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Research Article
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Hypertension Status among Chinese Adults Aged ≥50 Years Based on China-National Survey and SPRINT

Zengwu Wang[1]*, Ying Dong[1], Xin Wang[1], Zuo Chen[1] and Zugui Zhang[2]

[1]Division of Prevention and Community Health, National Clinical Research center of Cardiovascular Disease, State Key Laboratory of Cardiovascular Disease, Fuwai Hospital, Peking Union Medical College and Chinese Academy of Medical Sciences, Beijing, China
[2]Value Institute, Christiana Care Health System, Newark, Delaware, USA

Abstract

Objectives: The Systolic Blood Pressure Intervention Trial (SPRINT) identified that a systolic blood pressure (SBP) target <120 mmHg, compared to <140 mmHg, was associated with reduced cardiovascular disease (CVD) risk. This study aimed to assess the prevalence, number and characteristics of Chinese adults aged ≥50 years who meet SPRINT eligibility criteria. Furthermore, we also made a comparison between using Framingham risk score and Chinese function to identify the number of SPRINT-eligible individuals.

Methods: We conducted a cross-sectional, population-based survey using data from the 2012-2015 national survey on hypertension in China. After excluding participants without BP measurements, physical and laboratory examinations, 20,137 participants aged 50 years or older were selected for final analysis.

Results: Using Framingham criteria, 96.3 million (95% confidence interval (CI): 93.5-99.1 million) or 29.7% (95% CI: 27.9%-31.5%) of Chinese adults met the SPRINT eligibility criteria. The percentages meeting SPRINT eligibility criteria were higher among older age (aged ≥75 years), men, living in rural areas and SBP of ≥140 mmHg. Among those with treated and untreated hypertension, 44.2% (95% CI: 38.7%-49.7%) or 24.5 million (95% CI: 23.0-26.1 million), and 26.7% (95% CI: 24.8%-28.7%) or 71.8 million (95% CI: 69.4-74.1 million) respectively met SPRINT eligibility criteria. However, using the Chinese function, only 44.5 million (95% CI: 42.9-46.2 million) or 13.7% (95% CI: 11.6%-16.2%) met the eligibility criteria of SPRINT.

Conclusions: A considerable percentage of Chinese adults aged ≥50 years meet the eligibility criteria of SPRINT. Further clinical studies are needed to test the feasibility, applicability and potential impact of SPRINT hypertension treatment goal for adults aged 50 years or older in China.

Keywords: Systolic blood pressure; Hypertension; Chinese population; SPRINT

Introduction

Cardiovascular disease (CVD) is one of the leading causes of disease burden and death worldwide [1]. Hypertension, a concomitant risk factor of CVD [2], accounts for 14% of cardiovascular deaths. Its prevalence is rising in both developed and developing countries [3].

In China, CVD is the top health problem [4]. In 2005, about 2.11 million cardiovascular deaths and 1.15 million premature cardiovascular deaths in China were attributed to hypertension [5]. Thus, lowering blood pressure (BP) is critical component to improving public health in China. Numerous meta-analyses have shown that lowering BP reduces the risk of cardiovascular events, including stroke, myocardial infarction, and cardiovascular death [6-8]. Therefore, Chinese hypertension guidelines (2010) state that treatment should include the maintenance of systolic BP (SBP)/diastolic BP (DBP) below 140/90 mmHg for the general population, below 130/80 mmHg for high-risk patients, and below 150/90 mmHg for patients aged 65 years or older [9].

In 2015, the Systolic Blood Pressure Intervention Trial (SPRINT), funded by the National Institutes of Health in the United States, demonstrated that a SBP goal of <120 mmHg reduced the relative risk of cardiovascular events by about 30% and mortality by 25% compared with a SBP goal of <140 mmHg [10]. Utilizing these lower SBP thresholds, Bress et al. [11] and Ko et al. [12] determined that a substantial percentage of adults meet SPRINT eligibility criteria in US and Korea, respectively. Meanwhile, to lower the risk of cardiovascular events in selected high-risk patients, the findings from SPRINT have been integrated into the Canada's 2016 Hypertension Education Guidelines and 2017 ACC/AHA guidelines on diagnosis and treatment of hypertension [13,14].

Whether the results of SPRINT should be applied to hypertension guidelines is a crucial challenge in the worldwide, as the generalizability of SPRINT remains to be examined in other populations/countries. To contribute to the growing body of literature regarding the application of SPRINT-based hypertension treatment goal, we assessed the number of Chinese adults who could benefit from the treatment based on SPRINT, and estimated the prevalence and characteristics of Chinese adults aged 50 years or older who meet SPRINT eligibility criteria. In addition, Liu et al. [15] found that the original Framingham risk score overestimated the risk of CVD in China, and developed a Chinese risk function. Thus, we also made a comparison between using

***Corresponding author:** Zengwu Wang, MD, PhD, Division of Prevention and Community Health, National Clinical Research center of Cardiovascular Disease, State Key Laboratory of Cardiovascular Disease, Fuwai Hospital, Peking Union Medical College and Chinese Academy of Medical Sciences, Beijing, 102308, China, Tel: +86 10 60866161; Fax: +86 10 60866161; E-mail: wangzengwu@foxmail.com

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Framingham risk score and Chinese function to identify the number of SPRINT-eligible individuals.

Methods

Design and sample

A cross-sectional study was conducted from 2012-2015. The subjects were sampled by a randomized stratified multistage method across the whole of mainland China. Detailed descriptions of the sampling method and more detailed information regarding the survey have been published previously [16]. As subgroup of the study, all 262 cities/counties selected previously were stratified into Eastern, Middle and Western regions according to economic development in China. Simple random sampling (SRS) method was used to select 16 cities and 17 counties (7 cities and 7 counties in Eastern region, 6 cities and 6 counties in Middle region, and 3 cities and 4 counties in Western region). Using same method, districts/townships and communities/villages were selected step by step. To meet the designed sample size of 35,000 participants aged ≥ 35 years and take non-response into account in the survey 56,000 subjects were randomly selected from the eligible cities. As a result, 34,994 participants completed the survey; the overall response rate was 62.5%. After excluded participants who did not have BP measurements (n=549) or did not complete physical (n=325) and laboratory (n=3,143) examinations and in order to meet the SPRINT eligible criteria, we restricted participants aged 50 years or older, finally, 20,137 participants were included in the current analysis. The ethnical review committee of Fuwai Hospital (Beijing, China) and each participating center approved the protocol. All participants provided written informed consent prior to data collection.

Data collection

All participants completed a questionnaire developed by the coordinating center, Fuwai Hospital (Beijing, China). The data set consisted of demographic clinical and social-economic information, including age, gender, urban vs. rural location, lifestyle behaviors (smoking status, alcohol consumption), self-reported history of stroke, heart failure, diabetes and use of antihypertensive and diabetes medication. Medications were classified as beta-blocker, alpha blocker, calcium channel blocker (CCB), thiazide diuretics, loop diuretic agents, potassium-sparing diuretic agents, aldosterone receptor antagonists, angiotensin-converting enzyme inhibitor (ACEI), angiotensin-receptor-blocker (ARB).

Blood pressure measurement

BP was measured on the right arm in a seated position after 5 minutes of rest with the OMRON HBP-1300 Professional Portable Blood Pressure Monitor (OMRON, Kyoto, Japan). The average of the three readings was be used for the analysis.

Laboratory measurements

Fasting venous blood and urine samples were collected. The specimens were stored in -80° C refrigerators until laboratory assays could be performed in designated central clinical laboratories (Beijing Adicon Clinical Laboratories, Inc, Beijing, China). Low density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula in subjects who had triglyceride levels <400 mg/dL [17].

SPRINT eligibility

To determine the number of SPRINT-eligible individuals in our study, we identified those who met all of the following criteria: age ≥50 years, SBP of 130-180 mmHg (130-180 mmHg on none or one antihypertensive medication, 130-170 mmHg on up to two medications, 130-160 mmHg on up to three medications, 130-150 mmHg on up to four medications), and an increased risk of cardiovascular events. Increased CVD risk included history of CVD (self-reported prior diagnosis of myocardial infarction, percutaneous coronary intervention, coronary artery bypass grafting), estimated glomerular filtration rate (eGFR) of 20 to <60/ml/min/1.73 m^2, a 10-year risk of CVD ≥15% based on the Framingham risk score, or age ≥75 years. According to the SPRINT exclusion criteria, individuals with self-report of a prior diagnosis of diabetes mellitus, stroke, heart failure, or eGFR <20/ml/min/1.73 m^2 were not considered SPRINT eligible criteria. Diabetes mellitus was defined as a prior diagnosis or current use of insulin or oral hypoglycemic medication or fasting blood glucose ≥7 mmol/L. Given that the Chinese risk function was for participants between age 35 to 59 years, to persons older than 60 years, risk scores on the basis of the Chinese function were adjusted by adding 1 more point with every 5 years from age 60 [18]. eGFR was calculated using the modification of diet in renal disease equation (MDRD) [19]. Treated hypertension was defined as self-reported using drugs to lower BP with one or more antihypertensive medications noted above.

Statistical Analysis

Among all adults aged 50 years or above with and without hypertension, hypertension with and without treatment, the percentage and numbers of Chinese adults who met the SPRINT eligibility criteria were calculated. Next, we also calculated the number and classes of antihypertensive medication used by Chinese adults and the treated hypertensive who met the SPRINT eligibility criteria. Furthermore, we also compare a 10-year risk of CVD by Framingham risk score and Chinese estimates. Sample weights were adjusted for non-response and the total population aged ≥50 years old as per the 2010 Chinese census [16] in order to obtain Chinese nationally representative prevalence estimates. All analyses were performed using SAS 9.3 (SAS Institute Inc., Cary, NC).

Results

In 2012-2015, using the Framingham score, 29.7% (95% CI: 27.9%-31.5%) of Chinese adults met the eligible criteria of SPRINT, 49.1% (95% CI: 45.3%-53.0%) of those with, and 12.6% (95% CI: 11.4%-13.9%) of without a diagnosis hypertension. Using Chinese function, 13.7% (95% CI: 11.6%-16.2%) of adults met the eligible criteria, among them 23.7% (95% CI: 20.3%-27.3%) with and 5.0% (95% CI: 3.9%-6.4%) without a diagnosis of hypertension, respectively (Table 1).

Among those with treated hypertension, 44.2% (95% CI: 38.7%-49.7%) and 20.2% (95% CI: 17.5%-23.2%) met the SPRINT eligibility criteria on the basis of Framingham risk score and Chinese function, respectively; and 26.7% (95% CI: 24.8%-28.7%) and 12.4% (95% CI: 10.4%-14.8%) of those with untreated hypertension based on the Framingham risk score and Chinese function, respectively (Table 2).

The percentages eligible for SPRINT was higher for the older age group (age ≥ 75 years) versus younger age group, for males versus females, for living in rural areas versus urban areas and for those with SBP ≥ 140 mmHg versus those in the SBP of 130 to 139 mmHg group (Table 1).

In general, using the Framingham score, 96.3 million (95% CI: 93.5-99.1 million) Chinese adults aged ≥50 years met the eligibility criteria of the SPRINT; on the basis of Chinese function, the number of eligible adults were 44.5 million (95% CI: 42.9-46.2 million). Of those

	Chinese adults (millions)	+SBP criteria	Framingham Risk Score		Chinese Function	
			+high CVD risk condition	+no exclusion criteria	+high CVD risk condition	+no exclusion criteria
Overall population						
Overall	324.0	56.1% (54.2-57.9%)	38.7% (37.0-40.5%)	29.7% (27.9-31.5%)	17.9% (15.4-20.7%)	13.7% (11.6-16.2%)
Age group						
50-59	158.9	50.5% (47.8-53.2%)	26.6% (24.2-29.1%)	20.1% (18.0-22.3%)	6.4% (4.8-8.3%)	5.1% (3.8-6.8%)
60-74	134.8	60.2% (57.4-62.9%)	46.7% (44.1-49.3%)	36.0% (33.8-38.2%)	20.4% (16.9-24.4%)	15.3% (12.2-19.0%)
≥75	30.4	67.0% (63.3-70.7%)	67.0% (63.3-70.7%)	52.3% (46.0-58.6%)	67.0% (63.3-70.7%)	52.3% (46.0-58.6%)
Sex						
Male	162.4	55.6% (53.3-57.9%)	49.1% (46.9-51.3%)	39.0% (36.6-41.5%)	17.0% (15.1-19.1%)	12.7% (11.3-14.3%)
Female	161.6	56.5% (54.4 -58.7%)	28.4% (25.6-31.1%)	20.4% (17.5-23.6%)	18.7% (15.3-22.7%)	14.8% (11.7-18.6%)
Area						
Rural	195.2	55.1% (52.6-57.5%)	37.1% (35.0-39.1%)	30.6% (27.8-33.4%)	16.8% (13.2-21.0%)	14.0% (10.6-18.3%)
Urban	128.9	57.6% (54.9-60.3%)	41.3% (38.5-44.0%)	28.4% (26.7-30.2%)	19.5% (16.6-22.8%)	13.3% (11.9-14.9%)
SBP, mmHg						
130-139	65.2	100.0% (99.9-100.0%)	56.8% (52.9-60.6%)	44.3% (40.5-48.1%)	22.1% (17.4-27.6%)	17.3% (13.5-21.9%)
≥140	126.7	91.9% (90.3-93.3%)	69.9% (67.2-72.5%)	53.2% (49.4-57.0%)	34.3% (30.0-38.7%)	26.2% (22.3-30.2%)
With hypertension						
Overall	152.0	86.2% (83.0-88.9%)	64.9% (62.5-67.4%)	49.1% (45.3-53.0%)	31.3% (27.6-35.0%)	23.7% (20.3-27.3%)
Age group						
50-59	61.7	89.0% (84.7-92.2%)	52.4% (48.5-56.3%)	39.3% (34.0-44.5%)	13.2% (10.6-16.3%)	10.6% (8.1-13.8%)
60-74	71.1	84.6% (81.7-87.0%)	70.7% (68.1-73.3%)	53.5% (49.9-57.2%)	32.9% (27.8-38.1%)	24.0% (19.7-29.0%)
≥75	19.1	83.5% (80.2-86.4%)	83.5% (80.2-86.4%)	64.5% (57.5-71.5%)	83.5% (80.2-86.4%)	64.5% (57.5-71.5%)
Sex						
Male	76.1	87.1% (84.5-89.3%)	80.0% (76.6-83.0%)	62.7% (57.0-68.3%)	31.6% (29.1-34.0%)	23.4% (20.9-26.0%)
Female	75.9	85.4% (81.3-88.7%)	49.8% (46.2-53.4%)	35.6% (31.0-40.2%)	31.0% (25.3-36.6%)	23.9% (19.1-29.6%)
Area						
Rural	86.0	88.0% (84.3-90.9%)	64.8% (61.7-67.9%)	52.5% (47.1-57.9%)	30.6% (24.8-36.5%)	25.1% (18.9-31.2%)
Urban	65.9	83.9% (77.4-88.8%)	65.0% (60.7-69.4%)	44.7% (39.4-50.0%)	32.1% (27.7-36.5%)	21.8% (19.2-24.6%)
SBP, mmHg						
130-139	14.5	99.9% (99.4-100.0%)	69.5% (64.3-74.6%)	49.7% (45.8-53.6%)	27.6% (21.2-34.0%)	18.7% (14.6-23.6%)
≥140	126.7	91.9% (90.3-93.3%)	69.9% (67.2-72.5%)	53.2% (49.4-57.0%)	34.3% (30.0-38.7%)	26.2% (22.3-30.2%)
Without hypertension						
Overall	172.1	29.4% (28.0-30.9%)	15.6% (14.6-16.8%)	12.6% (11.4-13.9%)	6.0% (4.7-7.6%)	5.0% (3.9-6.4%)
Age group						
50-59	97.1	26.0% (24.1-28.0%)	10.2% (8.9-11.8%)	7.9% (6.5-9.4%)	2.0% (1.2-3.3%)	1.5% (0.9-2.6%)
60-74	63.7	33.0% (30.6-35.4%)	19.8% (17.9-21.9%)	16.5% (14.9-18.2%)	6.4% (4.5-9.1%)	5.6% (3.7-8.2%)
≥75	11.2	38.7% (32.4-45.1%)	38.7% (32.4-45.1%)	31.6% (24.5-38.6%)	38.7% (32.4-45.1%)	31.6% (24.5-38.6%)
Sex						
Male	86.4	27.9% (26.0-29.8%)	21.9% (20.2-23.6%)	18.3% (16.4-20.3%)	4.2% (3.4-5.3%)	3.3% (2.7-4.2%)
Female	85.7	31.0% (29.1-32.9%)	9.4% (7.4-11.7%)	6.9% (5.0-9.3%)	7.8% (5.9-10.4%)	6.7% (4.9-9.1%)
Area						
Rural	109.1	29.1% (27.0-31.2%)	15.2% (13.8-16.8%)	13.3% (11.8-14.9%)	5.9% (4.0-8.5%)	5.3% (3.7-7.7%)
Urban	62.9	30.0% (28.0-32.0%)	16.3% (14.4-18.4%)	11.4% (9.8-13.2%)	6.3% (5.1-7.9%)	4.4% (3.6-5.4%)
SBP, mmHg						
130-139	50.7	100.0%	53.1% (49.5-56.7%)	42.8% (38.6-47.0%)	20.5% (16.0-25.8%)	17.0% (13.1-21.7%)
≥140	0.0	0%	0%	0%	0%	0%
Numbers in table are percentage (95% confidence interval).						
SBP criteria include: 130-180 mm Hg on 0 or 1 antihypertensive medication class, 130-170 mm Hg on up to 2 classes; 130-160 mm Hg on up to 3 classes, 130 to 150 mm Hg on up to 4 classes.						
Criteria for high CVD risk condition include: history of CHD (defined as self-report of a prior diagnosis of myocardial infarction, percutaneous coronary intervention, coronary artery bypass grafting), eGFR of 20 to 59 ml/min/1.73 m^2, 10-year risk for CVD ≥15% calculated using the Framingham risk score/Chinese Function for general clinical practice, and age ≥75 years.						
Exclusion criteria include diabetes, history of stroke, heart failure, estimated glomerular filtration rate <20 ml/min/1.73 m^2 or dialysis treatment in the past year.						

Table 1: Percentage of chinese adults aged ≥ 50 years meeting each sequential eligibility of sprint by overall, with or without hypertension.

	Chinese adults (millions)	+SBP criteria	Framingham Risk Score		Chinese Function	
			+high CVD risk condition	+no exclusion criteria	+high CVD risk condition	+no exclusion criteria
Treated hypertension						
Overall	55.6	73.8% (68.5-79.1%)	63.4% (58.7-68.1%)	44.2% (38.7-49.7%)	29.7% (26.6-32.9%)	20.2% (17.5-23.2%)
Age group						
50-59	21.3	76.2% (68.4-82.6%)	55.6% (50.2-60.9%)	38.4% (32.0-44.7%)	14.7% (11.4-18.7%)	10.6% (7.6-14.7%)
60-74	27.4	72.4% (67.6-77.3%)	67.2% (61.3-73.1%)	47.9% (40.9-54.9%)	30.7% (26.1-35.3%)	20.7% (17.2-24.8%)
≥75	6.9	72.0% (69.1-75.0%)	72.0% (69.1-75.0%)	47.3% (40.3-54.2%)	72.0% (69.1-75.0%)	47.3% (40.3-54.2%)
Sex						
Male	26.2	74.6% (69.7-79.4%)	73.7% (68.5-78.8%)	53.0% (46.6-59.4%)	28.9% (26.6-31.2%)	19.2% (16.4-22.4%)
Female	29.3	73.2% (67.0-79.3%)	54.2% (49.9-58.4%)	36.3% (31.7-40.9%)	30.5% (25.4-35.5%)	21.1% (17.3-25.4%)
Area						
Rural	25.0	76.3% (70.1-81.6%)	65.2% (60.4-70.0%)	49.1% (44.0-54.1%)	29.5% (24.1-35.0%)	22.7% (17.5-28.9%)
Urban	30.6	71.8% (62.5-81.0%)	61.9% (53.4-70.3%)	40.2% (30.4-50.0%)	29.9% (26.0-33.8%)	18.1% (15.8-20.7%)
SBP, mmHg						
130-139	10.7	99.9% (99.2-100%)	73.2% (66.9-79.6%)	49.9% (44.8-55.0%)	33.4% (26.7-40.0%)	21.8% (17.4-27.0%)
≥140	34.8	87.0% (83.2-90.0%)	78.5% (73.4-82.9%)	55.1% (49.6-60.6%)	37.2% (33.0-41.4%)	25.5% (21.7-29.3%)
Untreated hypertension						
Overall	268.5	52.4% (50.5-54.3%)	33.7% (32.1-35.2%)	26.7% (24.8-28.7%)	15.4% (13.2-17.9%)	12.4% (10.4-14.8%)
Age group						
50-59	137.6	46.5% (44.0-49.0%)	22.2% (20.0-24.5%)	17.2% (15.2-19.5%)	5.1% (3.7-6.9%)	4.2% (3.0-5.8%)
60-74	107.5	57.1% (54.3-59.9%)	41.4% (39.1-43.8%)	33.0% (31.1-34.9%)	17.8% (14.5-21.5%)	13.9% (10.8-17.7%)
≥75	23.4	65.5% (60.6-70.4%)	65.5% (60.6-70.4%)	53.8% (47.1-60.6%)	65.5% (60.6-70.4%)	53.8% (47.1-60.6%)
Sex						
Male	136.2	51.9% (49.6-54.3%)	44.4% (42.1-46.6%)	36.4% (33.6-39.2%)	14.7% (13.0-16.7%)	11.5% (10.1-13.0%)
Female	132.3	52.9% (50.8-55.0%)	22.6% (19.9-25.6%)	16.8% (13.9-20.3%)	16.1% (12.9-19.9%)	13.4% (10.4-17.1%)
Area						
Rural	170.2	52.0% (49.1-54.8%)	33.0% (30.7-35.3%)	27.9% (25.1-30.6%)	14.9% (11.7-18.8%)	12.8% (9.7-16.6%)
Urban	98.3	53.2% (51.0-55.3%)	34.8% (32.8-36.9%)	24.8% (23.2-26.5%)	16.3% (13.9-19.0%)	11.8% (10.4-13.4%)
SBP, mmHg						
130-139	54.5	100%	53.5% (50.1-56.9%)	43.2% (39.3-47.1%)	19.8% (15.6-24.9%)	16.5% (12.7-21.0%)
≥140	91.9	93.8% (92.5-94.9%)	66.6% (64.1-69.1%)	52.5% (48.5-56.4%)	33.3% (28.7-37.8%)	26.5% (22.2-30.8%)
Numbers in table are percentage (95% confidence interval).						
Treated hypertension was defined by self-reported use of antihypertensive medication with one or more classes of antihypertensive medication identified through the pill bottle review.						

Table 2: Percentage of chinese adults ≥50 years meeting each sequential eligibility of sprint by overall, with treated or untreated hypertension.

	All adults	With treated hypertension	With untreated hypertension
10-year risk calculated using the Framingham risk score*			
Eligible for SPRINT	96.3 (93.5-99.1)	24.5 (23.0-26.1)	71.8 (69.4-74.1)
Eligible for SPRINT and SBP 130-139 mmHg	28.9 (27.4-30.4)	5.4 (4.7-6.0)	23.5 (22.2-24.9)
Eligible for SPRINT and SBP ≥140 mmHg	67.4 (65.0-69.8)	19.2 (17.8-20.6)	48.2 (46.3-50.2)
10-year risk calculated using the Chinese Function†			
Eligible for SPRINT	44.5 (42.9-46.2)	11.2 (10.4-12.1)	33.3 (32.0-34.7)
Eligible for SPRINT and SBP 130-139 mmHg	11.3 (10.5-12.1)	2.3 (2.0-2.7)	9.0 (8.3-9.6)
Eligible for SPRINT and SBP ≥140 mmHg	33.2 (31.8-34.7)	8.9 (8.1-9.7)	24.4 (23.2-25.6)
Data in table are Number of millions (95% CI).			
*10-year risk for CVD ≥ 15% calculated using the Framingham risk score.			
†10-year risk for CVD ≥ 15% calculated using the Chinese Function.			

Table 3: Number of Chinese adults ≥ 50 years meeting the eligibility of SPRINT criteria, overall and those with treated or untreated hypertension.

eligible adults, 28.9 million (95% CI: 27.4-30.4 million) based on the Framingham score had SBP of 130-139 mmHg, while 11.3 million (95% CI: 10.5-12.1 million) had SBP of 130-139 mmHg on the basis of Chinese function. For those with treated hypertension, there were 24.5 million (95% CI: 23.0-26.1 million) who met the eligibility criteria of the SPRINT based on the Framingham score; there were 11.2 million (95% CI: 10.4-12.1 million) based on Chinese function (Table 3).

Of Chinese adults ≥50 years old, using the Framingham score, there were about 191.9 million who had SBP ≥ 130 mmHg, among whom 50.2% (95% CI: 46.8%-53.6%) met SPRINT eligibility criteria; 184.5 million had any high CVD risk condition, of whom 52.2% (95% CI: 49.3%-55.1%) met SPRINT eligibility criteria; 134.5 million had SBP ≥ 130 mmHg and high CVD risk condition, of whom 71.6% (95% CI: 67.3%-75.9%) met SPRINT eligibility criteria. On the basis of the Chinese function, there were about 191.9 million who had SBP ≥ 130 mmHg, among whom 23.2% (95% CI: 19.5%-27.4%) met SPRINT eligibility criteria; 90.2 million had any high CVD risk condition,

among whom 49.4% (95% CI: 45.6%-53.1%) met SPRINT eligibility criteria; 65.6 million had SBP ≥ 130 mmHg and high CVD risk condition, among whom 67.9% (95% CI: 62.9%-73.0%) met SPRINT eligibility criteria (Table 4).

Of those who met the SPRINT eligibility criteria based on Framingham, 74.5% (95% CI: 69.8%-79.3%) did not take any antihypertensive medication. Of patients with treated hypertension who met SPRINT criteria, 83.2% (95% CI: 79.8%-86.1%) who met the SPRINT eligibility criteria had taken one kind of medicine to treat their hypertension, 12.2% (95% CI: 10.4%-14.3%) two medications and 4.6% (95% CI: 2.4%-8.4%) three or more medications. CCBs were their most common medications used (Table 5).

Discussion

In this study, we estimate that 29.7% or 96.3 million Chinese adults aged 50 years or older meet the eligibility of SPRINT criteria based on Framingham, and may benefit from a more intensive SBP goal <120 mmHg. Among Chinese adults with treated hypertension, 44.2% (Table 2) or 24.5 million (Table 3) adults meeting the SPRINT eligibility criteria and those individuals may also benefit from the more intensive SBP goal. We found that the percentages meeting SPRINT eligibility criteria were higher among those aged ≥ 75 years, males, living in rural areas, and those with SBP of ≥ 140 mmHg. However, using a Chinese model resulted in a lower proportion of the targeted population (aged ≥ 50 years) meeting the SPRINT eligibility (29.7% or 96.3 million vs. 13.7% or 44.5 million).

In this study, 30.6% of those living in the rural areas met the SPRINT eligibility criteria, which was a slightly higher than those living in urban areas (28.4%). One of the reasons might be that those living in rural areas had a higher prevalence of hypertension [20], a lower rate of diabetes mellitus [21], heart failure [22], and stroke [23]. We note differences in the SPRINT eligibility criteria by sex. Females were less likely to meet the SPRINT eligibility criteria than males, since male residents are more likely to have a high risk of CVD. Similarly, people aged ≥ 75 years or SBP ≥ 140 mmHg were more likely to meet the eligibility of SPRINT criteria. Bress et al. [11] reported similar findings in their 2016 study. Ko et al. [12] also recently noted that stricter BP control (below SPRINT BP goals) could decrease the risk of major cardiovascular events.

As noted, the Framingham model overestimated CVD risk in China [18]. Differences between ethnic groups and countries, e.g. China and US, should be carefully considered when using an algorithm to estimate the specific population CVD risk. It is well known that mortality from stroke has been much higher than mortality from coronary heart disease in China, whereas the reverse prevails in America [24]. Therefore, the prevalence and numbers of patients who met the SPRINT eligibility criteria should be examined based on the different risk factor patterns and profiles of CVD in US and China [25]. When the Chinese functions were used to assess the CVD risk of Chinese adults, it showed that only 13.7% of Chinese adults met the SPRINT eligibility criteria, which was significantly lower than the 29.7% estimated by the Framingham risk score. Thus, risk estimation

Population	All adults		With treated hypertension	
	N of Chinese adults in million	% (95% CI) meeting SPRINT eligibility criteria	N of Chinese adults in million	% (95% CI) meeting SPRINT eligibility criteria
10-year risk calculated using the Framingham risk score*				
SBP ≥ 130 mmHg	191.9	50.2% (46.8-53.6%)	45.5	53.9% (49.3-58.5%)
Any high CVD risk condition	184.5	52.2% (49.3-55.1%)	46.1	53.2% (47.0-59.5%)
eGFR 20-59 ml/min/1.73 m^2	55.8	48.0% (43.8-52.2%)	14.5	50.1% (43.5-56.8%)
Framingham risk score ≥ 15%	153.5	53.9% (51.0-56.8%)	42.6	53.7% (47.8-59.6%)
SBP ≥ 130 mmHg with any high CVD risk condition	134.5	71.6% (67.3-75.9%)	46.1	53.2% (47.0-59.5%)
10-year risk calculated using the Chinese Function†				
SBP ≥ 130 mmHg	191.9	23.2% (19.5-27.4%)	45.5	24.6% (21.2-28.4%)
Any high CVD risk condition	90.2	49.4% (45.6-53.1%)	23.0	48.8% (43.5-54.0%)
eGFR 20-59 ml/min/1.73 m^2	55.8	48.0% (43.8-52.2%)	14.5	50.1% (43.5-56.8%)
Chinese function ≥ 15%	31.3	50.9% (46.7-55.2%)	9.9	40.7% (34.8-46.6%)
SBP ≥ 130 mmHg with any high CVD risk condition	65.6	67.9% (62.9-73.0%)	20.0	56.2% (51.5-60.9%)
*10-year risk for CVD ≥ 15% calculated using the Framingham risk score.				
†10-year risk for CVD ≥ 15% calculated using the Chinese Function.				

Table 4: Percentage of Chinese adults ≥ 50 years, overall and with treated hypertension, meeting the eligibility of SPRINT.

Group	Chinese population ≥50 years		Chinese population 50 years with treated hypertension	
	Overall	SPRINT Eligible	Overall	SPRINT Eligible
Number of classes				
0	82.9% (78.9-86.2%)	74.5% (69.8-79.3%)	0%	0%
1	13.9% (11.4-16.7%)	21.2% (17.9-24.9%)	80.8% (77.6-83.7%)	83.2% (79.8-86.1%)
2	2.4% (1.7-3.3%)	3.1% (2.4-4.1%)	13.7% (11.8-15.9%)	12.2% (10.4-14.3%)
≥ 3	0.9% (0.5-1.7%)	1.2% (0.6-2.4%)	5.5% (3.4-8.7%)	4.6% (2.4-8.4%)
Classes				
ACEI	2.5% (1.7-3.6%)	3.7% (2.4-5.5%)	14.4% (10.6-19.3%)	14.4% (10.0-20.4%)
ARB	1.2% (0.7-1.9%)	1.0% (0.7-1.5%)	6.9% (4.8-9.7%)	3.9% (2.7-5.4%)
β-Blocker	1.5% (0.9-2.5%)	1.9% (1.0-3.7%)	8.5% (5.6-12.7%)	7.6% (4.4-12.7%)
Calcium channel blocker	8.7% (6.4-11.6%)	13.0% (10.0-16.9%)	50.6% (41.2-60.0%)	51.2% (39.8-62.5%)
Thiazide diuretic	2.3% (1.5-3.6%)	3.5% (2.0-6.0%)	13.7% (9.3-19.6%)	13.7% (8.5-21.2%)

Table 5: Antihypertensive Medication Use among Chinese Adults Aged ≥ 50 Years and with Treated Hypertension, Overall and among Those Eligible for SPRINT.

based on Chinese function may be more suitable to Chinese adults, indicating that the generalizability of SPRINT for different cultures or ethnicities should consider these issues.

Lowering SBP targets <120 mmHg, in additions to benefits, may also have adverse events or side effects (e.g., hypotension, syncope, electrolyte abnormalities, etc.). Some of those adverse events may be associated with antihypertensive medications taken, and others may be related to lowering blood pressure [25]. More importantly, the long-term effects of intensive treatment are not known, especially on kidney function. Therefore, the risks and benefits of this intervention should be carefully weighted. A study by Thoma et al. [26] noted that there may be a higher prevalence of adverse events in real world settings given that the participants enrolled in this trial tended to be relatively healthy. In addition, the eligibility of SPRINT was very restrictive (e.g., an age ≥50 years, any increased risk of cardiovascular events, etc.), so caution should be exercised when extrapolating to the general population.

Furthermore, the current practice in hypertension management has been on the basis of JNC 8 report, for the general population aged ≥60 years the BP goal was a SBP <150 mmHg and DBP <90 mmHg; for those aged <60 years lowering their SBP <140 mmHg or DBP <90 mmHg [27]. However, there were 5.4 million treated hypertensive patients eligible for SPRINT with SBP 130-139 mmHg. If these participants were included within the intensive treatment group, additional antihypertensive drugs would be required, although their BP may have conformed to current guideline recommendation. Thus, while lowering SBP to <120 mmHg could prevent potential cardiovascular events, it could also increase in the cost of medications. A previous study presented that cost-effectiveness ratios ranged from 3.6 to 5.0 Yuan RMB (USD 0.55 to 0.76) per mmHg SBP decrease per person [28]. Thus, further investigation regarding to cost-effectiveness of lowering SBP to less than 120 mmHg vs. standard treatment is necessary.

The strength of this study lies in that it was a multi-stage sampling study which allowed us to analyze and generalize in Chinese adults aged ≥50 years. However, there are potential limitations. Our study did not have accurate diagnostic criteria for the presence of some clinical or subclinical conditions (i.e., abdominal aortic aneurysm, coronary artery calcium, ankle brachial index, etc.), which was substituted by self-report. Most importantly, SPRINT was a clinical trial conducted in US adults, and it is clear that there is not a one-size-fits-all approach to treating hypertension, especially for Chinese with its very large population. While the Framingham model may not be generalizable to China, the Chinese function considered more limited endpoints. Therefore, caution should be taken when generalizing the results of any algorithm to Chinese adults.

Conclusion

This study identified that a considerable percentage of Chinese adults aged ≥50 years meet the SPRINT eligibility criteria. After examining the generalizability of findings from SPRINT among a much larger patient population in China, we should further assess the effect of a high BP treatment strategy aimed at reducing SBP to a lower goal than is currently recommended in Chinese guidelines, which means that further clinical trials (which might be include Chinese functions to assess 10 years risk) are needed to assess efficacy and cost-effectiveness of intensive treatment of hypertension using SPRINT criteria in China.

Data Availability

The data about this article is not availability for open.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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Contributors

Investigation, XIN WANG, ZUO CHEN; Supervision, ZENGWU WANG, ZUGUI ZAHNG; Writing-original draft, YING DONG. They had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Ethical Approval

All the participants signed a written informed consent prior to data collection, and the study protocol was approved by ethical review committee of Fuwai Hospital (Beijing, China) and each participating center.

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