International Journal of Cardiology 227 (2017) 516–523

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Burden of hypertension in China: A nationally representative survey of 174,621 adults

Yichong Li [a,1,2], Ling Yang [b,1,2], Limin Wang [a,1], Mei Zhang [a,1], Zhengjing Huang [a,1], Qian Deng [a,1], Maigeng Zhou [a,1], Zhengming Chen [b,*,1], Linhong Wang [a,**,1]

[a] National Center for Chronic and Non-communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing 100050, China
[b] Clinical Trial Service Unit and Epidemiological Studies Unit (CTSU), University of Oxford, UK

ARTICLE INFO

Article history:
Received 14 June 2016
Accepted 30 October 2016
Available online 2 November 2016

Keywords:
Hypertension
Prevalence
Cross-sectional studies
Epidemiology
China

ABSTRACT

Background: Hypertension is a major cause of cardiovascular disease. Periodic nationwide surveys are essential for monitoring secular trend of hypertension and its control in population. We assessed prevalence of hypertension and related awareness, treatment and control rates in Chinese adults in 2013–14.
Methods: A nationally representative survey recruited 174,621 adults aged > 18 years from 31 provinces in mainland China between 2013 and 2014. Population-weighted prevalence of hypertension and related rates of awareness, treatment and control were calculated and compared by age, sex, region and other factors of interest.
Results: Overall, 27.8% of Chinese adults were hypertensive, with the adjusted prevalence higher in men than in women and increasing steeply with rising age. Of those with hypertension, 31.9% were previously diagnosed, of those diagnosed, 82.9% were treated, and of those treated, 34.6% had their blood pressure properly controlled, resulting in an overall control rates of 9.7% among those with hypertension. Despite similar prevalence, the awareness, treatment and control were much better in urban areas than in rural areas. Among hypertensive individuals, older age, higher levels of education or household income tended to be associated with better awareness, treatment and control rates. During 2013–14, 292 million adults in China had hypertension, representing an absolute increase of 139 million individuals since year 2002.
Conclusions: Among Chinese adults, more than one forth had hypertension and the prevalence has increased significantly during recent decades. Despite huge efforts, the levels of awareness, treatment and control rates of hypertension remain extremely low, foreshadowing substantial unnecessary disease burden.

1. Introduction

Hypertension is a leading cause of mortality and disability, causing almost 10 million deaths globally in 2013 [1]. In China, it accounted for 2.5 million deaths (28% of total deaths) and 15% of total disability-adjusted life-years in 2013, mainly from stroke and ischaemic heart disease [1,2]. It is well-established that appropriate control of hypertension, through drug therapy and/or lifestyle changes, can result in a significant reduction in cardiovascular morbidity and mortality [3–5].

Over the last several decades, large population surveys of hypertension, either nationwide [6–8] or in specific regions [9–14], have been undertaken in China. These surveys showed consistently a rapid increasing trend in the hypertension prevalence, from 5.1% in 1959 to 18.0% in 2002 at national level [6–8]. Despite this, few studies have provided reliable estimates about prevalence and management of hypertension in the current decade. Moreover, there is still limited data about the current burden of hypertension in certain population subgroups, e.g., by region, and by different socioeconomic status. Appropriate understanding of these issues would be of particular relevance for development of cost-effective and targeted control strategies in China, where the patterns of dietary, physical activity and other lifestyle factors are also changing rapidly [15–18].

We reported relevant findings from a large-scale nationally representative survey of 174,621 adults aged >18 years who were surveyed during 2013–14, as part of the China Chronic Disease and Risk Factors Surveillance (CCDRFS) survey, which covered all 31 provinces in the

* Correspondence to: Z. Chen, Clinical Trial Service Unit and Epidemiological Studies Unit (CTSU), University of Oxford, Richard Doll Building, Old Road Campus, Oxford OX3 7LF, UK.
** Correspondence to: L. Wang, National Center for Chronic and Non-communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, 27 Nanwei Road, Xicheng District, Beijing 100050, China.
E-mail addresses: zhengming.chen@ctsu.ox.ac.uk (Z. Chen), linhong@chinawch.org.cn (L. Wang).
[1] This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.
[2] Drs. Li and Yang contributed equally.

http://dx.doi.org/10.1016/j.ijcard.2016.10.110
0167-5273/

mainland China. The aims of the present report were to (i) examine the prevalence of hypertension, both overall and in certain population subgroups (e.g. by age, sex, region, and socioeconomic); (ii) assess, among those with hypertension, levels of awareness, treatment and control rate; and (iii) estimate the number of hypertension in China.

2. Methods

2.1. Survey methods

The 2013–14 China Chronic Disease and Risk Factors Surveillance (CCDRFS) survey was based at Chinese Center for Disease Control and Prevention's Disease Surveillance Points (DSP) system and organized by the National Center for Chronic and Non-communicable Disease Control and Prevention in Chinese Center for Disease Control and Prevention, and conducted between August 2013 and July 2014. Data were recorded by face-to-face interview, using a standardized questionnaire, on demographic characteristics, socioeconomic status, smoking, alcohol drinking, physical activities, dietary habits and history of hypertension and diabetes. Physical measurements (e.g. weight, height, hip circumference, blood pressure) and laboratory tests (e.g. blood glucose, lipid and HbA1c) were also undertaken for each participant. The ethics committee in China CDC approved the survey and a written informed consent was collected from each participant. The protocol of the survey abided by the ethical guidelines of the 1975 Declaration of Helsinki.

2.2. Sampling schemes

The survey used a stratified multistage sampling design to obtain a nationally representative sample of Chinese population. All 605 DSPs (rural county or urban street committee) in all 31 provinces in mainland China were listed as sampling frame, with all provinces stratified according to population size (high/low) and mortality rate (high/low) [19]. A total of 298 DSPs were randomly selected, and within each sampled DSP, 4 rural townships or urban sub-districts were selected using the method of probability proportional to population size. Within each selected township, 3 villages or residential communities were further selected using the similar sampling method. Subsequently, a residential group of at least 50 households was chosen from each sampled village or residential communities by simple random sampling. Households were eligible if one or more members aged 18 + years that had stayed in the survey site at least for 6 months in the last 12 months. Finally, one adult from each household was selected using Kish grid method. About 6.3% of the sampled families could not be accessed on three attempts in different 3 days, who were replaced by another household with a similar family structure in the same village or residential area. Overall, 176,740 participants were enrolled from 3576 village or residential communities.

2.3. Blood pressure measurement

Blood pressure was measured on a seated position by trained and qualified field workers, using an Omron digital BP device (HBP-1300) with a wide range cuff (9–17 in.), in a room with constant temperature around 25 °C. Each participant was asked to avoid any vigorous activity, beverage containing caffeine like tea and coffee, and exposure to cold weather 1 h before the measurement. Left upper arm measurement without cloth was preferred but not for the individuals with left arm disorders or disability. Blood pressure readings were first recorded on paper questionnaire and then double entered into an online data collection system. Each participant was measured three times with 1 min interval and the average of the last two readings was used for analyses. Quality control was performed by national, provincial and local designated staff according to standard protocol. Five percent of all measurements were double checked randomly, and among them 95.5% were consistent with readings from quality control staff.

Hypertension was defined as individuals who received anti-hypertensive treatment in the last two weeks, or had a measured mean SBP ≥ 140 mm Hg or mean DBP ≥ 90 mm Hg at survey. Based on the measured BP, participants were further classified into six categories [20], i.e. optimal (SBP < 120 mm Hg and DBP < 80 mm Hg); normal (SBP 120–129 mm Hg and/or DBP 80–84 mm Hg); high-normal (SBP 130–139 mm Hg and/or DBP 85–89 mm Hg); Stage 1 hypertension (SBP 140–159 mm Hg and/or DBP 90–99 mm Hg); Stage 2 hypertension (SBP 160–179 mm Hg and/or DBP 100–109 mm Hg); Stage 3 hypertension (SBP > 180 mm Hg and/or DBP > 110 mm Hg). Awareness of hypertension was defined as participants with hypertension who responded 'Yes' to the question of 'Have you ever been diagnosed as hypertension by a doctor?' and reported their condition was diagnosed in hospital at township level or above. Assessment of treatment for hypertension was limited to those with hypertension and also reported taking a prescribed antihypertensive medicine over the past two weeks. Control of hypertension was defined as having measured SBP < 140 mm Hg and DBP < 90 mm Hg among those with history of hypertension.

2.4. Statistical analysis

The present study excluded 1519 participants who had missing values of BP and/or other study variables of interest and all participants (600) from a survey site with extremely poor data quality of blood pressure measurement, leaving 174,621 individuals for the final analysis.

Basic characteristics were presented by certain hypertension relevant risk factors, such as demographic characteristics, education, annual household income, and lifestyle risk behaviors. Particularly, two types of metrics were used to measure burden of hypertension: population weighted indicators and model adjusted indicators, with the former used to obtain unbiased estimation about the absolute burden or level of hypertension and the latter to estimate relative burden for subgroup comparisons. The model adjusted indicators are able to attenuate possible bias due to unbalanced distribution of other related variables among subgroups, and therefore increase comparability.

According to the recommendations from the World Hypertension League Expert Committee [21], crude and population weighted means, standard deviations (SD), median, 25th percentile (Q1) and 75th percentile (Q3) of SBP and DBP were firstly determined by age and gender. Age-sex adjusted means of SBP were then calculated for each calendar month in survey period to explore the seasonal variation of blood pressure. Due to the limited recruitment, we pooled data for January and February (Chinese New Year) and May–July (survey preparation and finishing period). Region and season adjusted means of SBP and DBP were then plotted against age (5-year interval) to examine their age trends. In addition, region-season adjusted distribution of BP level was examined by age and gender. Finally, population weighted prevalence of hypertension and related index were estimated and the model adjusted prevalence of them was determined by age, gender, region, season, prior CVD status, education and income. We tested the differences of this prevalence among nominal categories (e.g., gender, region, and season) and their trends along ordered variables (e.g., age, education, and income).

Weights were calculated for all analysis, especially for estimation of population weighted indicators. The weights consisted of two components: sampling weights accounting for unequal probabilities of sample selection, and post-stratification weights which harmonized the sample structure of survey with that of 2010 Chinese population census. Particularly, we took into account the age (5-year increments), gender, rural/urban residency, and provinces simultaneously when doing the post-stratification [22]. With consideration of the complex design, the model adjusted means and prevalence were estimated and tested in design-based lineal regression and logistic regression, respectively [22,23]. For 95% confidence intervals (CIs) and statistical tests, we estimated sampling error using Taylor series linearization with finite population correction. All analyses used SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

3. Results

Of the 174,621 participants, 57% were women, 54% were from rural areas and mean age was 51.6 (SD: 14.7) years for men and 51.5 (13.8) for women (Table 1). Among men 52.9% smoked and 18.0% drank too much alcohol, as opposed to only 3.0% and 1.4% in women. Men tended to be better educated, and to have higher means of SBP and DBP and prevalence of CVD.

Overall, the population weighted mean of SBP was 127.8 (SD: 20.0) mm Hg and DBP was 76.5 (SD: 11.4) mm Hg, higher in men than women (SBP: 129.8 vs. 125.7; DBP: 78.3 vs. 74.7 mm Hg) (Table 2). Mean SBP increased linearly with age in both genders, while DBP increased with age until about 55 years and then fall thereafter (Table 2, Fig. 1). Before age 60 years men had higher SBP, and after that the opposite was true. Mean DBP was higher at all ages in men than women, but the gender difference appeared to diminish with increasing age. There was a significant seasonal variation of blood pressure, particularly among rural residents, with the mean SBP being about 5 mm Hg higher in winter than in summer (Fig. 2).

Table 3 presents region-season adjusted distribution of BP categories by age and gender. Older people had higher BP level than younger ones. Women under age 55 years had more preferable BP levels than men, but the opposite was true in those over age 65 years.

Overall, 27.8% (95% CI: 26.7–28.8) had hypertension (34.5% [33.2–35.9] in men and 29.5% [28.3–30.7] in women) (Table 4). Based on data from the 2010 Census, an estimated 292 million adults aged >18 years had hypertension, representing an absolute increase of 139 million individuals since year 2002 [7]. Among hypertensive people, 31.9% (30.2–33.5) aware their condition (82.9% [81.5–84.2] treated among those aware of their condition), 26.4% [24.8–28.1] received anti-hypertensive treatment, and 9.7% (8.8–10.7) had their BP controlled (34.6% [32.7–36.5] controlled among those been treated). The prevalence of hypertension and the awareness, treatment and control rate among hypertensive people increased with age (all $P < 0.01$), but decreased for the control among those receiving antihypertensive treatment. Compared with men, hypertensive women tend to get better awareness, more treatment and better controlled for the disease

(P < 0.01). The prevalence of hypertension was similar between urban and rural areas (32.3% vs. 31.6%, P = 0.37), but urban residents had relatively higher rates of awareness, treatment and control of hypertension (all P ≤ 0.01). Marked seasonal variation of hypertension prevalence was also observed, with lowest prevalence in summer (27.8%) and highest in winter (35.9%). Better BP control was also found in summer than other seasons. In contrast to individuals without CVD, those who were previously diagnosed with CVD had higher prevalence, better awareness, treatment and control of hypertension, while control rates among the treated were similar in between. Better socioeconomic status, i.e. higher education was associated with lower prevalence of hypertension, and awareness, treatment and controlled of the condition tended to improve with higher education and income (all P < 0.01).

4. Discussion

This large nationwide survey showed that more than one fourth of Chinese adults aged 18 years and above were hypertensive in 2013–2014, and that despite the high prevalence, about 3 out of 5 hypertensive individuals were not aware of their condition, about two third were not receiving anti-hypertensive medication, resulting in less than 10% of hypertensive individuals not properly controlled. In 2013 almost 300 million Chinese adults had hypertension, among whom 264 million were not controlled, foreshowing substantial CVD burden. Female gender and high socioeconomic status was associated with preferable hypertension prevalence, awareness, treatment and control. Similar prevalence was found between urban and rural areas, but a large gap in between still existed in the detection, medication and control of hypertension.

Table 1
Characteristic of participants in 2013–2014 CCDRFS survey[a].

	Men — no. (%)	Women — no. (%)	Total — no. (%)
Total	74,674(42.8)	99,947(57.2)	174,621(100.0)
Age — years			
18–24	3130(4.2)	3022(3)	6152(3.5)
25–34	7932(10.6)	9748(9.8)	1 7680(10.1)
35–44	13,367(17.9)	18,993(19)	32,360(18.5)
45–54	17,422(23.3)	26,780(26.8)	44,202(25.3)
55–64	18,729(25.1)	24,783(24.8)	43,512(24.9)
65–74	10,054(13.5)	11,917(11.9)	21,971(12.6)
75+	4040(5.4)	4704(4.7)	8744(5)
Mean age (SD)	51.6(14.7)	51.5(13.8)	51.6(14.2)
Region			
Urban	32,864(44.0)	47,874(47.9)	80,738(46.2)
Rural	41,810(56.0)	52,073(52.1)	93,883(53.8)
Education			
Illiterate	14,272(19.1)	34,956(35.0)	49,228(28.2)
Primary school	15,453(20.7)	19,341(19.4)	34,794(19.9)
Junior high school	26,999(36.2)	27,511(27.5)	54,510(31.2)
Senior high school	12,092(16.2)	12,353(12.4)	24,445(14.0)
College graduate or above	5858(7.8)	5786(5.8)	11,644(6.7)
Annual household income per capita[b]			
Don't know/not sure/refused	16,593(22.2)	24,611(24.6)	41,204(23.6)
Q1 (<1093 US$)	16,103(21.6)	19,995(20.0)	36,098(20.7)
Q2 (1093–1967 US$)	10,656(14.3)	13,834(13.8)	24,490(14.0)
Q3 (1968–3825 US$)	16,755(22.4)	22,811(22.8)	39,566(22.7)
Q4 (>3826 US$)	14,567(19.5)	18,696(18.7)	33,263(19.0)
Tobacco using			
Never regular	26,488(35.5)	96,320(96.4)	12 2808(70.3)
Ex-smoker	8692(11.6)	641(0.6)	9333(5.3)
Current regular	39,494(52.9)	2986(3.0)	42,480(24.3)
Excessive drinking			
No	61,207(82.0)	98,518(98.6)	159,725(91.5)
Yes	13,467(18.0)	1429(1.4)	14,896(8.5)
Prior CVD			
No	72,267(96.8)	97,459(97.5)	169,726(97.2)
Yes	2407(3.2)	2488(2.5)	4895(2.8)
Survey season			
Winter (Dec–Feb)	9201(12.3)	11,793(11.8)	20,994(12.0)
Spring (Mar–May)	24,741(33.1)	34,589(34.6)	59,330(34.0)
Summer (Jun–Aug)	7259(9.7)	9233(9.2)	16,492(9.4)
Autumn (Sep–Nov)	33,473(44.8)	44,332(44.4)	77,805(44.6)
Mean BMI (SD) — kg/m^2	24.2(3.5)	24.4(3.7)	24.3(3.6)
Mean SBP (SD) — mm Hg	133(19.6)	130.4(21.8)	131.5(20.9)
Mean DBP (SD) — mm Hg	79.5(11.5)	76.2(11.4)	77.6(11.6)

[a] Numbers in parentheses are percentages unless otherwise indicated.
[b] Based on the exchange rate of 6.1 Chinese Yuan to US$ 1 that was in effect on 31 December 2013.

Compared with the 2002 national survey, the prevalence of hypertension had increased from 18.0% in 2002 to 27.8% in 2013 [7]. The prevalence of hypertension now seen in China was generally comparable with that in many developed countries. For example, hypertension prevalence was 26.6% in 2008–2009 in Australia population [24]; 29.5% for US adults aged 18 years over in 2009–2010 [25]; but they were higher than that in many developing countries, e.g., 22% men and 26% women aged 20+ years in India [26]; and 21% in Thai people over age 15 years in 2009 [27]. The rapid increase in prevalence of hypertension in China may be explained by a number of prevailing lifestyle risk factors, such as high salt and more fat consuming in diet, more weight gaining (especially in men), less physical activities [15,16,18,28–30]. Rapid urbanization and rural-to-urban migration in the last decade may also change the lifestyle factors affecting BP in population [31–33].

The comparison of hypertension prevalence between urban and rural residents is of great relevance in health policy making. The present study found this difference in China is trivial, which was inconsistent with some previous studies which demonstrated significant higher burden of hypertension among urban residents [7,13]. One possible reason is the diminishing discrepancy between rural and urban residents in hypertension related risk factors. Our previous national survey reported a similar prevalence of current smoking and excessive drinking between areas in 2010 in China [34]. Misclassification of urban and rural areas might be another possible explanation. Outdated definition for urban and rural areas, which roughly considered district in city as urban and other areas as rural, has been broadly adopted by most important previous epidemiological surveys in the past decade [7,35–37]. Classifying urban/rural at county level can never capture the true differences in between in a setting of rapid urbanization. Using the new national standard released in 2009 [38], we believe the present study is more appropriate to reflect the actual urban–rural disparity in hypertension prevalence.

Rates of awareness, treatment and control of hypertension among the hypertensive individuals have been improved after joint efforts paid by public health practitioners and health professionals in the last decade. In 2002, 24% of the hypertensive individuals were aware of their condition, 20% were receiving anti-hypertensive medicine, and 4.5% had their BP controlled [7]. However, awareness, treatment, and control of hypertension were still very poor in China, with the rates under the global average level [39,40]. Compared with other developed countries, China ranks a much lower level on the awareness and control of hypertension, e.g. 70–80% awareness and 50% control rate in American around 2010 [25,41,42], and 65% control rate in Canadian adults in 2009 [43]. Based on a systematic review of 35 countries data, our estimated awareness and control of hypertension were also lower than the average level of developing countries, despite a relatively high treatment rate [40]. The low awareness in China may be due to limited knowledge of the disease hazard, relevant risk factors and how to control of hypertension among primary health care provider and general population, especially among rural residents. Although required by the government regulation, BP measurement was not systematically or frequently checked when patients visiting a health clinic, thus fail to get diagnosed promptly. Lack of professional health personnel and essential antihypertensive medication may attribute to the low control rate of hypertension, particularly in less developed areas. Unhealthy lifestyles among hypertensive people, such as being physically inactive, smoking, heavy alcohol drinking or consuming more fatty diet may also

Table 2
Mean, standard deviation, median and quantiles of SBP and DBP in Chinese adults, 2013–2014.

	Both genders				Men				Women			
	Mean	SD	Median	(Q1, Q3)*	Mean	SD	Median	(Q1, Q3)	Mean	SD	Median	(Q1, Q3)
SBP, mm Hg												
Overall (crude)	131.5	20.9	128.5	(117.0, 143.0)	133.0	19.6	130.0	(119.5, 143.5)	130.4	21.8	127.0	(115.0, 142.5)
Overall (weighted)	127.8	20.0	124.5	(114.0, 138.0)	129.8	18.3	127.0	(117.5, 139.0)	125.7	21.3	121.5	(110.5, 136.5)
Age group, years												
18–24	118.9	15.5	117.5	(109.0,126.0)	122.8	13.9	121.5	(114.0,129.0)	114.8	15.9	112.5	(104.5121.0)
25–34	120.3	15.6	119.0	(110.0,128.0)	124.5	14.6	122.5	(115.0,131.5)	115.9	15.4	114.0	(105.5123.0)
35–44	124.4	16.8	122.0	(113.0,133.0)	127.5	16.0	125.5	(117.0,135.5)	121.1	17.0	118.5	(110.0,129.0)
45–54	130.8	19.1	128.0	(117.5141.0)	131.5	18.1	129.0	(119.0,141.0)	130.1	20.0	127.0	(116.0,141.0)
55–64	137.2	20.9	135.0	(122.5149.5)	136.8	20.1	134.5	(122.5148.5)	137.6	21.7	135.0	(122.5150.5)
65–74	143.3	22.3	141.0	(127.5156.5)	142.5	21.8	140.0	(127.0,155.5)	144.0	22.8	141.5	(127.5158.0)
75+	144.5	23.2	142.0	(127.0,159.5)	142.8	22.1	141.0	(127.0,156.5)	145.8	24.0	143.0	(127.5161.5)
DBP, mm Hg												
Overall (crude)	77.6	11.6	77.0	(70.0, 84.5)	79.5	11.5	79.0	(71.5, 86.5)	76.2	11.4	75.5	(68.5, 83.0)
Overall (weighted)	76.5	11.4	75.5	(69.0, 83.5)	78.3	11.3	77.5	(70.5, 85.0)	74.7	11.1	74.0	(67.0, 81.5)
Age group, years												
18–24	72.1	9.7	71.5	(65.5,78.0)	73.5	9.5	73.0	(67.5,79.5)	70.7	9.7	70.0	(63.5,76.5)
25–34	74.0	10.4	73.0	(67.0,80.0)	76.0	10.5	75.0	(69.0,82.0)	71.8	10.0	71.0	(65.0,77.5)
35–44	77.1	11.3	76.0	(69.5,83.5)	79.5	11.3	79.0	(72.0,86.0)	74.7	10.8	74.0	(67.5,81.0)
45–54	79.8	11.6	79.0	(72.0,87.0)	81.5	11.5	81.0	(73.5,88.5)	78.1	11.4	77.0	(70.0,85.0)
55–64	79.7	11.4	79.5	(72.0,86.5)	81.1	11.3	80.5	(73.5,88.0)	78.2	11.3	77.5	(70.5,85.0)
65–74	78.0	11.6	77.5	(70.0,85.0)	79.0	11.4	78.5	(71.0,86.0)	76.9	11.7	76.0	(69.0,84.0)
75+	75.0	11.6	75.0	(66.5,82.5)	75.6	11.6	75.0	(67.5,82.5)	74.5	11.6	74.0	(66.0,82.5)

* Q1 indicates the 25th percentile and Q3 indicates the 75th percentile.

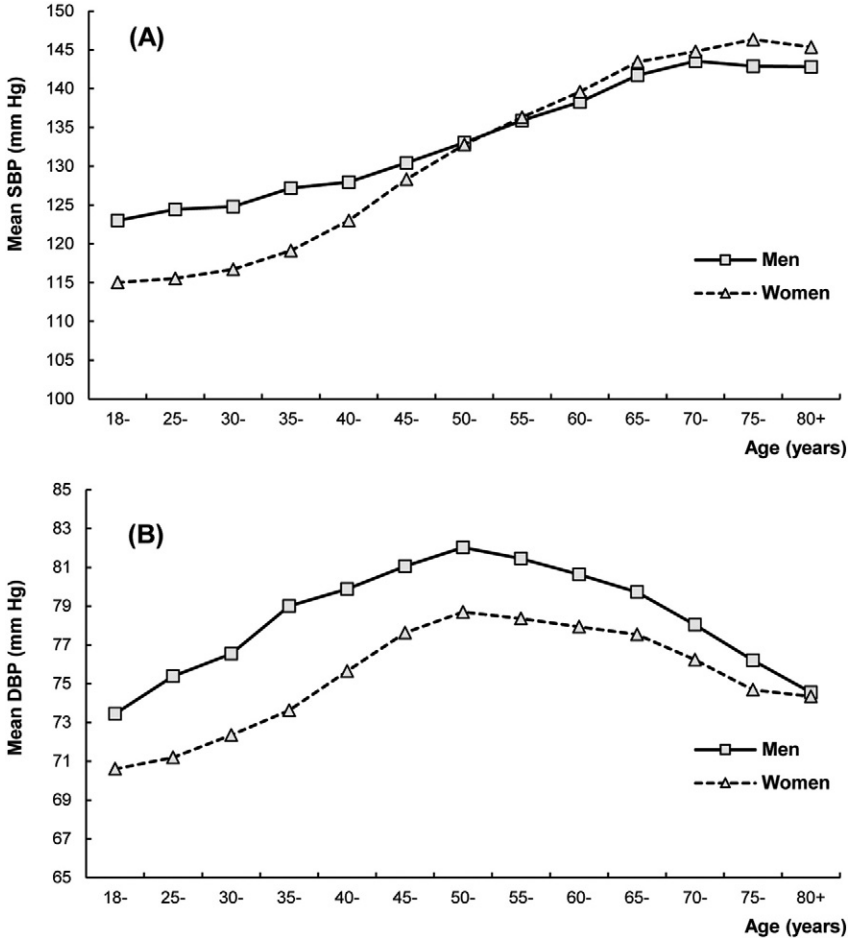

Fig. 1. Adjusted mean SBP and DBP by age and gender*. * Means adjusted for region and season.

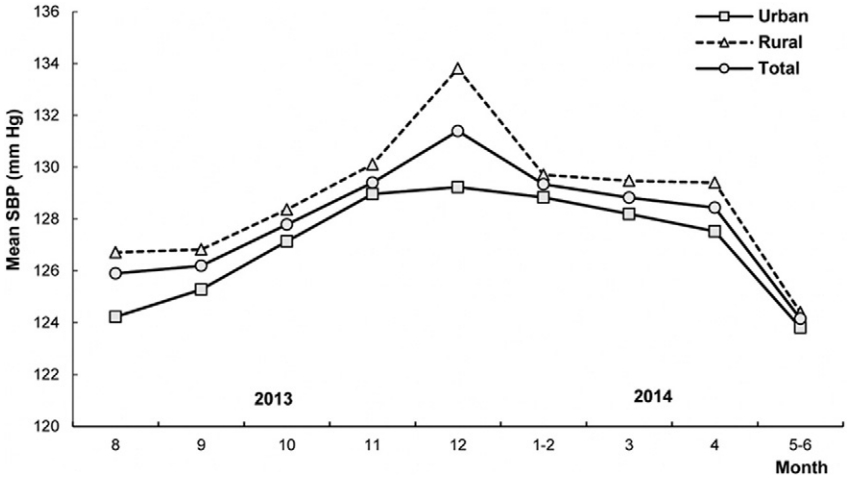

Fig. 2. Region and season adjusted mean SBP and DBP by age and gender.

contribute to the poor disease control [17,44,45]. In this study, we found that treatment rate was quite high among those who were aware of their condition, but only one quarter of hypertensive individuals being treated have their BP controlled. This suggests ineffectiveness in our current treatment approach, low compliance to prescribed medication, or poor aggressiveness in hypertension management by health care providers.

In 2011, Chinese government set a goal for controlling hypertension, i.e. aiming to get 40% of hypertensive individuals covered in routine management by local health professionals and 60% of them get properly controlled by 2015. The present study implied that the goal had hardly been achieved by the end of 2015. Our further CCDRFS data will provide reliable source on monitoring the trend of hypertension control in China. Two key components could be included to improve hypertension control: reinforcing the primary health care system in terms of hypertension diagnosis, patient management and effective treatment [46–48], and enhancing the primary prevention in general population, i.e. education on basic knowledge of hypertension and modification of lifestyle risk factors [49].

4.1. Strengths

Well-designed sampling scheme and wide spread survey sites provide representativeness and generalizability of the findings to China as a whole. Large sample size, standardized survey tools, training and field implementation guarantee the reliability of the analysis. The geographic and socioeconomic diversity of the sample allows in-depth exploration into the data. In addition, the survey was conducted throughout a whole year, and therefore we were able to examine season effects on hypertension prevalence and relevant indicators. The winter peak in CVD mortality found in various populations [50]

Table 3
Distribution of blood pressure levels by age and gender[a].

		Optimal	Normal	High normal	Stage 1 hypertension	Stage 2 hypertension	Stage 3 hypertension
Men	18–24	40.7(36.7, 44.6)	31.3(28.7, 33.9)	17.2(14.8, 19.6)	8.6(6.7, 10.6)	1.3(0.7,1.9)	0.9(0.2,1.6)
	25–34	36.1(33.2, 38.9)	29.6(27.9, 31.4)	18.9(17.3, 20.5)	11.8(10.4, 13.3)	2.3(1.8,2.9)	1.2(0.7,1.7)
	35–44	29.0(27.3, 30.6)	26.8(25.4, 28.2)	20.4(19.2, 21.6)	17.0(15.8, 18.1)	5.1(4.3,5.9)	1.7(1.3,2.2)
	45–54	23.9(22.1, 25.7)	22.7(21.6, 23.7)	20.9(19.7, 22.1)	22.1(20.6, 23.6)	7.9(7.3,8.6)	2.5(2.1,3.0)
	55–64	17.6(16.1, 19.2)	19.2(17.9, 20.5)	21.2(19.9, 22.5)	27.5(26.1, 28.9)	10.5(9.4,11.5)	4.0(3.4,4.6)
	65–74	13.8(10.3, 17.3)	15.9(14.1, 17.7)	17.8(16.3, 19.4)	31.5(29.1, 33.8)	15.2(13.7,16.8)	5.8(4.7,6.9)
	75+	14.1(10.8, 17.4)	18.8(14.8, 22.7)	14.9(12.3, 17.5)	31.3(26.8, 35.7)	13.5(11.4,15.5)	7.5(5.1,10.0)
	Total[b]	24.8(23.4, 26.1)	23.3(22.5, 24.1)	19.2(18.5, 19.9)	21.5(20.6, 22.5)	8.0(7.4,8.6)	3.2(2.7,3.7)
Women	18–24	67.4(63.3, 71.6)	18.8(16.7, 21.0)	7.2(5.1, 9.2)	5.0(3.5, 6.4)	0.9(0.4,1.3)	0.7(0.2,1.3)
	25–34	63.3(60.0, 66.6)	19.7(18.0, 21.5)	8.3(7.3, 9.2)	6.3(5.2, 7.3)	2.1(1.3,2.9)	0.4(0.2,0.6)
	35–44	51.2(48.8, 53.7)	22.0(20.7, 23.3)	12.9(11.8, 14.0)	9.6(8.8, 10.4)	3.1(2.7,3.5)	1.3(0.9,1.6)
	45–54	31.2(29.7, 32.8)	22.4(20.8, 24.0)	17.0(16.1, 17.9)	19.4(18.4, 20.4)	7.1(6.5,7.7)	2.8(2.4,3.2)
	55–64	19.5(17.8, 21.3)	17.9(16.9, 18.9)	19.4(18.5, 20.3)	27.6(26.5, 28.8)	11.3(10.4,12.2)	4.2(3.6,4.9)
	65–74	11.8(10.4, 13.2)	17.4(14.0, 20.9)	16.5(15.1, 17.9)	30.7(29.0, 32.5)	15.0(13.3,16.7)	8.5(5.7,11.2)
	75+	12.5(8.6, 16.5)	17.0(13.8, 20.1)	14.7(12.7, 16.7)	27.1(24.3, 29.9)	17.8(14.8,20.7)	10.9(6.4,15.4)
	Total[b]	36.4(34.3, 38.4)	19.6(18.7, 20.4)	14.2(13.6, 14.8)	18.1(17.3, 19.0)	7.9(7.4,8.5)	3.8(3.1,4.5)
Both genders	18–24	54.0(50.9, 57.1)	25.1(23.4, 26.8)	12.2(10.4, 14.0)	6.8(5.5, 8.1)	1.1(0.7,1.5)	0.8(0.4,1.3)
	25–34	49.7(46.9, 52.4)	24.7(23.4, 26.0)	13.6(12.5,14.7)	9.0(8.0, 10.1)	2.2(1.7,2.8)	0.8(0.5,1.1)
	35–44	40.1(38.3, 41.8)	24.4(23.5, 25.3)	16.7(15.8, 17.6)	13.3(12.4, 14.1)	4.1(3.6,4.6)	1.5(1.2,1.8)
	45–54	27.6(26.2, 29.0)	22.5(21.4, 23.6)	18.9(18.1, 19.8)	20.8(19.7, 21.8)	7.5(7.0,8.0)	2.7(2.4,3.0)
	55–64	18.6(17.2, 20.0)	18.5(17.6, 19.5)	20.3(19.5, 21.1)	27.5(26.5, 28.6)	10.9(10.1,11.7)	4.1(3.8,4.5)
	65–74	12.8(10.9, 14.8)	16.7(14.9, 18.4)	17.2(16.0, 18.4)	31.1(29.4, 32.9)	15.1(14.0,16.2)	7.1(5.6,8.6)
	75+	13.3(11.6, 15.0)	17.9(14.7, 21.0)	14.8(12.7, 16.9)	29.1(26.1, 32.1)	15.7(13.6,17.8)	9.3(5.9,12.6)
	Total[c]	30.6(29.0, 32.1)	21.4(20.8, 22.1)	16.7(16.2, 17.2)	19.8(19.0, 20.6)	8.0(7.5,8.4)	3.5(3.0,4.1)

[a] All analyses were adjusted for regions and survey months, and numbers in the parenthesis are 95% confidence intervals.
[b] In addition adjusted for age.
[c] In addition adjusted for age and sex.

Table 4
Prevalence and 95% CIs of hypertension, awareness, treatment and control among Chinese adults (%), 2013[a].

	Prevalence	Awareness among hypertension	Treatment among awareness	Treatment among hypertension	Control among treatment	Control among hypertension
Total[b]	27.8(26.7, 28.8)	31.9(30.2, 33.5)	82.9(81.5, 84.2)	26.4(24.8, 28.1)	34.6(32.7, 36.5)	9.7(8.8, 10.7)
Age[c]						
18–29	8.7(7.4, 10.4)	10.1(6.7, 15.0)	90.6(79.2, 96.0)	9.0(5.8, 13.7)	42.9(24.9, 63.0)	4.0(2.3, 6.8)
30–39	12.3(11.0, 13.8)	13.2(10.6, 16.2)	67.3(57.9, 75.6)	8.9(7.1, 11.1)	34.3(26.7, 42.8)	3.4(2.5, 4.6)
40–49	19.9(18.9, 21.0)	21.5(19.3, 23.8)	70.7(66.0, 74.9)	15.1(13.5, 17.0)	38.4(32.5, 44.7)	6.3(5.1, 7.8)
50–59	33.8(32.7, 35.1)	30.9(29.0, 32.8)	79.4(77.1, 81.5)	24.3(22.5, 26.1)	36.1(33.0, 39.2)	9.5(8.2, 10.8)
60–69	48.0(46.7, 49.3)	37.1(35.4, 38.7)	83.1(81.2, 84.8)	30.5(28.7, 32.3)	35.0(32.0, 38.0)	11.2(9.8, 12.8)
70+	61.1(59.7, 62.5)	40.2(38.0, 42.5)	85.3(83.2, 87.3)	33.9(31.6, 36.3)	31.8(28.8, 34.9)	11.3(9.8, 13.1)
P for trend	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Gender[d]						
Men	34.5(33.2, 35.9)	24.2(22.4, 26.1)	77.8(75.0, 80.4)	18.5(16.8, 20.2)	36.7(33.0, 40.6)	7.2(6.2, 8.3)
Women	29.5(28.3, 30.7)	27.5(25.5, 29.5)	82.2(79.9, 84.3)	22.0(20.2, 24.0)	34.5(30.8, 38.4)	7.9(6.7, 9.2)
P for difference	<0.01	<0.01	<0.01	<0.01	0.10	0.049
Region[e]						
Urban	32.3(30.9, 33.7)	32.5(30.2, 34.9)	84.4(82.0, 86.5)	26.8(24.6, 29.2)	37.9(34.0, 41.9)	10.1(8.8, 11.7)
Rural	31.6(30.2, 32.9)	20.1(18.4, 21.9)	74.9(72.1, 77.6)	14.9(13.4, 16.5)	33.4(29.5, 37.6)	5.5(4.6, 6.6)
P for difference	0.37	<0.01	<0.01	<0.01	0.01	<0.01
Season[f]						
Winter (Dec–Feb)	35.9(33.6, 38.3)	21.7(19.5, 24.1)	73.5(68.5, 78.0)	15.6(13.7, 17.7)	30.8(25.2, 37.0)	5.1(3.9, 6.6)
Spring (Mar–May)	33.3(31.6, 35.0)	26.2(24.1, 28.5)	81.8(79.2, 84.1)	21.0(19.1, 23.1)	32.2(28.9, 35.7)	7.0(6.1, 8.0)
Summer (Jun–Aug)	27.8(25.2, 30.7)	25.5(21.3, 30.2)	80.5(73.5, 86.0)	20.1(15.9, 25.1)	43.3(34.7, 52.2)	9.6(6.5, 14.1)
Autumn (Sep–Nov)	31.0(29.4, 32.6)	30.2(27.7, 32.9)	83.6(81.4, 85.6)	24.8(22.5, 27.3)	36.7(33.0, 40.6)	9.2(7.9, 10.6)
P for difference	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Prior CVD[g]						
No	31.2(30.1, 32.4)	24.3(22.7, 26.0)	79.1(76.7, 81.3)	18.8(17.3, 20.5)	35.7(32.2, 39.5)	7.2(6.2, 8.3)
Yes	60.0(56.6, 63.3)	59.6(54.6, 64.5)	88.0(84.9, 90.5)	50.7(45.3, 56.2)	34.6(30.2, 39.2)	15.0(12.8, 17.5)
P for difference	<0.01	<0.01	<0.01	<0.01	0.50	<0.01
Education[g]						
Illiterate	34.2(32.6, 35.9)	21.1(19.3, 23.1)	77.2(73.7, 80.3)	15.9(14.1, 17.8)	34.4(30.6, 38.5)	6.1(5.2, 7.2)
Primary school	31.8(30.4, 33.1)	24.2(22.1, 26.5)	79.4(76.4, 82.1)	18.7(16.8, 20.7)	33.8(29.7, 38.2)	6.6(5.5, 7.9)
Junior high school	32.7(31.3, 34.3)	26.5(24.4, 28.7)	80.8(78.2, 83.1)	20.9(19.0, 22.9)	34.9(30.9, 39.1)	7.5(6.3, 8.8)
Senior high school	30.3(28.6, 32.0)	31.6(29.0, 34.4)	82.2(78.3, 85.6)	25.4(22.9, 28.0)	37.1(32.7, 41.9)	9.3(7.7, 11.1)
College graduate or above	25.8(23.5, 28.2)	33.6(30.2, 37.1)	84.2(79.6, 87.9)	27.8(24.8, 31.0)	44.7(39.3, 50.3)	12.1(9.9, 14.8)
P for trend	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Annual household income per capita[g]						
Don't know/not sure/refused	31.5(29.9, 33.0)	25.9(23.7, 28.2)	79.8(76.5, 82.7)	20.1(18.2, 22.3)	36.1(31.9, 40.6)	7.6(6.4, 9.1)
Q1 (<1093 US$)	32.6(30.8, 34.5)	22.8(20.6, 25.2)	79.0(75.6, 82.1)	17.6(15.5, 19.9)	34.5(29.7, 39.7)	6.5(5.3, 8.1)
Q2 (1093–1967 US$)	32.6(31.0, 34.3)	23.6(21.4, 26.0)	77.7(73.9, 81.1)	17.9(15.8, 20.1)	31.8(27.3,36.6)	5.9(4.9, 7.1)
Q3 (1968–3825 US$)	31.0(29.8, 32.3)	26.5(24.6, 28.4)	80.5(77.9, 82.8)	20.9(19.2, 22.7)	36.2(32.0, 40.6)	7.9(6.7, 9.3)
Q4 (>3826 US$)	32.2(30.3, 34.2)	31.4(29.0, 33.8)	83.1(80.2, 85.7)	25.5(23.4, 27.7)	38.7(34.3, 43.2)	9.9(8.6, 11.3)
P for trend[h]	0.39	<0.01	<0.01	<0.01	0.03	<0.01

[a] Numbers in the parenthesis are 95% confidence intervals taking into account complex sample design. Least squared prevalence was used only for comparisons among subgroups not for estimating population of interested subgroup in China.
[b] Estimation is weighted to represent the total population of Chinese adults based on the 2010 Census data.
[c] Prevalence adjusted for gender, region and season.
[d] Prevalence adjusted for age, region and season.
[e] Prevalence adjusted for age, gender and season.
[f] Prevalence adjusted for age, gender and region.
[g] Prevalence adjusted for age, gender, region and season.
[h] Category "Don't know /not sure/refused" was excluded in the trend test.

implies that seasonal variation in BP should be taken into account in the diagnosis and treatment of hypertension. Central heating might help to control BP in winter, especially in areas with extremely cold weather.

4.2. Limitations

As for the cross-sectional nature of the study, blood pressure was not measured in separate occasions, and diagnosis based on serial measures on one occasion might affect the prevalence estimation. Systematic bias may also be introduced by the seasonal variation of BP, i.e. BP measurements inversely associated with outdoor temperature [51], which was also observed in the present study. With only a small portion of study sample been recruited in summer in the survey, the absolute hypertension burden might be overestimated, though model adjusted indicators was used to reduce the seasonal effect for comparisons across subgroups. However, we required that BP measurement must be taken indoors with constant temperature around 25 °C, and thus the bias should be small.

5. Conclusions

In general, hypertension prevalence in China has increased rapidly during the last decade. Although awareness and treatment of hypertension improved over the time, BP control was still unacceptably low among hypertensive individuals, leaving hundreds of millions of individuals at risk of CVD.

Authors' contribution

Prof. Linhong Wang had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Prof. Z. Chen, Prof. M. Zhou, Y. Li and L. Yang conceived the study design and the analytical plan. Y. Li performed statistical analysis.

Y. Li and L. Yang prepared the first draft. Y. Li, L. Yang and Prof. Z. Chen finished the draft based on comments from other authors. Prof. Linhong Wang, Prof. Limin Wang, Y. Li, M. Zhang, Q. Deng, Z. Huang acquired the data.

Funding

This work was supported by the Central Finance of the Chinese Government and the National Natural Science Foundation of China [grant number 81202287].

Conflict of interest statement

The authors report no relationships that could be construed as a conflict of interest.

Acknowledgment

We thank all involved provincial and local health administrative departments, the Centers for Disease Control and Prevention, and all field investigators for their support and effort during the survey.

References

[1] M.H. Forouzanfar, L. Alexander, H.R. Anderson, et al., Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013, Lancet 386 (2015) 2287–2323.
[2] L. Wang, L. Kong, F. Wu, Y. Bai, R. Burton, Preventing chronic diseases in China, Lancet 366 (2005) 1821–1824.
[3] L. Hansson, A. Zanchetti, S.G. Carruthers, et al., Effects of intensive blood-pressure lowering and low-dose aspirin in patients with hypertension: principal results of the Hypertension Optimal Treatment (HOT) randomised trial. HOT Study Group, Lancet 351 (1998) 1755–1762.
[4] Prevention of stroke by antihypertensive drug treatment in older persons with isolated systolic hypertension. Final results of the Systolic Hypertension in the Elderly Program (SHEP). SHEP Cooperative Research Group, JAMA 265 (1991) 3255–3264.
[5] B. Neal, S. MacMahon, N. Chapman, Effects of ACE inhibitors, calcium antagonists, and other blood-pressure-lowering drugs: results of prospectively designed overviews of randomised trials. Blood Pressure Lowering Treatment Trialists' Collaboration, Lancet 356 (2000) 1955–1964.
[6] S. Tao, X. Wu, X. Duan, et al., Hypertension prevalence and status of awareness, treatment and control in China, Chin. Med. J. 108 (1995) 483–489.
[7] Y. Wu, R. Huxley, L. Li, et al., Prevalence, awareness, treatment, and control of hypertension in China: data from the China National Nutrition and Health Survey 2002, Circulation 118 (2008) 2679–2686.
[8] Y.K. Wu, C.Q. Lu, R.C. Gao, J.S. Yu, G.C. Liu, Nation-wide hypertension screening in China during 1979–1980, Chin. Med. J. 95 (1982) 101–108.
[9] B. Xi, Y. Liang, K.H. Reilly, Q. Wang, Y. Hu, W. Tang, Trends in prevalence, awareness, treatment, and control of hypertension among Chinese adults 1991–2009, Int. J. Cardiol. 158 (2012) 326–329.
[10] Y. Zhao, H. Yan, R.J. Marshall, et al., Trends in population blood pressure and prevalence, awareness, treatment, and control of hypertension among middle-aged and older adults in a rural area of Northwest China from 1982 to 2010, PLoS One 8 (2013), e61779.
[11] J. Yang, F. Lu, C. Zhang, et al., Prevalence of prehypertension and hypertension in a Chinese rural area from 1991 to 2007, Hypertens. Res. 33 (2010) 331–337.
[12] Z. Wang, Y. Wu, L. Zhao, Y. Li, J. Yang, B. Zhou, Trends in prevalence, awareness, treatment and control of hypertension in the middle-aged population of China, 1992–1998, Hypertens. Res. 27 (2004) 703–709.
[13] Y. Gao, G. Chen, H. Tian, et al., Prevalence of hypertension in China: a cross-sectional study, PLoS One 8 (2013), e65938.
[14] X.Q. Lao, Y.J. Xu, M.C. Wong, et al., Hypertension prevalence, awareness, treatment, control and associated factors in a developing southern Chinese population: analysis of serial cross-sectional health survey data 2002–2010, Am. J. Hypertens. 26 (2013) 1335–1345.
[15] F. Zhai, H. Wang, S. Du, et al., Prospective study on nutrition transition in China, Nutr. Rev. 67 (Suppl. 1) (2009) S56–S61.
[16] S.W. Ng, E.C. Norton, B.M. Popkin, Why have physical activity levels declined among Chinese adults? Findings from the 1991–2006 China Health and Nutrition Surveys, Soc. Sci. Med. 68 (2009) 1305–1314.
[17] Y. Li, M. Zhang, Y. Jiang, F. Wu, Co-variations and clustering of chronic disease behavioral risk factors in China: China chronic disease and risk factor surveillance, 2007, PLoS One 7 (2012), e33881.
[18] S. Du, B. Lu, F. Zhai, B.M. Popkin, A new stage of the nutrition transition in China, Public Health Nutr. 5 (2002) 169–174.
[19] S. Liu, X. Wu, A.D. Lopez, et al., An integrated national mortality surveillance system for death registration and mortality surveillance, China, Bull. World Health Organ. 94 (2016) 46–57.
[20] G. Mancia, G. De Backer, A. Dominiczak, et al., 2007 Guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC), Eur. Heart J. 28 (2007) 1462–1536.
[21] M.E. Gee, N. Campbell, N. Sarrafzadegan, et al., Standards for the uniform reporting of hypertension in adults using population survey data: recommendations from the World Hypertension League Expert Committee, J. Clin. Hypertens. (Greenwich) 16 (2014) 773–781.
[22] S.G. Heeringa, B.T. West, P.A. Berglund, Applied Survey Data Analysis, CRC Press, Boca Raton, 2010 29–31.
[23] S. Lemeshow, L. Letenneur, J.F. Dartigues, S. Lafont, J.M. Orgogozo, D. Commenges, Illustration of analysis taking into account complex survey considerations: the association between wine consumption and dementia in the PAQUID study. Personnes Ages Quid, Am. J. Epidemiol. 148 (1998) 298–306.
[24] C. Harrison, H. Britt, G. Miller, J. Henderson, Prevalence of chronic conditions in Australia, PLoS One 8 (2013), e67494.
[25] F. Guo, D. He, W. Zhang, R.G. Walton, Trends in prevalence, awareness, management, and control of hypertension among United States adults, 1999 to 2010, J. Am. Coll. Cardiol. 60 (2012) 599–606.
[26] K.A. Moser, S. Agrawal, S.G. Davey, S. Ebrahim, Socio-demographic inequalities in the prevalence, diagnosis and management of hypertension in India: analysis of nationally-representative survey data, PLoS One 9 (2014), e86043.
[27] W. Aekplakorn, R. Sangthong, P. Kessomboon, et al., Changes in prevalence, awareness, treatment and control of hypertension in Thai population, 2004–2009: Thai National Health Examination Survey III–IV, J. Hypertens. 30 (2012) 1734–1742.
[28] L.D. Wang, Comprehensive Report, Chinese Nutrition and Health Survey in 2002, People's Medical Publishing House, Beijing, China, 2005.
[29] I.J. Brown, I. Tzoulaki, V. Candeias, P. Elliott, Salt intakes around the world: implications for public health, Int. J. Epidemiol. 38 (2009) 791–813.
[30] B. Xi, Y. Liang, T. He, et al., Secular trends in the prevalence of general and abdominal obesity among Chinese adults, 1993–2009, Obes. Rev. 13 (2012) 287–296.
[31] R. BeLue, T.A. Okoror, J. Iwelunmor, et al., An overview of cardiovascular risk factor burden in sub-Saharan African countries: a socio-cultural perspective, Glob. Health 5 (2009) 10.
[32] N.R. Poulter, K.T. Khaw, B.E. Hopwood, et al., The Kenyan Luo migration study: observations on the initiation of a rise in blood pressure, BMJ 300 (1990) 967–972.
[33] National Bureau of Statistics of the People's Republic of China. Brief Report on the Sixth National Population Census of the People's Republic of ChinaAvailable at http://www.stats.gov.cn/ztjc/zdtjgz/zgrkpc/dlcrkpc/dcrkpcyw/201104/t20110428_69407.htm2011 (Accessed on 2nd Sep 2014).
[34] National Center for Chronic and Non-communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Report on Chronic Disease Risk Factor Surveillance in China, 2010, Military Medical Science Press, Beijing, 2010.
[35] W. Yang, J. Lu, J. Weng, et al., Prevalence of diabetes among men and women in China, N. Engl. J. Med. 362 (2010) 1090–1101.
[36] Y. Xu, L. Wang, J. He, et al., Prevalence and control of diabetes in Chinese adults, JAMA 310 (2013) 948–959.
[37] Y. Li, Y. Jiang, M. Zhang, P. Yin, F. Wu, W. Zhao, Drinking behaviour among men and women in China: the 2007 China Chronic Disease and Risk Factor Surveillance, Addiction 106 (2011) 1946–1956.
[38] National Bureau of Statistics. Statistical Code for in Administrative Areas and Urban/Rural DivisionAvailable http://www.stats.gov.cn/tjsj/tjbz/tjyqhdmhcxhfdm/ (Accessed on 21 Sep 2015).
[39] C.K. Chow, K.K. Teo, S. Rangarajan, et al., Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries, JAMA 310 (2013) 959–968.
[40] M. Pereira, N. Lunet, A. Azevedo, H. Barros, Differences in prevalence, awareness, treatment and control of hypertension between developing and developed countries, J. Hypertens. 27 (2009) 963–975.
[41] B.M. Egan, Y. Zhao, R.N. Axon, US trends in prevalence, awareness, treatment, and control of hypertension, 1988–2008, JAMA 303 (2010) 2043–2050.
[42] C. Olives, R. Myerson, A.H. Mokdad, C.J. Murray, S.S. Lim, Prevalence, awareness, treatment, and control of hypertension in United States counties, 2001–2009, PLoS One 8 (2013), e60308.
[43] F.A. McAlister, K. Wilkins, M. Joffres, et al., Changes in the rates of awareness, treatment and control of hypertension in Canada over the past two decades, CMAJ 183 (2011) 1007–1013.
[44] Y. Li, L. Wang, Y. Jiang, M. Zhang, L. Wang, Risk factors for noncommunicable chronic diseases in women in China: surveillance efforts, Bull. World Health Organ. 91 (2013) 650–660.
[45] P. Muntner, D. Gu, X. Wu, et al., Factors associated with hypertension awareness, treatment, and control in a representative sample of the Chinese population, Hypertension 43 (2004) 578–585.
[46] T.A. Gaziano, K. Steyn, D.J. Cohen, M.C. Weinstein, L.H. Opie, Cost-effectiveness analysis of hypertension guidelines in South Africa: absolute risk versus blood pressure level, Circulation 112 (2005) 3569–3576.
[47] S. Mendis, L.H. Lindholm, G. Mancia, et al., World Health Organization (WHO) and International Society of Hypertension (ISH) risk prediction charts: assessment of cardiovascular risk for prevention and control of cardiovascular disease in low and middle-income countries, J. Hypertens. 25 (2007) 1578–1582.

[48] R. Beaglehole, R. Bonita, R. Horton, et al., Priority actions for the non-communicable disease crisis, Lancet 377 (2011) 1438–1447.
[49] D.A. Calhoun, D. Jones, S. Textor, et al., Resistant hypertension: diagnosis, evaluation, and treatment: a scientific statement from the American Heart Association Professional Education Committee of the Council for High Blood Pressure Research, Circulation 117 (2008) e510–e526.
[50] L. Yang, L. Li, S. Lewington, et al., Outdoor temperature, blood pressure, and cardiovascular disease mortality among 23,000 individuals with diagnosed cardiovascular diseases from China, Eur. Heart J. 36 (2015) 1178–1185.
[51] S. Lewington, L. Li, P. Sherliker, et al., Seasonal variation in blood pressure and its relationship with outdoor temperature in 10 diverse regions of China: the China Kadoorie Biobank, J. Hypertens. 30 (2012) 1383–1391.