

Original Article

Prevalence, awareness, treatment, control and the risk factors of hypertension in the Chinese Maonan and Han ethnic groups

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Abstract: Maonan ethnic group is an isolated minority residing in the Southwestern of China. The population size is 107,166 in 2010. The epidemic status of hypertension in this ethnic group has not been investigated previously. The aim of this study was to compare the difference in the prevalence, awareness, treatment, control and the risk factors of hypertension between the Maonan and Han ethnic groups. A cross-sectional study of hypertension and its risk factors in 1332 subjects of Maonan ethnic group and 1344 participants of Han nationality aged 18-98 was conducted by a stratified randomized sampling. Information on demographics, diet, lifestyle, and physical activity was collected with standardized questionnaires. Blood pressure, biochemical data, and several anthropometric parameters were obtained from all subjects. The levels of systolic, diastolic and pulse pressures, and the overall prevalence of hypertension (48.57% vs. 30.80%) and isolated systolic hypertension (14.79% vs. 9.90%) were higher in Maonan than in Han ($P < 0.001$ for all). The rates of awareness, treatment and control in Maonan and Han were 16.69% vs. 23.67% ($P < 0.01$), 15.30% vs. 20.77% ($P < 0.05$), and 5.41% vs. 10.63% ($P < 0.01$); respectively. Multivariate logistic regression analysis showed that the prevalence of hypertension was positively correlated with body mass index, hyperlipidemia, cigarette smoking, total fat and sodium intakes, and negatively associated with total dietary fiber intake in Maonan, whereas it was positively associated with age, body mass index, alcohol consumption, total fat and sodium intakes, and negatively associated with total dietary fiber intake in Han ($P < 0.05-0.001$). The difference in the prevalence of hypertension and its risk factors between the two ethnic groups might result from different body mass index, hyperlipidemia, diet, lifestyle, and genetic background.

Keywords: Blood pressure, hypertension, prevalence, awareness, treatment, control, risk factors

Introduction

Hypertension, also known as high or raised blood pressure, is the leading remediable risk factor for cardiovascular disease [1]. It affects more than 1 billion people and is responsible for more than 10 million largely preventable deaths globally each year [1, 2]. With economic rapid development, lifestyle change and urbanization in China, hypertension also becomes a major public health issue, accounting for 14.2% of total disability adjusted life years and 2.5 million deaths [2]. A rapid increase in the prevalence of hypertension has been repeatedly

observed in recent three decades [3-6]. The prevalence of hypertension in adults has quadrupled from 5% in 1959 to nearly 19% in 2002 [3]. A recent systematic review demonstrated that the age-standardized prevalence of hypertension increased by 1.4% per year from 2002 to 2012 [4]. In the 2007-2008 China National Diabetes and Metabolic Disorders Study, a total of 26.6% of Chinese adults had hypertension, and it was higher in men than in women (29.2% vs. 24.1%, $P < 0.001$) [5]. The most recent prevalence of hypertension in China reported from a nationally representative survey was 33.5%, indicating nearly 330 million Chinese residents

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aged 18 years and over are directly affected [6]. Hypertension and its complications have a large economic impact, both at household and macroeconomic level, due to catastrophic healthcare expenditures and through loss of income and labour productivity. Although the exact causes and mechanisms of hypertension remain unknown, it is generally believed that the levels of blood pressure and the prevalence of hypertension are determined by multiple environmental factors such as poor diet [7, 8], more sodium intake [3, 9], cigarette smoking [10], mental work [11], physical inactivity [12], overweight and obesity [13], and excessive alcohol consumption [14], as well as genetic factors [15, 16], and their interactions [17-19]. In addition, there may be a significant variation in the prevalence of hypertension across different countries, between different regions within each country [20], and among diverse racial/ethnic groups [21, 22]. Studies have indicated that detection, treatment and control of hypertension such as modification of a single one of these behavioral risk factors, or several at the same time are fundamental for managing hypertension and reducing the incidence of cardiovascular events [23].

China is a multi-ethnic country, including 56 nationalities. Han is the largest group and Maonan is one of the 55 minorities with a population of 107,166 (Rank 37) according to the sixth national census statistics of China in 2010. The Maonan people are mainly distributed in the Shangnan, Zhongnan, and Xianan townships of Huanjiang Maonan Autonomous County in the north of the Guangxi Zhuang Autonomous Region, which is situated in Southwestern China. More than 80% of the total Maonan people live in the Huanjiang Maonan Autonomous County. Thus, the county of Huanjiang has a reputation of "hometown of Maonan people". In addition, some Maonan people are scattered in the counties of Yishan, Nandan, Du'an, etc. The Maonan ethnic group has its own language but no written language. The Maonan people call themselves Anan, meaning "the people who live in this area or local people". This implies that the Maonan people are the aborigines of this area. The ancestors of the Maonan ethnic group had some relations with the Liao before the Tang Dynasty and the Ling of the Song, Yuan and Ming periods. In history, they were known as "Maotan, Angtan, and Maonan" successively.

Recent phylogenetic and principal component analyses revealed that the Maonan people belong to the Southeastern Asian group and are most closely related to the Buyi people [24]. Several previous studies have showed that the genetic relationship between Maonan nationality and other minorities in Guangxi [25] was much closer than that between Maonan and Han nationalities [26]. In spite of a very small population, the Maonan ethnic group is well known in China for its long history and unique culture. The special customs and culture, including their clothing, intra-ethnic marriages, dietary habits and lifestyle factors are different from those of local Han Chinese [27]. To the best of our knowledge, however, the levels of blood pressure and the prevalence of hypertension in this population have not been explored previously. Therefore, the present study was undertaken to compare the differences in the prevalence, awareness, treatment, control and the risk factors of hypertension in the Chinese Maonan and Han populations from the same area.

Materials and methods

Subjects

A total of 1332 unrelated subjects of Maonan nationality and 1344 participants of Han nationality aged 18-98 were surveyed by a stratified randomized sampling [15]. There were 660 males (49.55%) and 672 females (50.45%) in Maonan, and 671 men (49.93%) and 673 women (50.07%) in Han. All subjects were rural agricultural workers. The age of the subjects ranged from 18 to 96 (mean 57.41 ± 15.23) years in Maonan, and 18 to 98 (mean 57.26 ± 15.15) years in Han. Ages < 40, 40-49, 50-59, 60-69, 70-79, and ≥ 80 years in Maonan and Han ethnic groups were 173 (12.99%) vs. 179 (13.32%), 209 (15.69%) vs. 213 (15.85%), 282 (21.17%) vs. 282 (20.98%), 331 (24.85%) vs. 326 (24.26%), 245 (18.39%) vs. 250 (18.60%), and 92 (6.91%) vs. 94 (6.99%) persons; respectively. Inclusion criteria were: (i) three generations of their ancestors are Han or Maonan; (ii) unrelated men or women aged ≥ 18 years; (iii) with no severe chronic disease or systemic disease; (iv) willing and able to give informed consent; and (v) with complete data on key research variables. Subjects with medical diseases such as cardiovascular (heart attack, myocardial infarction, stroke, or conges-

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tive heart failure), hepatic, renal, thyroid diseases, and diabetes mellitus or fasting blood glucose ≥ 7.0 mmol/L determined by glucose meter, or pregnant women have been excluded. Some subjects were treated with antihypertensive drugs. Methods and procedures regarding the survey were conducted in accordance with the guidelines described in the declaration of Helsinki. The present study was approved by the Ethics Committee of the First Affiliated Hospital, Guangxi Medical University. Informed consent was obtained from all participants by signature or by fingerprint, as approved by the ethical review committee.

Epidemiological survey

The survey was carried out using internationally standardized methods. Research assistants were trained to assure the quality and validity of the measurements. Supervisors assessed the completeness and consistency of the questionnaire after each interview. In the survey, demographic, socioeconomic, dietary, lifestyle and medical information was collected by face-to-face interviews with standardized questionnaires. The dietary intakes of each subject were determined by the 24-h dietary recall method [28]. The intakes of macronutrients from the ingredients were calculated by using the 2002 Chinese Food Composition Table [29]. Global Physical Activity Questionnaire was used to evaluate physical activity of each respondent. Individuals with less than 150 minutes of moderate-intensity activity per week or equivalent were defined as insufficiently active [30]. The alcohol information included questions about the number of grams of rice wine, wine, beer, or liquor consumed during the preceding 12 months. Current smokers were defined as those who currently smoke every day or some days and who reported having smoked over 100 cigarettes during their lifetimes [31]. Harmful use of alcohol was defined as daily consumption of pure alcohol ≥ 15 g for women and ≥ 25 g for men, according to the Dietary Guidelines for Chinese Residents [30]. The physical measurements included body height, weight, blood pressure, heart rate, and waist circumference. Body mass index (BMI, kg/m^2) were calculated as weight in kilograms divided by the height in meters squared. Three measurements of sitting blood pressure, five minutes apart, were obtained by a properly trained

health-staff using the standard mercury sphygmomanometers, and the mean of the three measurements was used for blood pressure analyses. The first Korotkoff sound was the subject's systolic blood pressure (SBP), and the fifth Korotkoff sound was the diastolic blood pressure (DBP). Measuring tape was used to measure individual's body height to the nearest to 0.1 cm, without foot wear and any head gear. Body weight was measured with a portable electronic weighing scale to the nearest 0.1 kg. The participants were requested to wear light clothes without footwear during weighing. Waist circumference was measured to the nearest to 0.1 cm, using measuring tape, it was taken at midpoint between the lower margin of the last palpable rib and the top of the iliac crest (hip bone), in the standing position without clothing and directly over the skin.

Biochemical analysis

Peripheral venous blood samples were collected after an overnight fasting in all subjects who were participating. In this section, serum samples were utilized to examine the lipid profiles using commercially available kits which included total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C; RANDOX Laboratories Ltd., Ardmore, Diamond Road, Crumlin Co. Antrim, United Kingdom, BT29 4QY; or Daiichi Pure Chemicals Co., Ltd., Tokyo, Japan); and apolipoprotein (Apo) A1 and ApoB (RANDOX Laboratories Ltd.). All determinations were performed with an autoanalyzer (Type 7170A; Hitachi Ltd., Tokyo, Japan) in our Clinical Science Experiment Center [32, 33].

Diagnostic criteria

Hypertension was defined as an average SBP of ≥ 140 mmHg and/or an average DBP of ≥ 90 mmHg, and/or self-reported pharmacological treatment for hypertension within the 2 weeks prior to the interview [32, 33]. The subjects with only SBP ≥ 140 mmHg and DBP < 90 mmHg were defined as isolated systolic hypertension. Awareness was defined as having been informed about the diagnosis of hypertension by a physician or a healthcare professional. Treatment was defined as taking any class of anti-hypertensive medication in the past two weeks. Control in the treatment was achieved if SBP < 140 mmHg and DBP < 90

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Table 1. Comparison of the general characteristics between the Maonan and Han ethnic groups

Characteristics	Maonan (n = 1332)	Han (n = 1344)	T (x ²)	P
Age (years)*	57.41 ± 15.23	57.26 ± 15.15	0.255	0.798
Male/female	660/672	671/673	0.038	0.846
Education level (years)*	5.59 ± 3.95	4.17 ± 4.15	9.065	0.000
Physical activity (h/week)*	44.38 ± 8.89	43.98 ± 6.67	1.317	0.188
Height (cm)*	154.74 ± 8.27	146.48 ± 6.53	28.688	0.000
Weight (kg)*	54.11 ± 11.28	48.01 ± 6.84	16.932	0.000
Body mass index (kg/m ²)*	22.44 ± 3.51	21.29 ± 2.54	9.716	0.000
> 24 kg/m ² [n (%)]	368 (27.67)	311 (23.14)	7.115	0.008
Waist circumference (cm)*	79.39 ± 11.53	74.09 ± 9.95	12.734	0.000
Alcohol consumption [n (%)]	322 (24.17)	590 (43.90)	115.855	0.000
Cigarette smoking [n (%)]	352 (26.43)	416 (30.95)	6.697	0.010
Energy (kJ/day)*	8994.33 ± 503.11	8838.66 ± 487.36	8.129	0.010
Carbohydrate (g/day)*	421.08 ± 28.64	389.65 ± 26.45	29.495	0.000
Protein (g/day)*	50.22 ± 7.73	47.79 ± 7.12	8.459	0.000
Total fat (g/day)*	29.44 ± 5.77	25.34 ± 4.81	19.973	0.000
Dietary cholesterol (mg/day)*	198.36 ± 88.15	171.52 ± 92.17	7.697	0.000
Total dietary fiber (g/day)*	9.11 ± 4.12	10.64 ± 4.38	-9.306	0.000
Sodium intake (g/day)*	8.76 ± 3.88	7.71 ± 3.42	7.428	0.000
Serum total cholesterol (mmol/l)*	5.01 ± 1.06	4.90 ± 0.98	2.788	0.005
Triglyceride (mmol/l)*	1.63 ± 1.71	1.34 ± 1.27	4.983	0.000
HDL-C (mmol/l)*	1.60 ± 0.39	1.98 ± 0.50	-21.908	0.000
LDL-C (mmol/l)*	2.86 ± 0.82	2.70 ± 0.72	5.365	0.000
Apolipoprotein A1 (g/l)*	1.39 ± 0.31	1.46 ± 0.25	-6.433	0.000
Apolipoprotein B (g/l)*	0.88 ± 0.20	0.94 ± 0.22	-7.380	0.000
Apolipoprotein (Apo) A1/ApoB*	1.66 ± 0.57	1.65 ± 0.57	0.454	0.650
Prevalence of hyperlipidemia [n (%)]	692 (51.95)	552 (41.07)	31.837	0.000

*Data were shown as mean ± SD. HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

mmHg in the subgroup of hypertensive individuals currently receiving anti-hypertensive medications. The individuals with TC > 5.17 mmol/L and/or TG > 1.70 mmol/L were defined as hyperlipidemic [34]. Normal weight, overweight and obesity were defined as a BMI < 24, 24-28, and > 28 kg/m², respectively [35].

Statistical analysis

The measurement data are presented as mean ± SD. All analyses were performed with SPSS 11.5 (SPSS Inc., Chicago, Illinois). Differences in mean values were assessed using analysis of covariance (ANCOVA) and the Student's unpaired *t* test. Sex, age, BMI, hyperlipidemia, alcohol consumption, cigarette smoking were included in the statistical models as covariates. The enumeration data were expressed as percentage. The difference of percentage was tested by the Chi-square test. In order to evalu-

ate the risk factors for hypertension, unconditional logistic regression analysis was also performed in the combined population of Maonan and Han, Maonan, and Han; respectively. For the multiple logistic regression analysis, the data were recorded as follows: ethnic group: Maonan = 0, Han = 1; sex: female = 0, male = 1; age (year): < 40 = 0, 40-49 = 1, 50-59 = 2, 60-69 = 3, 70-79 = 4, ≥ 80 = 5; BMI (kg/m²): ≤ 24 = 0, > 24 = 1; TC (mmol/L): ≤ 5.17 = 0, > 5.17 = 1; TG (mmol/L): ≤ 1.70 = 0, > 1.70 = 1; non-hyperlipidemia (TC ≤ 5.17, TG ≤ 1.70 mmol/L) = 0, hyperlipidemia (TC > 5.17 and/or TG > 1.70 mmol/L) = 1; alcohol consumption (g/day): nondrinkers = 0, < 25 (women, < 15) = 1, ≥ 25 (women, ≥ 15) = 2; cigarette smoking (cigarettes/day): nonsmokers = 0, < 10 = 1, ≥ 10 = 2. Total intake of each nutrient was summed over all foods consumed. The Matlab 5.0 software was used for processing these

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Table 2. Blood pressure levels and the prevalence of hypertension between the Maonan and Han ethnic groups

Parameter	Maonan (n = 1332)	Han (n = 1344)	T (χ ²)	P
SBP (mmHg)*	136.03 ± 25.39	128.49 ± 18.81	8.734	0.000
Isolated SBP ≥ 140 mmHg [n (%)]	197 (14.79)	133 (9.90)	14.821	0.000
DBP (mmHg)*	81.08 ± 12.61	78.96 ± 11.21	4.597	0.000
Isolated DBP ≥ 90 mmHg [n (%)]	68 (5.11)	63 (4.69)	0.251	0.617
Both SBP ≥ 140 and ≥ 90 mmHg [n (%)]	382 (28.68)	218 (16.22)	59.695	0.000
Pulse pressure (mmHg)*	54.94 ± 18.65	49.55 ± 13.99	8.462	0.000
Prevalence of hypertension [n (%)]	647 (48.57)	414 (30.80)	88.283	0.000
Awareness rate [n (%)]	108 (16.69)	98 (23.67)	7.859	0.005
Treatment rate [n (%)]	99 (15.30)	86 (20.77)	5.250	0.022
Control rate [n (%)]	35 (5.41)	44 (10.63)	9.976	0.002

*Data were shown as mean ± SD. SBP, systolic blood pressure; DBP, diastolic blood pressure; Isolated SBP ≥ 140 mmHg, isolated systolic hypertension.

procedures by the method of multiplication of matrix [36]. A *P* value of less than 0.05 was considered statistically significant.

Results

General characteristics between the Maonan and Han ethnic groups

The demographic, dietary, lifestyle characteristics and serum lipid levels between the Maonan and Han populations are described in **Table 1**. The levels of education, height, weight, BMI, waist circumference, serum TC, TG, LDL-C and prevalence of hyperlipidemia; and the intakes of energy, carbohydrate, protein, cholesterol, total fat, and sodium were higher in Maonan than in Han ($P < 0.01-0.001$), whereas the levels of serum HDL-C, ApoA1, ApoB; and the percentage of subjects who consumed alcohol or smoked cigarettes were lower in Maonan than in Han ($P < 0.01-0.001$). There were no significant differences in the levels of physical activity, age and sex structure, and the ratio of ApoA1 to ApoB between the two ethnic groups ($P > 0.05$ for all).

Blood pressure levels and the prevalence of hypertension

The levels of SBP, DBP, and pulse pressure (PP) were significantly higher in Maonan than in Han ($P < 0.001$ for all). The overall prevalence of hypertension (48.57% vs. 30.80%, $P < 0.001$) and isolated systolic hypertension (14.79% vs. 9.90%, $P < 0.001$) was also significantly higher in Maonan than in Han (**Table 2**).

Awareness, treatment, and control of hypertension

Of 647 subjects with hypertension in Maonan, 16.69% were aware of their high blood pressure, 15.30% were treated, and 5.41% were controlled, whereas the rates of awareness, treatment and control among hypertensives in Han were 23.67% ($P < 0.01$), 20.77% ($P < 0.05$) and 10.63% ($P < 0.01$, **Table 2**), respectively.

Sex, BMI, hyperlipidemia, alcohol, smoking, and age on blood pressure levels

The effects of sex, BMI, alcohol consumption, cigarette smoking and age on blood pressure levels between Maonan and Han are shown in **Table 3**. For the Maonan population, the levels of SBP and DBP were higher in males than in females ($P < 0.001$ for each); the levels of SBP and DBP were higher in the subjects with a BMI > 24 kg/m² than a BMI ≤ 24 kg/m² ($P < 0.001$ for each); the levels of SBP, DBP and PP were higher in subjects with hyperlipidemia than those without hyperlipidemia ($P < 0.001$ for all); the levels of SBP, DBP and PP were lower in drinkers than in nondrinkers ($P < 0.001$ for all); the levels of SBP, DBP and PP were lower in smokers than in nonsmokers ($P < 0.01-0.001$); and the levels of SBP, DBP and PP were also different among the 6 age subgroups ($P < 0.01-0.001$).

For the Han population, the levels of DBP were higher but the levels of PP were lower in males than in females ($P < 0.001$ for each); the levels of SBP and DBP were higher in the subjects

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Table 3. Effects of sex, BMI, hyperlipidemia, alcohol consumption, cigarette smoking, and age on blood pressure levels between the Maonan and Han ethnic groups

Parameter	n	SBP (mmHg)	DBP (mmHg)	PP (mmHg)
Maonan				
Male	660	144.81 ± 21.29	90.16 ± 15.22	54.65 ± 17.67
Female	672	136.03 ± 25.39 ^c	81.08 ± 12.61 ^c	54.94 ± 18.65
BMI ≤ 24 (kg/m ²)	964	130.73 ± 27.97	79.35 ± 13.93	51.37 ± 19.80
BMI > 24 (kg/m ²)	368	139.97 ± 23.06 ^c	86.92 ± 12.95 ^c	53.05 ± 16.74
Non-hyperlipidemia	640	132.06 ± 25.52	81.47 ± 13.17	50.58 ± 18.12
Hyperlipidemia	692	139.06 ± 25.02 ^c	84.43 ± 12.62 ^c	54.63 ± 19.57 ^c
Nondrinker	1010	138.16 ± 25.50	83.78 ± 13.38	54.37 ± 19.21
Drinker	322	128.01 ± 23.94 ^c	80.59 ± 11.26 ^c	47.41 ± 17.25 ^c
Nonsmoker	980	138.13 ± 25.20	83.69 ± 13.34	54.44 ± 19.03
Smoker	352	128.89 ± 25.12 ^c	81.10 ± 11.65 ^b	47.79 ± 18.01 ^c
Age				
< 40	173	136.50 ± 23.49	84.54 ± 10.97	51.95 ± 16.70
40-49	209	133.41 ± 20.87	81.47 ± 9.74	51.94 ± 15.26
50-59	282	129.89 ± 23.75	81.69 ± 11.99	48.20 ± 15.57
60-69	331	138.98 ± 29.71	85.08 ± 14.92	53.89 ± 21.43
70-79	245	136.71 ± 25.09	81.93 ± 13.62	54.79 ± 22.35
≥ 70	92	142.74 ± 25.08	83.15 ± 15.23	59.59 ± 18.17
F for 6 age subgroups	-	5.985	3.723	6.702
P for 6 age subgroups	-	0.000	0.002	0.000
Han				
Male	671	128.74 ± 17.95 ^z	80.80 ± 11.64 ^z	47.96 ± 12.83 ^z
Female	673	128.24 ± 19.65 ^z	77.12 ± 10.45 ^{c,z}	51.13 ± 14.89 ^{c,z}
BMI ≤ 24 (kg/m ²)	1033	127.78 ± 19.14 ^y	78.33 ± 11.07	49.44 ± 14.39 ^x
BMI > 24 (kg/m ²)	311	130.86 ± 17.50 ^{a,z}	81.03 ± 11.43 ^{c,z}	49.91 ± 12.58 ^z
Non-hyperlipidemia	792	126.46 ± 18.03 ^z	77.67 ± 10.94 ^z	48.79 ± 13.85 ^x
Hyperlipidemia	552	131.39 ± 19.53 ^{c,z}	80.80 ± 11.34 ^{c,z}	50.62 ± 14.12 ^{a,z}
Nondrinker	754	128.29 ± 20.53 ^z	77.51 ± 10.98 ^z	50.80 ± 15.62 ^z
Drinker	590	128.74 ± 16.37	80.81 ± 11.23 ^c	47.94 ± 11.39 ^c
Nonsmoker	928	128.75 ± 19.29 ^z	78.12 ± 10.75 ^z	50.64 ± 14.79 ^z
Smoker	416	127.91 ± 17.71	80.83 ± 11.96 ^c	47.10 ± 11.66 ^c
Age				
< 40	179	115.24 ± 12.23 ^z	74.36 ± 9.74 ^z	40.99 ± 8.38 ^z
40-49	213	122.50 ± 16.25 ^z	77.85 ± 10.55 ^z	44.65 ± 10.55 ^z
50-59	282	128.59 ± 17.03	80.66 ± 10.97	47.92 ± 11.42
60-69	326	130.65 ± 17.96 ^z	79.03 ± 10.73 ^z	51.62 ± 14.46
70-79	250	135.90 ± 20.12	81.42 ± 12.43	54.47 ± 15.30
≥ 70	94	139.79 ± 20.56	78.29 ± 11.40 ^z	61.50 ± 16.05
F for 6 age subgroups	-	43.388	10.590	47.834
P for 6 age subgroups	-	0.000	0.000	0.000

Data were shown as mean ± SD. SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; ^aP < 0.05, ^bP < 0.01 and ^cP < 0.001 in comparison with male, BMI ≤ 24 (kg/m²), non-hyperlipidemia, nondrinker, or nonsmoker of the same ethnic group; ^xP < 0.05, ^yP < 0.01 and ^zP < 0.001 in comparison with the same subgroup of Maonan.

with a BMI > 24 kg/m² than a BMI ≤ 24 kg/m² (P < 0.05-0.001); the levels of SBP, DBP and PP

were higher in subjects with hyperlipidemia than those without hyperlipidemia (P < 0.05-0.001); the levels of DBP were higher but the levels of PP were lower in drinkers than in nondrinkers (P < 0.001 for each); the levels of DBP were higher but the levels of PP were lower in smokers than in nonsmokers (P < 0.001 for each); and the levels of SBP, DBP and PP were also different among the 6 age subgroups (P < 0.001 for all).

Sex, BMI, hyperlipidemia, alcohol, smoking, and age on the prevalence of hypertension

The effects of sex, BMI, alcohol consumption, cigarette smoking, and age on the prevalence of hypertension between the two ethnic groups are shown in **Table 4**. For the Maonan population, the prevalence of hypertension was higher in subjects with a BMI > 24 kg/m² than a BMI ≤ 24 kg/m² (P < 0.001), and in subjects with hyperlipidemia than in those without hyperlipidemia (P < 0.001). But the prevalence of hypertension was lower in drinkers than in nondrinkers or in

smokers than in nonsmokers. There was also significantly different in the prevalence of hy-

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Table 4. Effects of gender, BMI, alcohol consumption, cigarette smoking, and age on the prevalence of hypertension between the Maonan and Han populations

Parameter	N	SBP ≥ 140 mmHg	DBP ≥ 90 mmHg	SBP ≥ 140 and DBP ≥ 90 mmHg	Prevalence of hypertension
Maonan					
Male	660	80 (12.12)	57 (8.64)	201 (30.45)	338 (51.21)
Female	672	117 (17.41) ^b	11 (1.64) ^c	181 (26.93)	309 (45.98)
BMI ≤ 24 (kg/m ²)	964	151 (15.66)	45 (4.67)	244 (25.31)	440 (45.64)
BMI > 24 (kg/m ²)	368	46 (12.50)	23 (6.25)	138 (37.50) ^c	207 (56.25) ^c
Non-hyperlipidemia	640	86 (13.44)	22 (3.44)	156 (24.38)	264 (41.25)
Hyperlipidemia	692	111 (16.04)	46 (6.65)	226 (32.66) ^c	383 (55.35) ^c
Nondrinker	1010	143 (14.16)	54 (5.35)	315 (31.19)	512 (50.69)
Drinker	322	54 (16.77)	14 (4.35)	67 (20.81) ^c	135 (41.93) ^b
Nonsmoker	980	141 (14.39)	52 (5.31)	302 (30.82)	495 (50.51)
Smoker	352	56 (15.91)	16 (4.55)	80 (22.73) ^b	152 (43.18) ^a
Age					
< 40	173	28 (16.18)	4 (2.31)	48 (27.75)	80 (46.24)
40-49	209	47 (22.49)	4 (1.91)	48 (22.97)	99 (47.37)
50-59	282	30 (10.64)	10 (3.55)	72 (25.53)	112 (39.72)
60-69	331	33 (9.97)	18 (5.44)	132 (39.88)	183 (55.29)
70-79	245	44 (17.96)	25 (10.20)	52 (21.22)	121 (49.39)
≥ 80	92	15 (16.30)	7 (7.61)	30 (32.61)	52 (56.52)
X ² for 6 age subgroups	-	22.174	23.009	32.424	17.718
P for 6 age subgroups	-	0.001	0.000	0.000	0.003
Han					
Male	671	57 (8.49) ^x	54 (8.05)	119 (17.73) ^z	230 (34.28) ^z
Female	673	76 (11.29) ^y	9 (1.34) ^c	99 (14.71) ^z	184 (27.34) ^{b,z}
BMI ≤ 24 (kg/m ²)	1033	94 (9.10) ^z	48 (4.65)	157 (15.20) ^z	299 (28.94) ^z
BMI > 24 (kg/m ²)	311	39 (12.54)	15 (4.82)	61 (19.61) ^z	115 (36.98) ^{b,z}
Non-hyperlipidemia	792	81 (10.23)	37 (4.67)	98 (12.37) ^z	216 (27.27) ^z
Hyperlipidemia	552	52 (9.42) ^z	26 (4.71)	120 (21.74) ^{c,z}	198 (35.87) ^{c,z}
Nondrinker	754	96 (12.73)	21 (2.79) ^y	101 (13.40) ^z	218 (28.91) ^z
Drinker	590	37 (6.27) ^{c,z}	42 (7.12) ^c	117 (19.83) ^b	196 (33.22) ^z
Nonsmoker	928	100 (10.78) ^x	24 (2.59) ^y	151 (16.27) ^z	275 (29.63) ^z
Smoker	416	33 (7.93) ^z	39 (9.38) ^{c,y}	67 (16.11) ^x	139 (33.41) ^z
Age					
< 40	179	1 (0.56) ^z	10 (5.59)	6 (3.35) ^z	17 (9.50) ^z
40-49	213	4 (1.88) ^z	15 (7.04) ^x	24 (11.27) ^y	43 (20.19) ^z
50-59	282	23 (8.16)	20 (7.09)	46 (16.31) ^y	89 (31.56) ^x
60-69	326	34 (10.43)	14 (4.29)	54 (16.56) ^z	102 (31.29) ^z
70-79	250	34 (13.60)	4 (1.60) ^z	71 (28.40)	109 (43.60)
≥ 80	94	37 (39.36) ^z	0 (0) ^y	17 (18.09)	54 (57.45)
X ² for 6 age subgroups	-	129.299	16.687	53.219	100.007
P for 6 age subgroups	-	0.000	0.005	0.000	0.000

SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; ^aP < 0.05, ^bP < 0.01 and ^cP < 0.001 in comparison with male, BMI ≤ 24 (kg/m²), non-hyperlipidemia, nondrinker, or nonsmoker of the same ethnic group; ^xP < 0.05, ^yP < 0.01 and ^zP < 0.001 in comparison with the same subgroup of Maonan.

pertension among the 6 age subgroups ($P < 0.001$).

For the Han population, the prevalence of hypertension was higher in males than in

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Table 5. Risk factors for hypertension between the Maonan and Han ethnic groups

Ethnic group	Risk factor	Regression coefficient	Standard error	Wald	P value	Odds ratio	95% Confidence interval
Maonan + Han	Ethnic group	-0.809	0.125	41.735	0.000	0.445	0.349-0.569
	Age	0.163	0.037	6.464	0.011	1.327	1.067-1.651
	Body mass index	0.693	0.109	40.394	0.000	1.999	1.025-1.683
	Hyperlipidemia	0.419	0.101	17.327	0.000	1.520	1.248-1.851
	Total fat	0.466	0.168	8.221	0.004	1.435	1.319-1.998
	Sodium intake	0.512	0.187	10.478	0.001	1.541	1.286-2.138
	Total dietary fiber	-0.333	0.173	8.132	0.004	1.397	1.174-1.947
Maonan	Body mass index	0.273	0.126	4.656	0.031	1.314	1.025-1.683
	Hyperlipidemia	0.471	0.114	17.126	0.000	1.601	1.281-2.001
	Cigarette smoking	0.119	0.061	3.843	0.050	1.126	1.000-1.269
	Total fat	0.475	0.204	15.115	0.000	1.543	1.247-2.369
	Sodium intake	0.448	0.118	8.777	0.003	1.483	1.157-2.469
	Total dietary fiber	-0.388	0.179	6.137	0.015	1.386	1.088-1.949
Han	Age	0.517	0.050	3.949	0.047	1.104	1.037-1.315
	Alcohol consumption	0.151	0.088	34.752	0.000	1.677	1.412-1.992
	Body mass index	0.558	0.251	4.935	0.026	1.747	1.068-2.858
	Total fat	0.403	0.210	4.978	0.025	1.462	1.144-1.858
	Sodium intake	0.481	0.177	7.987	0.004	1.332	1.264-2.321
	Total dietary fiber	-0.313	0.148	9.146	0.002	1.556	1.244-2.457

females ($P < 0.01$), higher in subjects with a BMI $> 24 \text{ kg/m}^2$ than a BMI $\leq 24 \text{ kg/m}^2$ ($P < 0.01$), higher in subjects with hyperlipidemia than in those without hyperlipidemia ($P < 0.001$). There was also significantly different in the prevalence of hypertension among the 6 age subgroups ($P < 0.001$).

Risk factors for hypertension

Multivariate logistic regression analysis revealed that the prevalence of hypertension was positively correlated with BMI, hyperlipidemia, cigarette smoking, total fat, and sodium, and negatively associated with total dietary fiber in Maonan ($P < 0.05-0.001$), whereas it was positively associated with age, alcohol consumption, BMI, total fat, and sodium, and negatively associated with total dietary fiber in Han ($P < 0.05-0.001$, **Table 5**).

Discussion

Hypertension is one of the most important and modifiable risk factors for cardiovascular disease, and is also a principal cause of mortality and morbidity in China. Although both preventable and manageable, hypertension remains the top leading risk factor in 2013, accounting

for 14.2% of total disability adjusted life years and 2.5 million deaths [2, 30]. The results of the present study showed that the levels of SBP, DBP and PP, and the overall prevalence of hypertension and isolated systolic hypertension were higher in Maonan than in Han. Notably, higher levels of SBP and DBP, and the prevalence of hypertension were found among the Maonan young people (< 40 -year subgroup). But the rates of awareness, treatment and control were lower in Maonan than in Han. These differences in the blood pressure levels and the prevalence of hypertension between the two ethnic groups might result from different BMI, hyperlipidemia, diet, lifestyle, and genetic background. In the present cross-sectional study, we showed that the educational level was significantly low in the both ethnic groups. A lack of public awareness and understanding of hypertension and its complications may contribute to the epidemic of hypertension in the Maonan and Han populations [32, 33]. These results also underscore the urgent need for developing a good blood pressure education program to coordinate the efforts in detection, prevention, and treatment of hypertension in the rural areas of China. It is well accepted that healthy public policies to create healthy environments and communities are required to

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encourage healthy choices in the places people work, live and play [37].

It is widely recognized that overweight and obesity are closely associated with hypertension [13]. BMI is recommended as an objective way to estimate the relative degree of adiposity based on weight and height. A recent study of relatively lean rural adults in the southwest of China reported that general adiposity in terms of higher BMI is more strongly associated with hypertension than waist circumference [38]. The BMI levels in this study were significantly higher in Maonan than in Han. The levels of SBP and DBP, and the prevalence of hypertension in both ethnic groups were higher in the subjects with a BMI > 24 kg/m² than a BMI ≤ 24 kg/m². Although not all overweight/obese people develop hypertension, weight gain is usually associated with a corresponding increase in blood pressure [39]. The prevalence of hypertension in children is estimated to be 3% to 14% for normal weight children and 11% to 30% for obese children [40]. Excess adiposity is the single most powerful risk factor for higher blood pressure and contributes to more than half of the risk for developing hypertension [41]. Obesity can also cause metabolic syndrome [42], increased cardiac load and peripheral vascular resistance. A previous study reported that the increases/decreases in BMI were significantly associated with increases/decreases in SBP and DBP [43]. It has been found that aldosterone levels are correlated with the magnitude of central adiposity [44]. Elevated levels of aldosterone are present in obese patients with resistant hypertension, and weight loss improves hypertension and lowers aldosterone levels [45]. Laffin *et al.* [46] have found that subcutaneous fat cells from obese postmenopausal predominately African American women produce aldosterone.

In the present study, we showed that the prevalence of hyperlipidemia was significantly higher in Maonan than in Han. The levels of SBP, DBP and PP, and the prevalence of hypertension in both ethnic groups were higher in the subjects with hyperlipidemia than in those without hyperlipidemia. Although the relationship between hyperlipidemia and hypertension is not fully understood, serum lipid metabolism and blood pressure regulation were associated in several previous studies [47]. Previous hyperlipidemia may be one of the causes of future

hypertension [48]. Higher levels of plasma TC, non-HDL-C, and the TC/HDL-C ratio were independently associated with a subsequent increased risk of incident hypertension in apparently healthy men. Elevated lipid levels appeared to predate the onset of hypertension by years [49]. Therefore, early treatment of hyperlipidemia may be able to prevent or delay the occurrence of hypertension.

Unhealthy diet is strongly associated with hypertension [7, 8]. In the current study, we found that the intakes of total energy, total fat, dietary cholesterol, and sodium were higher in Maonan than in Han. Multivariate logistic regression analysis also showed that the prevalence of hypertension was positively correlated with total fat and sodium intakes in both ethnic groups. The discrepancies in blood pressure levels between the two ethnic groups may mainly be attributed to the differences in dietary patterns. The dietary patterns and lifestyle may be more disadvantageous for blood pressure regulation in Maonan than in Han. The Maonan people chiefly engage in agriculture, but also weave bambooware, raise beef cattle, make wooden articles and cast iron. They are proud of their beef cattle, which sells well in South China. The Maonan people like to pickle sour meat, snails and vegetables, which are their traditional foods for guest's reception. They get meat mainly from poultries and livestock, such as pigs, oxen, chickens, ducks and so on. A typical food, Minglun Sliced Pig is a well known dish of the Maonan ethnic group. It is made from their local pig, Guangxi Huanjiang Xiang Pig [50], which is a unique miniature pig strain from Huanjiang Maonan Autonomous County of Guangxi, China, and shows great potential values in the agricultural production and biomedical engineering. Most of the Maonan people like to eat food which is cooked half ripe, as they believe that some kinds of vegetables and meat, especially chickens, will lose their delicious flavor if they are boiled to be too much ripe. In addition, they also like to eat beef, pork and/or animal offals in a hot pot which contain abundant saturated fatty acid. Long-term high saturated fat diet is an important risk factor for obesity, dyslipidemia, atherosclerosis, and hypertension [7, 8]. In addition, dietary salt intake has impact on blood pressure levels in different populations [3, 9]. A population-based epidemiological study from Turkey showed that the Turkish population con-

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sumes a large amount of salt (18.01 g/day). Salt intake was higher in obese participants, rural residents, participants with lower education levels and elderly. Salt intake was positively correlated with SBP and DBP. Each 100 mmol/day of salt intake resulted in 5.8 and 3.8 mmHg increase in SBP and DBP, respectively. Salt intake was also significantly correlated with SBP in normal weight individuals [9]. Thus, interventions are needed in order to reduce the intake of salt and saturated fat, as well as to increase the consumption of fruits and vegetables, along with efforts to decrease the incidence of overweight and obesity and to implement monitoring for early detection and treatment for hypertensive individuals.

Available evidence indicates that alcohol in larger amounts (more than two portions a day) increase blood pressure and overall mortality [14, 51]. A previous meta-analysis of 15 randomized controlled trials showed that decreased alcohol consumption was associated with reduction of SBP and DBP by 3.31 and 2.04 mmHg, respectively, which was similar in normotensives and hypertensives [51]. In the present study, however, we showed that the percentage of subjects who consumed alcohol was lower in Maonan than in Han. The levels of SBP, DBP and PP, and the prevalence of hypertension in Maonan were lower in drinkers than in nondrinkers. The levels of DBP in Han were higher in drinkers than in nondrinkers. The prevalence of hypertension in drinkers had also an increasing trend. The reason for these discrepancies is not well-known. One of the causes may result from different kinds of wine. Most of the adult men of the Maonan people like to drink. They even have the custom that it will be considered to be impolite to treat their guests without wines. Some families make wines themselves using grain sorghums and corns. Therefore, 90% of the wine drunk by Maonan in this study was rum or local wine, in which the alcohol content is low. In contrast, a great deal of the wine drunk by Han was white spirit or rice wine sold in the markets, in which the alcohol content is high.

The relationship between cigarette smoking and hypertension is contradictory. In a systematic review from Myanmar, a positive association between smoking and hypertension was demonstrated [52]. In another study from the

same country, cigarette smoking was not associated with hypertension in men, and showed an inverse relationship among women [53]. In the WHO STEPwise approach to Surveillance (STEPS) study from Yangon Region in 2003-2004, no association between cigarette smoking and hypertension was found, but separate figures for male and female were not reported in that study [54]. In the present study, however, we showed that the levels of SBP, DBP and PP, and the prevalence of hypertension in Maonan were lower in smokers than in non-smokers. But the levels of DBP in Han were higher in smokers than in nonsmokers. The prevalence of hypertension in smokers had also an increasing trend. These findings are completely consistent with those in drinkers and nondrinkers. We suspect that the reason for these discrepancies is the vast majority of smokers also consumed alcohol. There were 188 (53.41%) drinkers among 352 smokers and 134 (13.67%) drinkers among 980 non-smokers in the Maonan population; and 277 (66.58%) drinkers among 416 smokers and 313 (33.73%) drinkers among 928 nonsmokers in the Han population. These results suggest that cigarette smoking may not be the main risk factor for hypertension in the two ethnic groups.

In addition to the environmental factors, genetic variants might also be involved in the development of hypertension. The genetic influence or heritability estimation on blood pressure variation displays remarkable range (30 to 50%) [55]. Genetic variations can considerably affect hypertensive genesis which significantly exhibits risk factor for progressive renal damage, stroke, ischemic heart disease, and peripheral vascular disease [56]. Most recent studies have conducted an investigation of genetic causes of essential hypertension associated with analysis of candidate genes [15, 16]. Intra-ethnic marriages were popular in Maonan. For example, more than 80% of the Maonan people share the same surname: Tan. Other frequent surnames in this ethnic group are Lu, Meng, Wei and Yan. Thus, the hereditary characteristics and phenotypes of some candidate hypertension-susceptibility genes in Maonan may be different from those in Han. Previous study has showed that the genetic polymorphisms of some genes in the Maonan population were different from those in Han Chinese [26]. But this remains to be conclusively determined.

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The levels of SBP, DBP and PP, and the prevalence of hypertension and isolated systolic hypertension were significantly higher in the Maonan than in the Han populations, but the rates of awareness, treatment and control of hypertension were significantly lower in Maonan than in Han. These findings suggest that there is an urgent need to develop a hypertension education program and coordinate the effort of detection, prevention, and treatment of hypertension in the Chinese rural minority areas.

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Disclosure of conflict of interest

None.

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