatment was defined by participant self-reporting taking medication to lower hypertension in the last two weeks (0 = no, 1 = yes). (3) Hypertension control was defined according to the 1999 WHO standard for hypertensive participants.[20] Participants were coded as 1 (under optimal control) if aged 60 years or older with mean SBP < 140 mmHg and DBP < 90 mmHg or 18–59 years old with mean SBP < 130 mmHg and DBP < 85 mmHg, otherwise, 0 (not under control).

2.3. Anthropometry measures and body weight status

For China data, height was measured using mechanical anthropometry stadiometers (Bengbu Equipment; Anhui, China). Weight was measured using electronic body scales with regular calibration. Waist circumference (WC) was measured using torch shape measuring tape (Foshan Equipment, China).

For US data, height was measured using a stadiometer with a fixed vertical backboard and an adjustable head piece. Weight was measured using a digital weight scale. WC was measured using snug tape to the closest 0.1 cm after palpating.

Body mass index (BMI) was calculated as weight (kg) divided by height square (m^2). Using BMI and WC, participants were classified into different weight groups: (1) Chinese criteria (used for China): underweight (< 18.5), normal weight (18.5 to 23.9), overweight (24.0 to 27.9), and general obesity (≥ 28.0); central obesity was defined as a WC ≥ 90 cm in men and ≥ 85 cm in women;[21] and (2) WHO criteria (used for China and the US), underweight (BMI < 18.5), normal weight (18.5 to 24.9), overweight (25.0 to 29.9) and general obesity (≥ 30.0);[22] central obesity was defined as WC ≥ 102 cm (men) and WC ≥ 88 cm (women).[23]

For China-US comparison and consistent with previously published Chinese studies, both the Chinese and WHO criteria were used to assess weight status for China, but only the WHO criteria for the US.

2.4. Covariates and hypertension risk factors

Physical activity (PA) level was estimated from the Global Physical Activity Questionnaire (GPAQ) in both countries. The minutes of physical activity (PA) were converted into metabolic equivalents (METs) and then categorized into three groups according to the GPAQ guideline: low, moderate, or high.[24]

For CCDRFS, current smoker was defined as who self-reported cigarette use every day or some days at the time of survey; former smoker was defined as an adult who self-reported cigarette use in his or her lifetime but who had quit smoking at the time of interview; non-smoker was defined as an adult who self-reported never having smoked in his or her lifetime. Annual drinking frequency was categorized as light (less than once per month/1–3 days/month), moderate (1–4 days/week), or heavy (5–7 days/week) among respondents who consumed alcohol in the past 12 months.

For NHANES, current smoker was defined as an adult who had smoked at least 100 cigarettes and who currently smokes cigarettes; former smoker was defined as an adult who had smoked at least 100 cigarettes in his or her lifetime but who had quit smoking at the time of interview; non-smoker was defined as an adult who had never smoked, or who has smoked fewer than 100 cigarettes in his or her lifetime.[25] Average daily drinking volume was categorized as follows: men were classified as "light drinker" < 1 (operationally < 0 to 0.49) drinks/day, "moderate drinker" 1 to 2 (0.5 to 2.49) drinks/day, and "heavier drinker" ≥ 3 (≥ 2.5) drinks/day; women were categorized as "light drinker" < 1 (< 0 to 0.49) drinks/day, "moderate drinker" 1 (0.5 to 1.49) drinks/day, and "heavier drinker" ≥ 2 (operationally ≥ 1.5) drinks/day.[26]

Sociodemographic factors included age, marital status, education, household income, disease history, and medical insurance coverage. All the measures for both China and US data were based on the same or similar survey questions except for the household income. For China data, household income was classified according to the per capita household income by tertiles, while for the US data, household income was defined using the family poverty income-to-poverty ratio (PIR)[27] with low (≤ 130%), middle (131%–350%), and high (≥ 350%).[9]

2.5. Statistical analysis

Descriptive analysis was conducted to describe the study sample and to obtain point (rate or proportion) and 95% confidence interval (*CI*) estimates for the four outcome variables (prevalence, awareness, treatment, and control of hypertension). Sample weights were used to provide nationally representative estimates; and the estimated rates for China and the US at the national levels were age-standardized using the direct method and the 2010 Census data in China and 2010 projected population data in the US. The estimated 95% *CIs* were used to compare the China-US difference in the outcome measures. An outcome measure was considered as significantly different between China and the US at the $P < 0.05$ level if there was no overlap in the estimated 95% *CIs*.

To explore the associations between the four outcome measures and sociodemographic factors, body weight status, anti-hypertensive therapy and behavioral factors, multivariable logistical regressions were used when an observed event rate was < 10% to avoid overestimate of the prevalence/risk ratio;[28] and Poisson regression was used when an observed event rate was ≥ 10%.

In all statistical models, sociodemographic factors (age, gender, household income, education level, medical insurance) and other risk factors such as drinking, smoking, weight status and diseases history were included. Adjusted odds ratio (*OR*) or prevalence ratio (*PR*) with 95% *CI* was used to measure the associations. In addition, $P < 0.05$ was used for statistical inference.

Statistical analyses were conducted using Stata (version 15.0, StataCorp, College Station, Texas, USA).

Table 1
Characteristics of study samples and potential risk factors of hypertension in China and the US: analysis of nationally representative data from the 2010 and 2013 CCDRFS and NHANES (%).

Characteristics	Total		Hypertensive		Normal blood pressure		P^*	P^{**}
	China (n = 270 779)	The US (n = 10 230)	China (n = 105 529)	The US (n = 4 226)	China (n = 165 250)	The US (n = 6 004)		
Age							0.08	0.51
20–< 40 years	43.1	36.1	20.2	36.1	54.3	49.0		
40–< 60 years	39.3	38.3	45.6	38.3	36.3	38.3		
≥ 60 years	17.6	25.7	34.2	25.7	9.4	12.7		
Gender							0.62	0.62
Man	50.6	49.5	53.5	49.5	49.2	49.0		
Woman	49.4	50.5	46.5	50.5	50.8	51.0		
Marital status							**< 0.01**	**<0.01**
Unmarried	10.4	18.4	4.2	18.4	13.4	23.2		
Married	82.6	63.1	84.3	63.1	81.8	62.8		
Ever-married	7.0	18.5	11.5	18.5	4.8	14.1		
Education							**< 0.01**	**<0.01**
Below high school	73.6	16.9	80.6	16.9	70.1	15.5		
High school or vocational school	16.3	22.2	13.6	22.2	17.7	20.4		
College and above	10.1	60.9	5.8	60.9	12.2	64.1		
Household income[§]							0.08	0.05
Low	34.2	21.0	36.2	21.0	33.3	21.1		
Medium	36.4	40.1	36.1	40.1	36.5	38.9		
High	29.4	38.9	27.7	38.9	30.2	40.0		
Medical insurance[⁎]	98.1	80.7	98.4	80.7	97.9	**76.7**	**< 0.01**	**< 0.01**
Weight status							**< 0.01**	**< 0.01**
Underweight	4.3	1.5	2.2	1.5	5.5	2.0		
Normal weight	50.0	28.9	35.3	28.9	57.1	35.5		
Overweight	32.1	33.9	39.4	33.9	28.5	34.1		
General obesity	13.6	35.6	23.1	35.6	8.9	28.4		
Central obesity[⁎]	28.6	52.9	44.0	52.9	21.1	44.2	**< 0.01**	**< 0.01**
Disease history[⁎]								
Diabetes	10.0	12.0	18.2	12.0	6.0	5.6	0.23	0.99
Cancer	0.7	10.5	9.0	10.5	6.4	7.0	0.09	0.77
Dyslipidemia	58.9	64.3	64.8	64.3	55.5	55.1	**< 0.05**	0.82
Stroke	1.0	2.6	2.4	2.6	0.3	1.0	0.45	0.99
CVDs	0.5	6.6	1.1	6.6	0.3	2.9	**< 0.01**	0.25
Smoking status							**< 0.01**	**< 0.01**
Former smoker	5.1	24.3	7.8	24.3	3.7	20.0		
Current smoker	28.1	20.2	28.1	20.2	28.2	21.6		
Never smoked	66.8	55.5	64.1	55.5	68.1	58.4		
Drinking status							**< 0.01**	**< 0.05**
Light	62.9	63.0	53.7	63.0	67.6	63.0		
Moderate	21.7	31.8	23.8	31.8	20.6	32.0		
Heavier	15.4	5.2	22.5	5.2	11.8	5.1		
Physical activity							**< 0.01**	**< 0.01**
Low	9.0	45.9	10.2	45.9	8.4	40.1		
Moderate	49.2	24.3	47.8	24.3	49.9	26.0		
High	41.8	29.8	42.0	29.8	41.7	33.8		

Bold font indicates statistical significance. Chi-square test was used for categorical variables and t-test (normally distributed) or Wil-coxon rank-sum (not normally distributed) test was used for continuous variable. $^*P$ for hypertension group; $^{**}P$ for normal blood pressure group; [§]Household income of low, medium, and high were determined using tertiles of the per capita household income for China and family income-to-poverty level ratio for the US; [⁎]The proportion of the population who answered were classified into "Yes". CCDRFS: The China Chronic Disease and Risk Factors Surveillance; NHANES: The National Health and Nutrition Examination Survey; CVDs: Cardiovascular diseases.

3. Results

3.1. Prevalence, awareness, treatment, and control of and over time changes in hypertension

Of the total sample, proportions of overweight, obesity and central obesity were 32.1%, 13.6% and 28.6 in China, and 33.9%, 35.6% and 52.9% in the US, respectively. The proportions of overweight, obesity and central obesity were higher in hypertensive participants than those with normal blood pressure in both countries (Table 1).

Table 2 presents the prevalence levels of the four outcomes measured at two times for China and the US. In China, age-standardized prevalence (95% *CI*) of hypertension was 35.7% (95% *CI:* 35.4% to 36.1%) in 2010 and 29.8% (95% *CI:* 29.4% to 30.2%) in 2013, while in the US it was 35.3% (95% *CI:* 33.6% to 37.1%) in 2010 and 37.9% (95% *CI:* 36.0% to 39.7%) in 2013. The rates of awareness, treatment, and control were much lower in China than in the US. For example, only about 1 in 3 Chinese participants knew about their hypertension diagnosis, 1 in 5 received treatment, and 5.7% of them achieved control.

Similar patterns of the four outcome measures, including levels and changes over time were observed for different age- and gender-specific subgroups in both China and the US (P < 0.05 based on the 95% *CI*).

3.2. Associations between weight status and hypertension outcomes

Fig. 2 depicts the four outcome measures by body weight status. First, overweight, general obesity, and central obesity were all associated with higher prevalence in China and the US. Second, although no significant differences in the prevalence between China and the US, the rates of awareness, treatment, and control were lower in China than in the US (P < 0.05), regardless of body weight status.

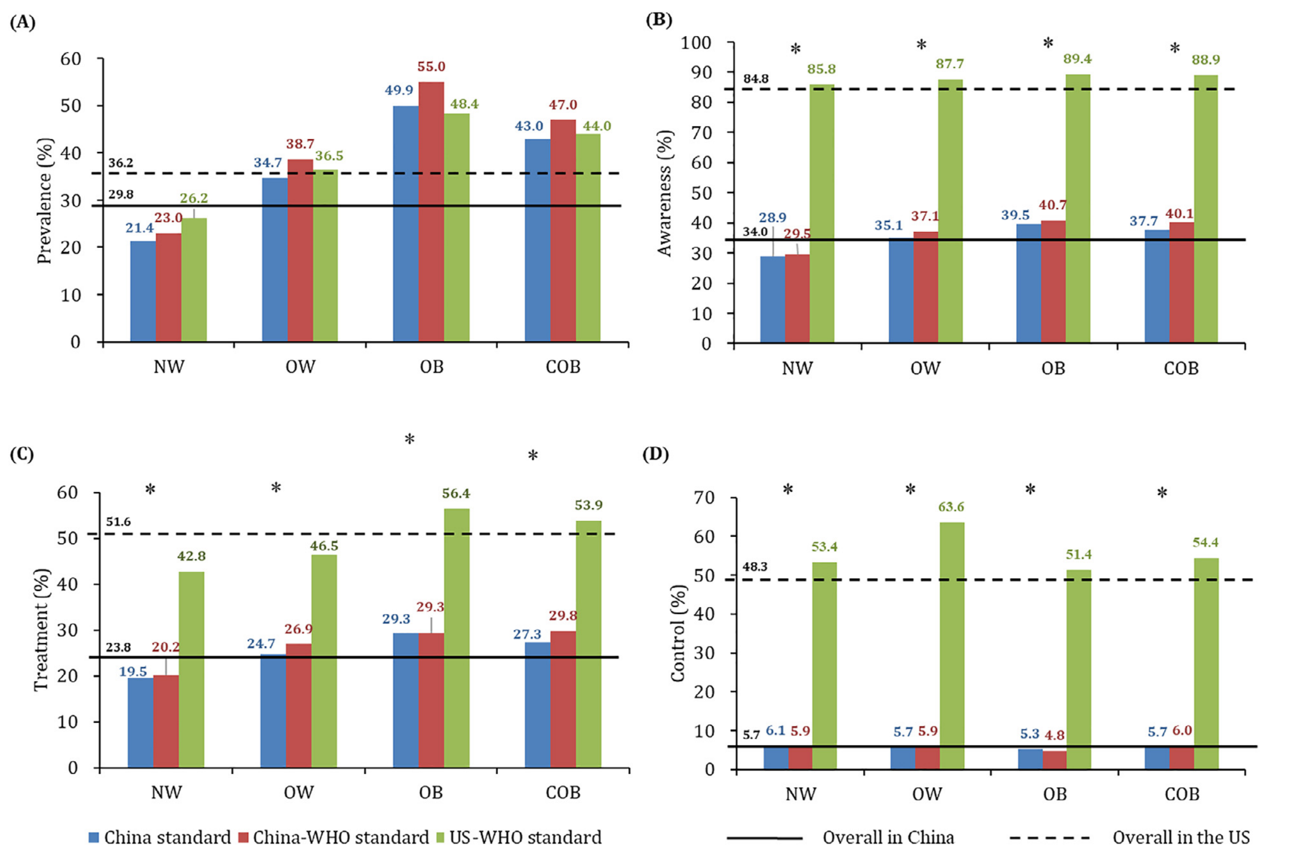

Fig. 2. The age-adjusted prevalence (A), rates of awareness (B), treatment (C), and control (D) of hypertension by weight status in China and the US. The data in 2013 were used for the association analyses. All analyses accounted for sample weights to provide nationally representative estimates. Chi-square test was used between China and the US by weight status according to WHO criteria. $^*P < 0.05$. NW: Normal weight; OW: Overweight; OB: Obesity; COB: Central obesity.

Table 3 indicates that in China, general obesity and central obesity were positively associated with higher hypertension prevalence (general obesity: *PR* 1.94, 95% *CI*: 1.72 to 2.20; central obesity: *PR* 1.25, 95% *CI*: 1.13 to 1.38), awareness (general obesity: *PR* 1.14, 95% *CI*: 1.07 to 1.21; central obesity: *PR* 1.17, 95% *CI*: 1.04 to 1.33), treatment (general obesity: *PR* 1.18, 95% *CI*: 1.10 to 1.27; central obesity: *PR* 1.09, 95% *CI*: 1.04 to 1.15), but with a lower control rate (general obesity: *OR* 0.67, 95% *CI*: 0.55 to 0.82; central obesity: *OR* 0.86, 95% *CI*: 0.75 to 0.99). Similar results were observed in the US except for the association with treatment and control rates.

3.3. Other factors associated with hypertension outcomes

Education was negatively associated with hypertension prevalence for Chinese (*PR* 0.80, 95% *CI*: 0.71to 0.91), and positively associated with hypertension treatment (*PR* 1.17, 95% *CI*: 1.00 to 1.36). High household income was positively associated with hypertension awareness and control rates for Chinese participants (*PR* 1.15, 95% *CI*: 1.03 to 1.28; *OR* 1.82, 95% *CI*: 1.24 to 2.68) but not for American. Higher levels of PA were associated with lower hypertension prevalence in China (*PR* 0.94, 95% *CI*: 0.89 to 0.99) and in the US (*PR* 0.83, 95% *CI*: 0.71 to 0.98). Details of the factors associated with the four outcomes are presented in the Table 3.

3.4. Obesity negatively interacted with antihypertensive medication on hypertension control

Compared with those who did not take hypertensive drugs, participants who had hypertensive drugs were more likely to have their hypertension under control regardless of obesity status for American participants (no-general obese and medication, *PR* 1.98, 95% *CI*: 1.50 to 2.62; general obesity and medication, *PR* 1.49, 95%*CI*: 1.04 to 2.13; no-central obese and medication, *PR* 1.81, 95% *CI*: 1.28 to 2.57; central obese and medication, *PR* 1.69, 95% *CI*: 1.39 to 2.06). Similar results were also observed for Chinese participants except those with general obesity (Table 4).

In the US, both SBP and DBP were relatively higher for participants without antihypertensive medication, while in China only DBP was higher for participants without anti-hypertension medication regardless of their body weight status (Fig. 3).

4. Discussion

To our knowledge, this study is the first that compared hypertension outcomes and associated factors between China and the US using nationally representative data collected over time. There were substantial differences between the two countries in some outcomes: the rates of awareness, treatment, and control in China were much lower than those in the US, but hypertension prevalence was similarly high in both countries. High levels of education, household income and PA were positively related with hypertension management in China, but only higher household income was positively associated with treatment in the US. Moreover, those who used antihypertensive drug were more likely to have their blood pressure under control regardless of obesity status for both countries, except for those who had obesity in China.

4.1. High rates of prevalence and low rates of awareness, treatment and control of hypertension in China

Compared to the US, China is much less developed; however, the prevalence of hypertension in China is comparable to that in the US.

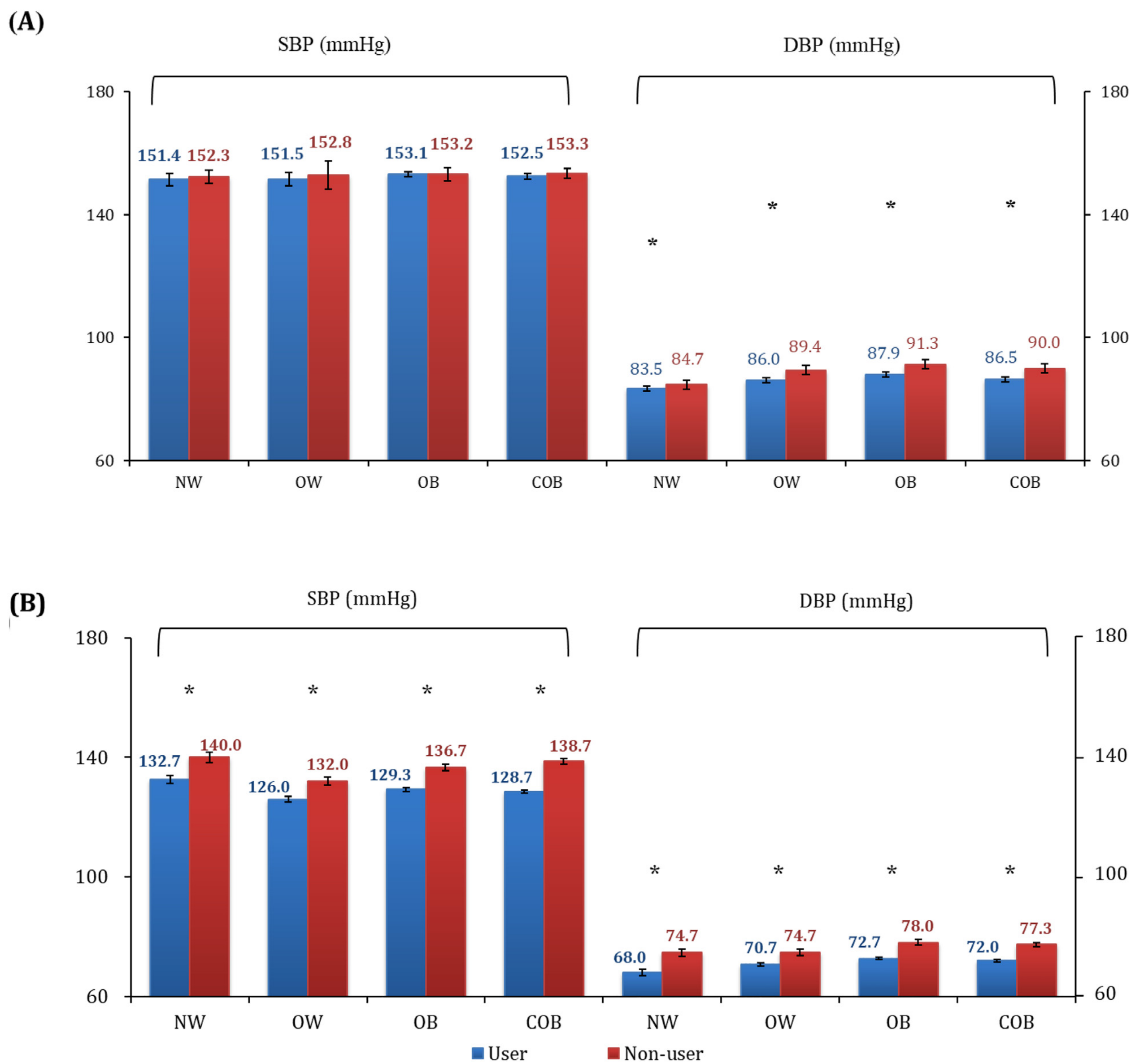

Fig. 3. Mean systolic and diastolic blood pressure (mmHg) among hypertensive adults using antihypertensive medications by weight status in China (A) and the US (B).

In China, we used Chinese weight standard and in the US, we used the US weight standard. The data in 2013 were used for the association analyses. All analyses accounted for sample weights to provide nationally representative estimates. * There were significant differences in blood pressure between users and non-users by *t*-tests ($P < 0.05$). NW: Normal weight; OW: Overweight; OB: Obesity; COB: Central obesity; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

More alarming than the high prevalence are the lower rates of awareness, treatment, and control of hypertension in China than in the US. Only 30%–34% patients with hypertension in China are aware of their status, compared to 83%–85% in the US. Fortunately, there is a recent decline in hypertension prevalence in China probably due to several national health promotion programs, including the Lifestyle for All program started in 2007 and the Healthy China 2020 launched in 2009.[29-30] These national health programs are designated to encourage healthier lifestyle and promote risk reduction behaviors. Studies are needed to document the effect and to investigate mechanisms of these program for blood pressure control.

Among the three indicators of hypertension awareness, treatment, and control in China, addressing the low rates of awareness is a priority step toward the optimal control of hypertension and other NCDs. Although the awareness and treatment rates increased a bit during 2010–2013, the rates are much lower than those in the US. By contrast, the US performed better in controlling hypertension. Reported studies suggest the role of strong healthcare systems and some evidence-based public health intervention programs (e.g., Life's Simple 7 program).[31] These programs were launched in the 1960–1970s.[29-30] Although China has launched several health promotion programs recently, these programs started much later. Greater efforts are needed to enhance the awareness, to strengthen the health system for prevention by integrating hypertension screening and follow-up services into the routine primary care practice.

Economic development creates an economic disparity in society, leaving hunger and malnutrition among the poor unresolved, and increasing hypertension due to overnutrition among the wealthy. Aging with accompanying unhealthy lifestyle further exacerbated the disparity in low and middle income countries (LMICs). The rates of hypertension awareness, treatment, and control in high-income countries (HICs) were at least twice higher than those in LMICs over the past decade.[32] For ex-

Table 2
Differences in the age-standardized prevalence, awareness, treatment and control rates of hypertension in China and the US (2010–2013) [% (95% *CI*)].

Item	Prevalence		Awareness		Treatment		Under control	
	China	The US	China	The US	China	The US	China	The US
Overall								
Time 1†	35.7 (35.4 to 36.1)	35.3 (33.6 to 37.1)	29.6 (28.9 to 30.3)	83.1 (79.5 to 86.8)	18.4 (17.9 to 18.9)	54.5 (50.3 to 58.7)	3.2 (3.0 to 3.5)	50.6 (46.2 to 55.0)
Time 2‡	29.8 (29.4 to 30.2)	37.9 (36.0 to 39.7)	34.0 (33.1 to 34.9)	88.2 (85.2 to 91.2)	23.8 (23.1 to 24.6)	50.9 (46.5 to 55.3)	5.7 (5.3 to 6.0)	55.3 (50.3 to 60.3)
Gender								
Male								
Time 1†	37.6 (37.1 to 38.2)	36.6 (33.5 to 39.7)	28.2 (27.2 to 29.1)	80.3 (76.3 to 84.2)	16.7 (16.0 to 17.3)	50.2 (45.1 to 55.4)	2.8 (2.5 to 3.1)	45.6 (40.8 to 50.4)
Time 2‡	32.1 (31.5 to 32.6)	39.2 (37.0 to 41.5)	31.8 (30.6 to 32.9)	84.7 (79.9 to 89.5)	21.7 (20.7 to 22.7)	48.9 (44.0 to 53.9)	5.2 (4.7 to 5.6)	51.4 (44.1 to 58.6)
Female								
Time 1†	33.7 (33.2 to 34.1)	33.9 (32.4 to 35.4)	31.3 (30.2 to 32.4)	87.1 (82.6 to 91.6)	20.5(19.7 to 21.4)	60.3 (55.7 to 64.8)	3.9 (3.5 to 4.4)	58.2 (51.8 to 64.6)
Time 2‡	27.5 (27.0 to 28.0)	36.4 (33.7 to 39.1)	37.0 (35.5 to 38.5)	92.5 (90.4 to 94.6)	26.5 (25.3 to 27.7)	53.3 (47.8 to 58.8)	6.4 (5.8 to 7.1)	60.9 (54.8 to 67.0)
Age								
20–< 40 years								
Time 1†	17.2 (16.6 to 17.8)	12.5 (10.3 to 14.6)	18.1 (16.7 to 19.4)	78.5 (71.3 to 85.6)	7.7 (6.8 to 8.6)	26.1 (19.5 to 32.7)	2.5 (2.0 to 2.9)	51.1 (39.8 to 62.5)
Time 2‡	13.7 (13.0 to 14.4)	15.8 (13.5 to 18.1)	20.1 (18.3 to 22.0)	89.2 (84.8 to 93.5)	11.7 (10.2 to 13.3)	24.2 (18.6 to 29.9)	3.0 (2.4 to 3.7)	58.3 (52.1 to 64.4)
40–< 60 years								
Time 1†	42.1 (41.5 to 42.6)	34.6 (30.6 to 38.6)	35.8 (35.0 to 36.7)	86.1 (81.8 to 90.4)	23.5 (22.8 to 24.3)	66.3 (61.2 to 71.5)	2.8 (2.5 to 3.1)	45.0 (40.7 to 49.4)
Time 2‡	34.1 (33.6 to 34.6)	38.9 (35.5 to 42.4)	41.9 (41.0 to 42.8)	86.6 (81.2 to 91.9)	29.6 (28.8 to 30.4)	58.2 (49.0 to 67.4)	5.4 (5.0 to 5.8)	50.1 (43.5 to 56.6)
≥ 60 years								
Time 1†	68.1 (67.3 to 69.0)	69.6 (66.2 to 73.0)	44.6 (43.5 to 45.6)	85.4 (82.2 to 88.6)	34.1 (33.1 to 35.1)	77.9 (73.8 to 82.1)	6.0 (5.5 to 6.5)	58.1 (53.9 to 62.3)
Time 2‡	60.6 (59.8 to 61.4)	68.3 (65.3 to 71.3)	51.4 (50.4 to 52.4)	89.2 (86.9 to 91.5)	41.5 (40.4 to 42.5)	78.6 (74.2 to 82.9)	12.7 (11.9 to 13.5)	58.9 (54.1 to 63.8)

No overlap in the 95% confidence interval of the estimated prevalence indicates significant changes over time as well as significantly difference between China and the US at $P < 0.05$ level. †Time 1: 2010 for China and the US; ‡Time 2: 2013 for China and the US. *CI*: Confidence interval.

ample, Japan and Australia had a higher prevalence and higher rates of awareness, treatment and control of hypertension, compared with China.[3] The control rate may be as low as around 5%–10% in China and about 20%–30% in Japan and Australia.[3]

4.2. Significant differences in the associations of hypertension outcomes with risk factors

To our surprise, overall, similar risk factors for hypertension were found for participants in China and the US. These factors include older age, overweight/obesity, and less PA. This result suggests the need for China to learn from the US to improve hypertension control at the population level. Experience in the US and other countries demonstrate the fundamental role of modifiable risk factors for hypertension control among aging societies across the globe.[33]

One exceptional finding of our study is that low educational level and male gender were directly associated with hypertension prevalence only in the China, but not in the US. Over the past two decades, China has experienced rapid economic growth,[34] accompanied by increases in adverse health-related behaviors, including insufficient physical activity and low fruit/vegetable intake.[13] Further studies are needed to examine if these factors play a role in China. Older age, higher income, and higher PA were associated with hypertension awareness in China, but not in the US. These findings are very useful to prioritize subpopulations for targeted interventions, including those who are younger than 40 years of age with low household incomes.

Promoting PA may also enhance people's awareness of their blood pressure status. PA is associated with both hypertension and awareness in China, but not in the US. Due to China's rapid urbanization, occupational and domestic PA significantly declines over the last decades, but it was still in a high level (≥150 min/week, 84.0% in 2013 and 78.0% in 2018).[35] On contrast, in the US, the PA was relatively lower (≥150 min/week, 49.9% in 2013 and 54.2% in 2018), and remain relatively stable (0.9 /years) during 2008–2018.[36] Participants who were aware of their condition were more likely to adopt intervention including increased PA. However, how to develop or maintain regular PA is still a big challenge. This may give an explanation that no positive associations among PA and hypertension treatment and control rates were observed in both countries.

It is worth mentioning the lack of associations of several key risk factors (e.g., higher income, and more PA) in the US. This could be due to the effective antihypertensive medication and adherence (the US vs. China 51.3% vs. 17.7%).[37] When the intervention reached its ceiling, common risk factors will become insignificant, since the treatment might have successfully reached all individuals regardless of income and PA. This evidence provides further evidence supporting the need for China to promote hypertension treatment adherence. Finally, overweight and obesity are positively associated with awareness in both China and the US. It seems participants with overweight and obesity are more likely to recognize their health status.

4.3. Antihypertensive treatment modifies the effect of obesity on hypertension control

Another important finding of this study is that the use of antihypertensive drugs significantly modified the effect of central obesity to achieve hypertension control for both countries, but not general obesity in China. This finding is consistent with previous studies.[15,38] For example, the joint statement of the European Associations of Obesity and Hypertension demonstrated people with obesity require two or more antihypertensive drugs.[15]

How to combine weight loss strategies with antihypertensive treatment to achieve an optimal clinical outcome has not been resolved. This is also a serious challenge in China given its high prevalence of overweight and obesity among adults (> 50%). Obesity is not widely recognized as a disease in China yet.[13,21] Asians are found to have a

Table 3
Factors associated with prevalence, awareness, treatment, and control of hypertension in China and the US using 2013 data [*PR* (95% *CI*)].

Variables	Prevalence[#]		Awareness[†]		Treatment[†]		Control[†]	
	China	The US	China	The US	China	The US	China	The US
Age								
20–<40 years	REF	REF	REF	REF	REF	REF	REF	REF
40–< 60 years	**1.72 (1.57 to 1.90)**	**1.94 (1.63 to 2.32)**	**1.91 (1.59 to 2.31)**	0.95 (0.88 to 1.03)	**2.37 (1.83 to 3.08)**	**1.91 (1.40 to 2.60)**	**2.60 (1.48 to 4.56)**	0.90 (0.71 to 1.14)
≥ 60 years	**2.52 (2.26 to 2.80)**	**2.82 (2.35 to 3.40)**	**2.07 (1.69 to 2.54)**	0.96 (0.91 to 1.02)	**3.02 (2.28 to 3.99)**	**2.34 (1.83 to 3.01)**	**6.24 (3.46 to 11.25)**	0.99 (0.81 to 1.21)
Gender								
Man	REF	REF	REF	REF	REF	REF	REF	REF
Woman	**0.75 (0.65 to 0.87)**	1.00 (0.93 to 1.07)	1.03 (0.84 to 1.26)	1.05 (1.00 to 1.10)	1.05 (0.80 to 1.37)	1.08 (0.98 to 1.18)	1.04 (0.58 to 1.85)	1.11 (0.99 to 1.25)
Education								
Below high school	REF	REF	REF	REF	REF	REF	REF	REF
High or vocational school	0.96 (0.88 to 1.05)	1.10 (0.96 to 1.26)	1.05 (0.90 to 1.23)	1.00 (0.92 to 1.08)	1.14 (0.94 to 1.39)	0.94 (0.80 to 1.10)	0.88 (0.53 to 1.48)	1.08 (0.89 to 1.32)
College and above	**0.80 (0.71 to 0.91)**	0.94 (0.80 to 1.11)	1.12(0.93 to 1.34)	1.04 (0.98 to 1.09)	**1.17 (1.00 to 1.36)**	0.94 (0.87 to 1.01)	1.08 (0.65 to 1.80)	1.16 (0.99 to 1.36)
Household income								
Low	REF	REF	REF	REF	REF	REF	REF	REF
Middle	0.94 (0.86 to 1.02)	0.93 (0.81 to 1.07)	1.07 (0.94 to 1.21)	1.00 (0.97 to 1.04)	0.86 (0.73 to 1.02)	**1.07 (1.01 to 1.14)**	1.15 (0.75 to 1.77)	1.00 (0.87 to 1.16)
High	0.95 (0.87 to 1.03)	0.94 (0.83 to 1.06)	**1.15 (1.03 to 1.28)**	0.96 (0.92 to 1.00)	1.03 (0.89 to 1.19)	1.00 (0.89 to 1.11)	**1.82 (1.24 to 2.68)**	0.97 (0.82 to 1.13)
Weight status								
Normal weight	REF	REF	REF	REF	REF	REF	REF	REF
Overweight	**1.46 (1.32 to 1.62)**	**1.29 (1.09 to 1.53)**	**1.07 (1.02 to 1.13)**	**1.11 (1.05 to 1.17)**	**1.08 (1.02 to 1.15)**	1.05 (0.91 to 1.21)	**0.82 (0.71 to 0.95)**	**1.38 (1.14 to 1.68)**
General obesity	**1.94 (1.72 to 2.20)**	**1.53 (1.31 to 1.79)**	**1.14 (1.07 to 1.21)**	**1.13 (1.04 to 1.23)**	**1.18 (1.10 to 1.27)**	1.13 (0.98 to 1.30)	**0.67 (0.55 to 0.82)**	**1.24 (1.02 to 1.52)**
Central obesity								
No	REF	REF	REF	REF	REF	REF	REF	REF
Yes	**1.25 (1.13 to 1.38)**	**1.14 (1.02 to 1.28)**	**1.17 (1.04 to 1.33)**	0.98 (0.94 to 1.03)	**1.09 (1.04 to 1.15)**	1.01 (0.89 to 1.14)	**0.86 (0.75 to 0.99)**	0.94 (0.77 to 1.15)
Physical activity								
Low	REF	REF	REF	REF	REF	REF	REF	REF
Moderate	**0.94 (0.89 to 0.99)**	**0.83 (0.71 to 0.98)**	1.04 (0.98 to 1.11)	0.99 (0.93 to 1.06)	1.01 (0.95 to 1.09)	1.01 (0.89 to 1.15)	0.66 (0.40 to 1.09)	0.98 (0.87 to 1.10)
High	**0.95 (0.90 to 1.00)**	**0.82 (0.73 to 0.91)**	**1.07 (1.01 to 1.14)**	0.98 (0.86 to 1.11)	1.03 (0.96 to 1.10)	1.08 (0.95 to 1.23)	0.66 (0.39 to 1.11)	1.04 (0.88 to 1.22)

Bold font indicates statistical significance. Multivariable logistic regression was used when an observed event rate was < 10%, while Poisson regression was used when an observed event rate was ≥ 10%. Sample weights are considered in all analyses to provide nationally representative estimates. Covariates included in all regression models were age, gender, smoking status, drinking status, household income, education level, medical insurance, BMI, central obesity and disease history. The values in bold indicate statistically significant.[#]Prevalence rates of hypertension were for participants 20 years old and older; [†]Rates of awareness, treatment and control were computed among patients with hypertension. *OR*: Odd ratio; *PR*: Prevalence ratio; *CI*: Confidence interval; REF: Reference.

Table 4
Interactions between obesity (general obesity and central obesity) and antihypertensive medication on blood pressure control among hypertensive adults in China and the US using 2013 data.

Obesity-antihypertensive medication interaction	China [*OR* (95% *CI*)]	The US [*PR* (95%*CI*)]
General obesity		
No obese		
No medication	REF	REF
Medication	**2.42 (1.96 to 2.98)**	**1.98 (1.50 to 2.62)**
Obese		
No medication	REF	REF
Medication	1.27 (0.81 to 2.00)	**1.49 (1.04 to 2.13)**
Central obesity		
No obese		
No medication	REF	REF
Medication	**2.53 (1.99 to 3.21)**	**1.81 (1.28 to 2.57)**
Obese		
No medication	REF	REF
Medication	**1.75 (1.35 to 2.27)**	**1.69 (1.39 to 2.06)**

Bold font indicates statistical significance. All analyses accounted for sampling weights to provide nationally representative estimates. Covariates included in all regression models were age, gender, smoking status, drinking status, household income, education level, medical insurance, body mass index, central obesity and disease history. *OR*: Odd ratio; *PR*: Prevalence ratio; *CI*: Confidence interval; REF: Reference.

higher body fat content and visceral fatness with the same age, gender, and BMI, when compared to with Caucasians.[39] Based on the above evidence, we proposed individuals who were classified as general obesity are more likely to have central obesity who may have antihypertensive drugs previously, contributing to the disparity in general and central obesity group in China.

Furthermore, some clinicians are reluctant to use weight-loss and antihypertensive medications due to safety concerns until they had serious related metabolic disorder in China.[40] These approaches may explain, at least in part, the lack of modification effect of antihypertensive medication on hypertension control. Besides, the success of hypertension control in a challenging diverse cultural, and racial and ethnic settings in the US encourages China to promote health weight and to increase awareness, treatment for effective hypertension control.

4.4. Strengths and limitations

This study has several strengths. First, it focused on a comparison of China, the largest transitional country, with the US, the largest industrialized country. The study findings are of great significance in global efforts for chronic disease prevention and control. Second, data we used were pulled from the CCDRFS in China and the NHANES in the US, two authoritative sources with good data quality. Third, both status and over time changes in the target outcomes are studied.

This study has limitations. The data used are cross-sectional in nature. Thus, causality cannot be inferred. Second, we could not use more updated data from China. Third, in order to make the China-US comparisons more meaningful and with available data, we only chose medication for both countries to define the treatment. Finally, the definitions of several covariates (e.g., current smoking, drinking and income levels) used in China and the US are different. Caution is needed while interpreting such results.

4.5. Perspectives and recommendations

China, with the largest population globally, has made good progress overall. Along with rapid economic growth, hypertension prevalence in China is similar to that in the US, but its awareness, treatment, and control rates are still much lower. With effective national intervention efforts, these rates in China can be improved to become similar to the US. These may be true for other LMICs as well.

Our study further revealed that hypertension management had significant age- and gender disparities in China and the US. To effectively control hypertension, vigorous population-specific interventions are needed to help prevent and treat obesity and NCDs. In addition, public health education programs need to promote healthy lifestyles, such as healthy eating, physical activity, and tobacco control.

To achieve the national goals presented in "Healthy China 2030," we recommend that public health professionals and policymakers in China need recognize obesity as a chronic disease, support life-course health promotion programs, and engage all stakeholders from schools, communities, healthcare systems, and the related industries to promote public health.

5. Conclusion

This study is the first to systematically compare the status and changes in hypertension outcomes in China and the US. China has a similar prevalence as the US. Hypertension awareness, treatment, and control rates increased over time in China but remained low and were much lower than in the US. Some social demographic and lifestyle factors and weight status were associated with hypertension outcomes. Effective national intervention efforts can improve these rates in China to become similar to those in the US. Findings from this study provide valuable insights for other LMICs as well.

Availability of data and materials

The China datasets generated and analyzed during the current study are not publicly available due privacy and ethical restrictions. The US datasets analyzed during the current study are available in the NHANES (https://wwwn.cdc.gov/nchs/nhanes/Default.aspx).

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Xiaomin Sun: Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft. **Xinguang Chen:** Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft. **Zumin Shi:** Methodology, Writing – review & editing. **Alice Fang Yan:** Methodology, Writing – review & editing. **Zhongying Li:** Methodology, Writing – review & editing. **Shiqi Chen:** Methodology, Writing – review & editing. **Bingtong Zhao:** Methodology, Writing – review & editing. **Wen Peng:** Data curation, Project administration, Writing – review & editing. **Xi Li:** Data curation, Project administration, Writing – review & editing. **Mei Zhang:** Data curation, Project administration, Writing – review & editing. **Limin Wang:** Data curation, Project administration, Writing – review & editing. **Jing Wu:** Conceptualization, Project administration, Writing – review & editing, Funding acquisition. **Youfa Wang:** Conceptualization, Project administration, Writing – review & editing, Funding acquisition.

Ethics approval and consent to participate

The CCDRFS was approved by the Chinese Center for Disease Control and Prevention ethical review committee and other participating institutes, and NHANES was approved by the National Center for Health Statistics Ethics Review Board; participants in both studies gave written informed consent.

Funding

The study was supported in part by research grants from the National Key Research and Development Program of China (Grant Number: 2017YFC0907200 and 2017YFC0907201).

References

1. Hypertension. World Health Organization website. https://www.who.int/news-room/fact-sheets/detail/hypertension.htm. Accessed December 20, 2022.
2. Sun X, Yan AF, Shi Z, et al. Health consequences of obesity and projected future obesity health burden in China. *Obesity (Silver Spring)*. 2022;30(9):1724-1751.
3. NCD Risk Factor Collaboration. Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. *Lancet*. 2021;398(10304):957-980.
4. Bao MY, Wang LN. The longitudinal trend of hypertension prevalence in Chinese adults from 1959 to 2018: a systematic review and meta-analysis. *Ann Palliat Med*. 2020;9(5):2485-2497.
5. Lu J, Lu Y, Wang X, et al. Prevalence, awareness, treatment, and control of hypertension in China: data from 1.7 million adults in a population-based screening study (China PEACE million persons project). *Lancet*. 2017;390(10112):2549-2558.
6. Zhang M, Wang L, Wu J, et al. Data resource profile: china chronic disease and risk factor surveillance (CCDRFS). *Int J Epidemiol*. 2021;51(2):e1-e8.
7. Guan Y, Zhang M, Zhang X, et al. Hypertension prevalence, awareness, treatment, control, and associated factors in the labor force population-China, 2015. *China CDC Wkly*. 2020;2(10):147-155.
8. Zhang M, Wu J, Zhang X, et al. Prevalence and control of hypertension in adults in China, 2018. *Chin J Epidemiol*. 2021;42(10):1780-1789.
9. Li Y, Yang L, Wang L, et al. Burden of hypertension in China: a nationally representative survey of 174,621 adults. *Int J Cardiol*. 2017;227:516-523.
10. Zhang YY, Moran AE. Trends in the prevalence, awareness, treatment, and control of hypertension among young adults in the United States, 1999 to 2014. *Hypertension*. 2017;70(4):736-742.
11. Rana J, Oldroyd J, Islam MM, Tarazona-Meza CE, Islam RM. Prevalence of hypertension and controlled hypertension among United States adults: evidence from NHANES 2017–18 survey. *Int J Cardiol Hyper*. 2020;7:100061.
12. Lu Y, Wang P, Zhou T, et al. Comparison of prevalence, awareness, treatment, and control of cardiovascular risk factors in China and the United States. *J Am Heart Assoc*. 2018;7(3).
13. Wang Y, Zhao L, Gao L, Pan A, Xue H. Health policy and public health implications of obesity in China. *Lancet Diabetes Endocrinol*. 2021;9(7):446-461.
14. Hall JE, do Carmo JM, da Silva AA, Wang Z, Hall ME. Obesity-induced hypertension interaction of neurohumoral and renal mechanisms. *Circ Res*. 2015;116(6):991-1006.
15. Straznicky N, Grassi G, Esler M, et al. European Society of Hypertension Working Group on Obesity antihypertensive effects of weight loss: myth or reality? *J Hypertens*. 2010;28(4):637-643.
16. Hall ME, Cohen JB, Ard JD, et al. Weight-loss strategies for prevention and treatment of hypertension: a scientific statement from the American Heart Association. *Hypertension*. 2021;78(5):e38-e50.
17. Wang L, Gao P, Zhang M, et al. Prevalence and ethnic pattern of diabetes and prediabetes in China in 2013. *JAMA*. 2017;317(24):2515-2523.
18. National Health and Nutrition Examination Survey. US centres for disease control and prevention website. https://www.cdc.gov/nchs/nhanes/index.htm. Accessed July 22, 2019.
19. Campbell NRC, Paccot Burnens M, Whelton PK, et al. 2021 World Health Organization guideline on pharmacological treatment of hypertension: policy implications for the region of the Americas. *Lancet Reg Health Am*. 2022;9: 100219.
20. Chalmers J, MacMahon S, Mancia G, et al. 1999 World Health Organization-International Society of Hypertension Guidelines for the management of hypertension. Guidelines sub-committee of the World Health Organization. *Clin Exp Hypertens*. 1999;21(5-6):1009-1060.
21. Wang Y, Sun M, Yang Y. *China Blue Paper On Obesity Prevention and Control*. Beijing: Peking University Medical Publisher; 2019.
22. Obesity and overweight. World Health Organization website. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.pdf. Accessed January 25, 2023.
23. Ross R, Neeland IJ, Yamashita S, et al. Waist circumference as a vital sign in clinical practice: a consensus statement from the IAS and ICCR working group on visceral obesity. *Nat Rev Endocrinol*. 2020;16(3):177-189.
24. Rudolf K, Lammer F, Stassen G, Frobose I, Schaller A. Show cards of the global physical activity questionnaire (GPAQ) - do they impact validity? A crossover study. *BMC Public Health*. 2020;20(1):223.
25. Adult tobacco use information. U.S. Centers for Disease Control and Prevention. https://www.cdc.gov/nchs/nhis/tobacco/tobacco_glossary.htm. Accessed December 14, 2022.
26. 2015–2020 dietary guidelines. U.S. Department of Health and Human Services website. https://health.gov/our-work/nutrition-physical-activity/dietary-guidelines/previous-dietary-guidelines/2015. Accessed January 25, 2023.
27. Gahche JJ, Bailey RL, Potischman N, Dwyer JT. Dietary supplement use was very high among older adults in the United States in 2011–2014. *J Nutr*. 2017;147(10):1968-1976.
28. Martinez BAF, Leotti VB, Silva GDE, Nunes LN, Machado G, Corbellini LG. Odds ratio or prevalence ratio? An overview of reported statistical methods and appropriateness of interpretations in cross-sectional studies with dichotomous outcomes in veterinary medicine. *Front Vet Sci*. 2017;4:193.
29. Wu FG, Zhang L, Guo WB, et al. Evaluation of China healthy lifestyle for all interventions based on RE-AIM framework - China, 2007–2020. *China CDC Wkly*. 2022;4(19):403-406.
30. The Lancet Public Health. China's health reform: 10 years on. *Lancet Public Health*. 2019;4(9):e431.
31. Mahato P, Ganesh R, Hanumanthu BK, et al. Implementation of the 2017 American College of Cardiology/American Heart Association Guidelines on Hypertension in Clinical Practice. *Ochsner J*. 2021;21(3):254-260.
32. Mills KT, Bundy JD, Kelly TN, et al. Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. *Circulation*. 2016;134(6):441-450.
33. Diabetes. World Health Organization website. https://www.who.int/news-room/fact-sheets/detail/diabetes.pdf. Accessed January 5, 2022.
34. Wang L, Zhou B, Zhao Z, et al. Body-mass index and obesity in urban and rural China: findings from consecutive nationally representative surveys during 2004–18. *Lancet*. 2021;398(10294):53-63.
35. Wang L, Peng W, Zhao Z, et al. Prevalence and treatment of diabetes in China, 2013–2018. *JAMA*. 2021;326(24):2498-2506.
36. 2008 Physical Activity Guidelines for Americans. U.S. Centers for Disease Control and Prevention website. https://www.cdc.gov/physicalactivity/downloads/trends-inthe-prevalence-of-physical-activity-508.pdf. Accessed January 5, 2023.
37. Gao WJ, Liu H, Ge CY, et al. A clinical prediction model of medication adherence in hypertensive patients in a Chinese community hospital in Beijing. *Am J Hypertens*. 2020;33(11):1038-1046.
38. Schmieder RE, Gatzka C, Schächinger H, Schobel H, Rüddel H. Obesity as a determinant for response to antihypertensive treatment. *BMJ*. 1993;307(6903):537-540.
39. Williams R, Periasamy M. Genetic and environmental factors contributing to visceral adiposity in Asian populations. *Endocrinol Metab*. 2020;35(4):681-695.
40. Zeng Q, Li N, Pan XF, Chen L, Pan A. Clinical management and treatment of obesity in China. *Lancet Diabetes Endocrinol*. 2021;9(6):393-405.