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Association of prehypertension and cardiovascular risk factor clustering in Inner Mongolia: a cross-sectional study

Guoju Li,[1] Guanghong Guo,[2] Wenrui Wang,[3] Ke Wang,[4] Hailing Wang,[3] Fen Dong,[5] Yonggang Qian,[3] Haiying Gong,[6] Guodong Xu,[5] Yanlong Li,[1] Li Pan,[1] Biao Zhang,[1] Guangliang Shan[1]

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GL and GG contributed equally.

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[1]Department of Epidemiology and Statistics, Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences, School of Basic Medicine, Peking Union Medical College, Beijing, China
[2]Department of Clinical Biochemistry, Chinese PLA General Hospital, Beijing, China
[3]Inner Mongolia Center for Disease Control and Prevention, Hohhot, China
[4]Department of Obstetrics, Key Laboratory of 9 Birth Defects and Related Diseases of Women and Children (Sichuan University), Ministry of Education, West China 10 Second University Hospital, Sichuan University, Chengdu, China
[5]China-Japan Friendship Hospital, Beijing, China
[6]Fangshan District Center for Disease Control and Prevention, Beijing, China

Correspondence to
Guangliang Shan; guangliang_shan@163.com

ABSTRACT

Objectives To assess the clustering of cardiovascular disease (CVD) risk factors in Han and Mongolian adults with prehypertension or hypertension in Northern China.

Methods We selected 3227 Han and Mongolian participants (20–80 years old) using a multistage cluster sampling method in 2014. The participants were interviewed by standard questionnaires and underwent anthropometric measurement and biochemical testing. Han and Mongolian participants were divided into optimal, prehypertension, and hypertension groups based on blood pressure. A multinomial logit analysis was performed to explore relationships between CVD risk factor clustering and prehypertension or hypertension, and the heterogeneity between Han and Mongolian was evaluated by the Cochran Q test. The differences between the ethnic groups in the proportions of risk factors was tested with the χ^2 test.

Results The clustering of two or three CVD risk factors in the prehypertension or hypertension groups was consistently higher than in the optimal group (Bonferroni, p<0.0167). The odds ratios (ORs) of prehypertension and hypertension increased with the number of CVD risk factors (p_{trend} <0.0001). In multivariate modelling, the adjusted ORs of one, two, and ≥3 CVD risk factors versus no risk factors was, respectively, 1.95, 2.25, and 2.28 in Han prehypertensive participants, and 1.73, 2.83, and 3.69 in Mongolian prehypertensive participants. In addition, the adjusted ORs were 3.15, 4.75, and 6.49 in Han hypertensive participants, and 1.90, 5.29, and 8.13 in Mongolian hypertensive participants (all p<0.05). There was no significant heterogeneity between Han and Mongolian participants in the prehypertension or hypertension groups. The age-standardised prevalence of ≥3 risk factors was 38.30% in Han men and 39.79% in Mongolian men. The rate was significantly lower in Han women than Mongolian women (9.18% vs 14.55%, p=0.002).

Conclusions These findings showed clustering of CVD risk factors in prehypertensive Han and Mongolian adults, and showed prehypertension may be a useful target for intervention.

Strengths and limitations of this study

- The present study was first designed to assess the clustering of CVD risk factors in prehypertensive and hypertensive Han and Mongolian adults in Inner Mongolia, China.
- The high quality study design and implementation with a high response rate, the use of trained interviewers, and checks by the people who trained the interviewers on the responses of the participants, improved the validity of our self-reported data.
- The unclear temporal relationships between CVD risk factors and hypertension are due to inherent weaknesses of cross-sectional studies, and have been heatedly debated in epidemiological studies.
- Furthermore, important confounding factors possibly associated with CVD, such as nutrition and physical activity, were not evaluated in the present study.
- The age-standardised prevalence of CVD risk factor clustering was not shown by optimal, prehypertension, and hypertension groups because of small sample sizes.

INTRODUCTION

Cardiovascular disease (CVD) is a major cause of death worldwide, accounting for >17 million deaths in 2013.[1] Hypertension is one of the most important risk factors for developing CVD.[2 3] In 2010, hypertension was the leading risk factor for global disease burden, and it was the major contributor to CVD mortality in East Asia, Southeast Asia, Central Asia, the Caribbean, North Africa, and the Middle East.[3] The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7) defined prehypertension as a systolic blood pressure (SBP) of 120–139 mmHg and/or a diastolic blood pressure (DBP) of 80–89 mmHg.[4] Further understanding has shown that hypertension is a consecutive process, from optimal to high blood pressure (BP). Studies have demonstrated that individuals with prehypertension are at an increased risk for developing hypertension and CVD.[5–8] A prospective cohort study conducted in China also showed that the population-attributable risk associated with prehypertension was 10.6% and 7.1% for CVD incidence and mortality,[9] respectively. In addition, it has been shown that if prehypertension was eliminated, 15.9% of CVD, 14.6% of coronary heart disease, and 19.6% of stroke cases could be prevented.[10] Current smoking, overweight or obesity, diabetes, and dyslipidaemia are well-established risk factors for CVD.[11–13] It has been demonstrated that hypertension is associated with both increased blood lipid levels[14–16] and diabetes.[17–19] Among the defined traditional CVD risk factors, hypertension is not only the most conveniently measurable, but is often the most easily controllable. However, it is unclear to what extent there is clustering of major CVD risk factors with prehypertension or hypertension.

The Inner Mongolia Autonomous Region is in Northern China, and Han and Mongolian constitute approximately 96% of the total population. These two ethnic groups have different genetic backgrounds, cultures, customs, and food consumption patterns. Several studies have noted striking ethnic disparities in CVD risk factor clustering in China and overseas.[20–22] The present study aims to assess the clustering of CVD risk factors in Han and Mongolian adults with prehypertension or hypertension, which may assist in creating preventative measures against CVD in this population.

METHODS

Study population

A cross-sectional survey was performed in Bayan Nur, Xilingol League, Ulanqab, and Hohhot in Inner Mongolia, China, in 2014. The survey is one part of the China National Health Survey (CNHS), which is an ongoing national programme aiming to evaluate the 'physiological constant and health condition' in Chinese people. A sample of adults, aged 20–80 years old, was selected using a multistage cluster sampling method, which has been extensively described previously.[23] Residents who had been living in Inner Mongolia for 1 year or longer were recruited, and all participants provided written informed consent. The survey was approved by the Institutional Review Board of the Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences. In total, 3464 participants were investigated. Of these, 58 participants were excluded because of missing data, and 179 participants were excluded because their parents were not Mongolian or Han. Ultimately, a total of 3227 individuals were included in the analysis, including 2308 Han adults and 919 Mongolian adults.

Health survey/measurements

Data on demographic information, smoking, alcohol drinking, and history of diseases were collected with standard questionnaires. The use of trained interviewers, and checks by the people who trained the interviewers on the responses of the participants, improved the validity of the self-reported data. The ethnicity of participants was determined by their ID cards and their parents' ethnic status. Participants and their parents were required to be all Han or Mongolian adults. Alcohol consumption was divided into two categories: never-drinkers and ever-drinkers (including current drinkers and former drinkers). Information on personal history of hypertension and diabetes was also obtained. Height was measured to the nearest 0.1 cm using a fixed stadiometer, and weight was measured to the nearest 0.1 kg in a standing position by bioelectrical impendence analysis (BIA) with a commercially available body composition analyser (BC-420, TANITA, Japan) with participants in light clothes. Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2). Sitting BP was measured three times by trained research assistants following a standardised procedure using an Omron digital BP measuring device (Omron HEM-907, Japan). Blood samples were drawn after fasting overnight for at least 8 hours, and were immediately processed, refrigerated, and transported to the laboratory in Beijing. The blood samples were kept at −80°C before biochemical testing. Fasting glucose and lipids, including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C), were assessed in the General Hospital of Chinese People's Liberation Army (PLA).

Definitions

BP was divided into optimal BP, prehypertension, and hypertension. Optimal BP was defined as an average SBP<120 mmHg and DBP <80 mmHg. Prehypertension was defined as an average SBP of 120–139 mmHg and/or DBP of 80–89 mmHg.[4] Hypertension was defined as an average SBP ≥140 mmHg and/or DBP ≥90 mmHg, or self-reported diagnosis of hypertension.[24]

BMI was graded into healthy (BMI <25 kg/m^2), overweight (BMI 25–29 kg/m^2), and obese (BMI ≥30 kg/m^2) according to the WHO criteria.[25] Diabetes was defined as fasting blood glucose (FPG) ≥7.0 mmol/L and/or a previous diagnosis of diabetes,[26] and dyslipidaemia was defined as TC ≥6.22 mmol/L and/or TG ≥2.26 mmol/L and/or HDL-C <1.04 mmol/L and/or LDL-C ≥4.14 mmol/L.[27] Current smoking status was determined when participants answered 'yes' to the question 'Do you smoke now?' and had smoked ≥1 cigarette per day for at least 6 months.[28]

Statistical analysis

The data were expressed as mean±SD for continuous variables and percentage and 95% CI. The χ^2 test or one-way analyses of variance were used to compare characteristics of optimal BP, prehypertensive and hypertensive participants in each ethnic group (see table 1). The Bonferroni test was used for multiple comparisons. Variables with a skewed distribution (eg, TG levels) were log-transformed and their 95% CI were reported.

A multinomial logit analysis was performed to evaluate the relationship between CVD risk factors (current

Table 1 Demographic characteristic of the study population among optimal BP, prehypertension and hypertension groups in Mongolian and Han adults

Variables	Han (n=2308)				Mongolian(n=919)			
	Optimal BP (n=1009)	Prehypertension (n=664)	Hypertension (n=635)	p value	Optimal BP (n=398)	Prehypertension (n=232)	Hypertension (n=289)	p Value
Age, years (mean±SD)	39.10±12.08	45.92±13.43*	53.47±11.37†‡	<0.0001	38.02±11.91	43.98±11.74*	53.59±11.16†‡	<0.0001
Male % (95% CI)	24.68 (22.02 to 27.34)	51.51 (47.70 to 55.31)*	48.03 (44.15 to 51.92)†	<0.0001	22.36 (18.27 to 26.46)	53.02 (46.60 to 59.44)*	50.17 (44.41 to 55.94)†	<0.0001
BMI, kg/m^2 (mean±SD)	22.93±3.23	24.91±3.76*	26.46±3.64†‡	<0.0001	23.19±3.38	25.43±3.64*	27.18±4.18†‡	<0.0001
SBP, mmHg (mean±SD)	108.20±7.21	126.10±6.49*	140.90±15.02†‡	<0.0001	107.50±7.98	125.20±6.33*	141.30±15.30†‡	<0.0001
DBP, mmHg (mean±SD)	69.06±5.98	79.54±6.01*	88.07±10.31†‡	<0.0001	68.62±6.24	79.61±5.38*	90.34±11.56†‡	<0.0001
FPG, mmol/L (mean±SD)	5.09±1.12	5.34±1.04*	5.75±1.53†‡	<0.0001	4.98±0.85	5.34±1.26*	5.73±1.56†‡	<0.0001
TC, mmol/L (mean±SD)	4.57±0.98	4.92±0.98*	5.07±1.02†‡	<0.0001	4.65±0.90	5.07±0.92*	5.37±1.04†‡	<0.0001
TG, mmol/L (geometric mean, 95% CI)	1.23 (1.19 to 1.27)	1.57 (1.51 to 1.64)*	1.86 (1.78 to 1.94)†‡	<0.0001	1.08 (1.03 to 1.13)	1.48 (1.37 to 1.60)*	1.83 (1.72 to 1.95)†‡	<0.0001
LDL-C, mmol/L (mean±SD)	2.69±0.78	2.94±0.87*	3.00±0.91†	<0.0001	2.78±0.76	3.04±0.84*	3.32±0.93†‡	<0.0001
HDL-C, mmol/L (mean±SD)	1.37±0.34	1.30±0.34*	1.25±0.34†	<0.0001	1.46±0.36	1.36±0.38*	1.31±0.35†	<0.0001
Current smoker, % (95% CI)	17.24 (14.91 to 19.58)	29.67 (26.19 to 33.14)*	25.35 (21.97 to 28.74)†	<0.0001	17.09 (13.39 to 20.78)	30.60 (24.67 to 36.53)*	20.76 (16.09 to 25.44)‡	0.0003
Alcohol drinking, % (95% CI)	33.20 (30.30 to 36.11)	46.84 (43.04 to 50.63)*	46.77 (42.89 to 50.65)†	<0.0001	40.70 (35.88 to 45.53)	59.48 (53.17 to 65.80)*	56.06 (50.33 to 61.78)†	<0.0001
Overweight or obesity, % (95% CI)	25.17 (22.50 to 27.85)	46.99 (43.19 to 50.78)*	63.46 (59.72 to 67.21)†‡	<0.0001	29.90 (25.40 to 34.40)	57.76 (51.40 to 64.11)*	71.97 (66.79 to 77.15)†‡	<0.0001
Dyslipidaemia, % (95% CI)	25.57 (22.88 to 28.26)	41.11 (37.37 to 44.86)*	49.92 (46.03 to 53.81)†‡	<0.0001	19.10 (15.23 to 22.96)	37.50 (31.27 to 43.73)*	52.94 (47.19 to 58.70)†‡	<0.0001
Diabetes, % (95% CI)	2.58 (1.60 to 3.55)	6.78 (4.87 to 8.69)*	14.80 (12.04 to 17.57)†‡	<0.0001	1.26 (0.16 to 2.35)	5.17 (2.32 to 8.02)*	12.46 (8.65 to 16.26)†‡	<0.0001

Data are expressed as the mean±SD, % (95% CI) or geometric mean (95% CI).
*Statistical significance between optimal BP and prehypertension (the Bonferroni method was used for multiple comparisons).
†Statistical significance between optimal BP and hypertension (the Bonferroni method was used for multiple comparisons).
‡Statistical significance between prehypertension and hypertension (the Bonferroni method was used for multiple comparisons).
BMI, body mass index; BP, blood pressure; DBP, diastolic blood pressure; FPG, fasting blood glucose; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SBP, systolic blood pressure; TC, total cholesterol; TG, triglyceride.

Table 2 Relationships of prehypertension and hypertension with CVD risk factors

	Han		Mongolian	
	Prehypertension (n=664)	Hypertension (n=635)	Prehypertension (n=232)	Hypertension (n=289)
CVD risk factors	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Current smoking (yes vs no)	0.79 (0.57 to 1.09)	0.70 (0.49 to 1.01)	0.76 (0.45 to 1.27)	**0.54 (0.31 to 0.93) ***
Overweight/obesity (yes vs no)	**2.13 (1.70 to 2.67) ***	**3.82 (3.00 to 4.88) ***	**2.15 (1.49 to 3.12) ***	**3.09 (2.07 to 4.60) ***
Dyslipidaemia (yes vs no)	1.15 (0.91 to 1.46)	**1.37 (1.07 to 1.76) ***	**1.53 (1.02 to 2.30) ***	**2.58 (1.71 to 3.91) ***
Diabetes (yes vs no)	1.44 (0.86 to 2.42)	**2.36 (1.45 to 3.85) ***	1.56 (0.52 to 4.71)	2.41 (0.87 to 6.71)

Adjusted for age, gender, and alcohol drinking in multivariate logistic regression model.
*Compared with optimal blood pressure: p<0.05; CVD risk factors were included in models with an enter method.
CVD, cardiovascular disease.

smoking, BMI ≥25 kg/m^2, dyslipidaemia, diabetes) and prehypertension and hypertension (see table 2). Proportions of individuals with CVD risk factors clustering in optimal, prehypertensive and hypertensive groups were presented as percentage and 95% CI and were analysed with the χ^2 partition (CSP) method; the differences between the ethnic groups in the proportions of risk factors was tested with the χ^2 test (see table 3).

A multinomial logit analysis was performed to explore the relationships of prehypertension and hypertension with one, two and ≥3 risk factors clustering after adjustment for age, gender, and alcohol drinking in Han and Mongolian adults (see table 4). In the analysis, stratified by Han and Mongolian participants, optimal BP, prehypertension, and hypertension served as three levels of the dependent variable, and age, gender, alcohol consumption, and the number of CVD risk factors clustering were independent variables. The heterogeneity of associations between the Han and Mongolian participants was evaluated by using the Cochran Q test. Additionally, dose–response relationships between CVD risk factor clustering and prehypertension or hypertension were examined using the number of CVD risk factors as a continuous variable in multinomial logit models.

Age direct standardisation of CVD risk factors to the National 2010 Census was conducted in the Han and Mongolian adults. A two-tailed p<0.05 was considered statistically significant. All statistical analyses were performed using SAS software version 9.3 (SAS Institute Inc, Cary, NC, USA).

Table 3 Comparisons of proportions (%) of different risk factors clustering among optimal blood pressure, prehypertension and hypertension groups in Han and Mongolian

	Number of risk factors clustering			
	0	1	2	≥3
Han				
Optimal (n=1009)	53.82 (50.74 to 56.89)	27.25 (24.51 to 30.00)‡	13.78 (11.65 to 15.90)	5.15 (3.79 to 6.52)
Prehypertension (n=664)	**26.20 (22.86 to 29.55)***	**36.14 (32.49 to 39.80)***	**25.60 (22.28 to 28.92)***	**12.05 (9.57 to 14.52)***
Hypertension (n=635)	**14.65 (11.90 to 17.40)*†**	**36.54 (32.79 to 40.28)***	**31.50 (27.88 to 35.11)*¶**	**17.32 (14.38 to 20.27)*†**
Mongolian				
Optimal (n=398)	50.75 (45.84 to 55.67)	34.92 (30.24 to 39.61)	10.80 (7.75 to 13.85)	3.52 (1.71 to 5.33)
Prehypertension (n=232)	**21.55 (16.26 to 26.84)***	38.79 (32.52 to 45.06)	**27.59 (21.83 to 33.34)***	**12.07 (7.88 to 16.26)***
Hypertension (n=289)	**13.15 (9.25 to 17.04)*†**	32.18 (26.79 to 37.57)	**39.10 (33.47 to 44.73)*†**	**15.57 (11.39 to 19.75)***

*Compared with optimal blood pressure p<0.0167.
†Compared with pre-hypertension p<0.0167.
‡Compared with Mongolian p<0.05 in optimal blood pressure.
¶Compared with Mongolian p<0.05 in hypertension.

Table 4 Adjusted odds ratios of prehypertension and hypertension with CVD risk factor clustering

Number of risk factors clustering	Prehypertension		Hypertension	
	Adjusted OR (95% CI) *	p Value	Adjusted OR (95% CI) *	p Value
Han				
0 (n=810)	1.00 (ref)		1.00 (ref)	
1 (n=747)	1.95 (1.51 to 2.52)	**<0.0001**	3.15 (2.32 to 4.28)	**<0.0001**
2 (n=509)	2.25 (1.65 to 3.06)	**<0.0001**	4.75 (3.38 to 6.69)	**<0.0001**
≥3 (n=242)	2.28 (1.48 to 3.52)	**0.0002**	6.49 (4.11 to 10.24)	**<0.0001**
p for trend	**<0.0001**		**<0.0001**	
Mongolian				
0 (n=290)	1.00 (ref)		1.00 (ref)	
1 (n=322)	1.73 (1.12 to 2.68)	**0.014**	1.90 (1.15 to 3.12)	**0.0119**
2 (n=220)	2.83 (1.64 to 4.88)	**0.0002**	5.29 (3.02 to 9.26)	**<0.0001**
≥3 (n=87)	3.69 (1.69 to 8.08)	**0.0011**	8.13 (3.59 to 18.41)	**<0.0001**
p for trend	**<0.0001**		**<0.0001**	

*The odds ratios were adjusted for age, gender and alcohol drinking in multinomial logistic regression models.
CVD, cardiovascular disease.

RESULTS

A total of 3227 individuals were included in the analysis, including 2308 (71.52%) Han adults and 919 (28.48%) Mongolian adults. When compared with Han adults, the Mongolian adults were more likely to drink alcohol (50.27% vs 40.86%), be overweight or obese (50.16% vs 41.98%), and have higher BMI (25.01 vs 24.47 kg/m^2), DBP (78.22 vs 77.31 mmHg), TC (4.98 vs 4.81 mmol/L), LDL-C (3.02 vs 2.85 mmol/L), and HDL-C (1.39 vs 1.32 mmol/L) values (all p<0.05). The prevalence of prehypertension and hypertension was 28.77% and 27.51% in the Han participants, and 25.24% and 31.45% in the Mongolian participants, respectively.

The characteristics of Han adults were similar to those of Mongolian adults. Specifically, the mean age was higher in the hypertension group than in the prehypertension and optimal BP groups (Bonferroni, all p<0.0167) in both the Han and Mongolian participants. In each ethnic group, the mean BMI, SBP, DBP, fasting glucose, TC, and TG were consistently higher in participants with hypertension than in those with prehypertension (Bonferroni, all p<0.0167). These variables were also higher in the prehypertension group than in the optimal BP group (Bonferroni, all p<0.0167). HDL-C levels were lower in the optimal BP group than in the hypertension or prehypertension groups, and there was no statistical difference in values between the hypertension and prehypertension groups. The proportions of men in the prehypertension and hypertension groups were considerably higher than in the optimal BP group (Bonferroni, all p<0.0167). Compared with the prehypertension and optimal groups, the proportions of overweight/obesity, dyslipidaemia, and diabetes were highest in the hypertension group (Bonferroni, p<0.0167). Alcohol consumption differed only between the optimal BP group and either the prehypertension or hypertension group, without a statistical difference between the prehypertension and hypertension groups. In addition, ethnic disparities of smoking status were observed. The proportion of current smokers was higher in the hypertension and prehypertension groups than in the optimal BP group in the Han participants, while the proportion of current smokers in the prehypertension group was higher than in the optimal BP and hypertension groups in the Mongolian participants (Bonferroni, all p<0.0167) (table 1).

A multinomial logit analysis was performed to evaluate the relationship between CVD risk factors and prehypertension or hypertension. Overweight or obesity was significantly associated with an increased risk of prehypertension and hypertension in both the Mongolian and Han adults (OR 2.13, 95% CI 1.70 to 2.67 for prehypertensive Han; OR 3.82, 95% CI 3.00 to 4.88 for hypertensive Han; OR 2.15, 95% CI 1.49 to 3.12 for prehypertensive Mongolian participants; OR 3.09, 95% CI 2.07 to 4.60 for hypertensive Mongolian participants, all p<0.05). Dyslipidaemia was significantly associated with an increased risk of prehypertension and hypertension in the Mongolian participants, but was only associated with hypertension in the Han participants (p<0.05). In the Han participants, those with diabetes experienced an increased risk of hypertension (p<0.05). In the Mongolian participants, current smoking was significantly associated with a decreased risk of hypertension (p<0.05) (table 2).

Overall, the proportion of participants with no CVD risk factors was 35.10% in the Han participants and 31.56% in the Mongolian participants, without a significant difference (p>0.05). table 3 shows comparisons of CVD risk factor clustering among the optimal BP, prehypertension, and hypertension groups in Han and Mongolian participants. In each ethnic group, the proportions of two or ≥3 CVD risk factor clustering were consistently higher in hypertensive or prehypertensive individuals than in those with optimal BP (Bonferroni, p<0.0167). Additionally, we observed that more hypertensive Han individuals had ≥3 CVD risk factor clustering, compared with prehypertensive Han participants. In Mongolian participants, however, more hypertensive individuals had two CVD risk factor clustering than prehypertensive participants (Bonferroni, all p<0.0167). There was no statistically significant difference between prehypertension and hypertension in the Mongolian participants with ≥3 CVD risk factors. The proportions of one CVD risk factor clustering in the optimal BP group (p=0.0045) and two CVD risk factors clustering in the hypertension group (p=0.0236) were higher in the Mongolian adults than in the Han adults.

With the optimal BP group as a reference, the adjusted odds ratios (ORs) of prehypertension and hypertension associated with CVD risk factor clustering in Mongolian and Han participants were estimated in multinomial logistic models (table 4). In both Han and Mongolian adults, the ORs of prehypertension or hypertension increased with an increased number of CVD risk factor clustering (p_{trend}<0.0001). Compared with no risk factors, the adjusted ORs of prehypertension among one, two, and ≥3 CVD risk factors were 1.95, 2.25, and 2.28 for the Han participants, and 1.73, 2.83, and 3.69 for the Mongolian participants, respectively (all p<0.05). The adjusted ORs of hypertension among one, two, and ≥3 CVD risk factors were 3.15, 4.75, and 6.49 for the Han participants, and 1.90, 5.29, and 8.13 for the Mongolian participants, respectively (all p<0.05). In the prehypertension group, there was no significant heterogeneity between the Han and Mongolian participants, and there was no heterogeneity in the hypertension group (both p>0.05).

As hypertension is a well-known risk factor for CVD, we combined hypertension with the CVD risk factors mentioned above to assess the overall prevalence of CVD risk factor clustering. In men, the prevalences of one, two, and ≥3 CVD risk factors were 23.03%, 28.90%, and 38.30% in the Han participants, and 27.51%, 26.19%, and 39.79% in the Mongolian participants, respectively. In women, the prevalences of one, two, and ≥3 CVD risk factors were 26.36%, 18.29%, and 9.18% in the Han participants, and 29.90%, 15.07%, and 14.55% in the Mongolian participants, respectively. With respect to gender, men tended to have a higher prevalence of either two or ≥3 CVD risk factor clustering than women (p<0.05). The age-standardised prevalence of ≥3 risk factor clustering was significantly lower in Han women than Mongolian women (p=0.002) (figure 1).

DISCUSSION

Our study found that participants with prehypertension had higher levels of CVD risk factors such as BMI,

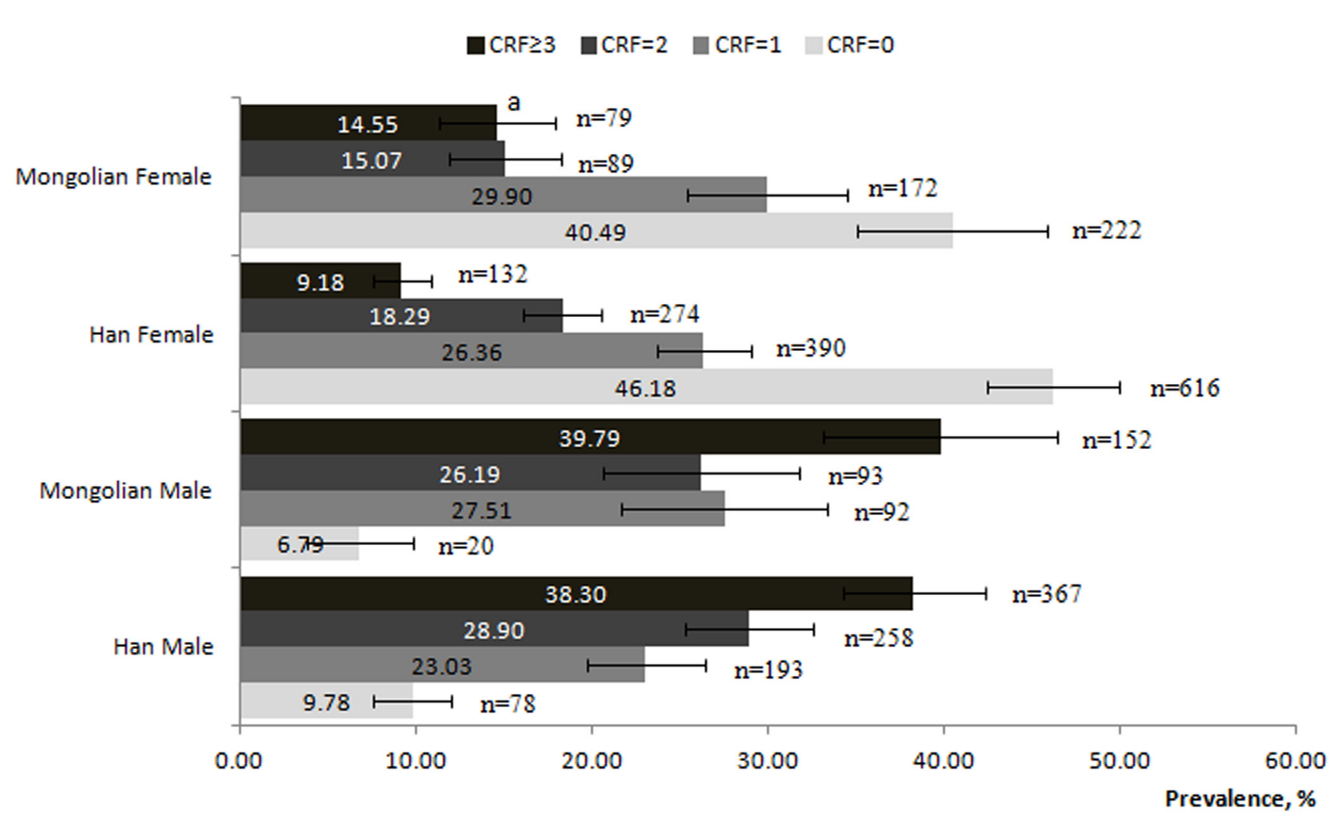

Figure 1 Age-standardised prevalence of major cardiovascular disease risk factors in Han and Mongolian adults by gender (%). (**a**) The difference in the age-standardised prevalence of ≥3 risk factor clustering between Han women and Mongolian women (p=0.002). CRF, cardiovascular disease risk factor.

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FPG, TC, TG, and LDL-C than those with optimal BP, and that participants with hypertension had higher levels of BMI, FPG, TC, and TG than those with prehypertension. These findings indicate that hypertension is a consecutive process from optimal to high BP, and that prehypertension is an important intermediate phase before hypertension. A cohort study conducted in Brazil showed that four in five individuals with prehypertension, aged 40 to 49 years old, would be fully hypertensive within 10 years.[29] Winegarden also reported that, compared with optimal BP, the estimated RR for the subcategory 'normal' (SBP 120–129 mmHg or DBP 80–85 mmHg) was 2.0 (95% CI 1.6 to 2.6), and for 'high normal' values (SBP 130–139 mmHg or DBP 85–89 mmHg) was 2.9 (95% CI 2.3 to 3.7).[30] In addition, the proportions of two and ≥3 CVD risk factor clustering were higher in the prehypertension or hypertension groups than the optimal BP group. These results are consistent with the study conducted in Beijing in 2007,[31] which suggested that CVD risk factor clustering was common among people with prehypertension and hypertension. Furthermore, our study showed a dose–response relationship between the number of CVD risk factors and prehypertension or hypertension. Specifically, the ORs of prehypertension or hypertension increased as the number of CVD risk factors increased. A cohort study of 4.1 million adults in the UK showed that a 20 mmHg higher SBP and a 10 mmHg higher DBP were associated with a 58% and 52% higher risk of new-onset diabetes, respectively.[32] A recent Korean epidemiology study also demonstrated that individuals with prehypertension (HR 1.27, 95% CI 1.09 to 1.48) and hypertension (HR 1.51, 95% CI 1.29 to 1.76) had a higher risk of developing diabetes than those with optimal BP.[33] A careful re-analysis of diagnosis times for hypertension and diabetes (n=76) in our study showed that 74.67% (57/76) of hypertension diagnoses were made before diabetes diagnoses. Evidence in our study indicates that hypertension might be more likely to develop before diabetes. The prehypertensive participants had higher levels of TC, LDL-C, and TG, and lower levels of HDL-C than the optimal BP participants.[34] Our findings also suggest that prehypertension may result in CVD risk factor clustering. As a modifiable condition, prehypertension may be a useful target for intervention, and antihypertensive medications have been found to reduce the relative risk of CVD and death by 15% in secondary prevention studies of prehypertension.[35] In China, according to the national basic public health service specification, primary care practitioners should screen for hypertension in adults ≥35 years old. Education of the public about the risks of prehypertension is a new challenge in primary care. In the JNC7 guidelines, the recommended management approach to uncomplicated prehypertension is health-promoting lifestyle modifications and antihypertensive medications given to adults with comorbid prehypertension and clinical cardiovascular disease.[36] Primary care practitioners must conduct further screening for prehypertension and prevent the incidence of hypertension, diabetes, and dyslipidaemia in their patients. Overweight or obesity has been linked to increased incidence of hypertension.[37] In addition, BMI has also been shown to be an important risk factor for developing CVD.[38] The association between smoking and hypertension is a more complex issue. Several studies have concluded that smokers have a lower prevalence of hypertension,[39] while other studies have suggested that smoking is positively associated with hypertension.[40] Despite the contradictory results, smoking is still a well-known risk factor for developing CVD.[41] Overall, body weight reduction, tobacco cessation, and BP control in prehypertensive patients are important ways to prevent hypertension, diabetes, and dyslipidaemia, thus lowering their risk of developing CVD.

When evaluating ethnic differences in CVD risk factors, we found that the Mongolian participants were more likely to have a lipid disorder and be overweight or obese than the Han participants. They also had higher fasting glucose levels than the Han participants. Such ethnic differences have been reported in previous studies.[42 43] A cross-sectional study conducted in Xinjiang concluded that Mongolian adults >30 years old tend to have higher TC, LDL-C, FBG, and BMI than Han adults.[20] Compared with a similar study in Inner Mongolia in 2003,[44] the levels of TC, TG, HDL-C, LDL-C, FBG, and BMI of Mongolian adults in our study were higher, which may be due to economic development and lifestyle changes.[45] When analysing ethnic differences in CVD risk factor clustering, we found that Mongolian participants with optimal BP had a higher proportion of one risk factor clustering than Han participants, and hypertensive Mongolian participants had a higher proportion of two risk factor clustering than hypertensive Han participants. This may be due to a different culture, customs, and food consumption patterns between the two ethnic groups. Traditionally, Mongolians are accustomed to a higher intake of animal fat and drink strong wine. A careful re-analysis of the participants' characteristics in our study demonstrated that the Mongolian participants had a higher proportion of overweight or obese participants (71.97% and 63.46% in hypertension, respectively) than the Han participants, and they tended to drink more alcohol (56.06% and 46.77% in hypertension, respectively). Differences in the prevalence of CVD risk factors between Han and Mongolian adults imply a need to develop tailored prevention programmes targeting ethnic groups, thereby reducing the prevalence of CVD risk factors in the general population.

Another important finding was the age-standardised prevalence of one, two, and ≥3 CVD risk factor clustering in Mongolian and Han populations. About 90.22% of Han men and 93.21% of Mongolian men had at least one CVD risk factor, which was similar to the study conducted in Beijing in 2007 (91.3%).[46] However, the proportions of ≥3 CVD risk factors in Han and Mongolian men were 38.30% and 39.79%, respectively, which were higher than the results of the latter study (22.6%).[46] Because of the sharp differences in smoking rates (55.58% in Han men vs 2.41% in Han women, 48.46% in Mongolian men vs 4.63% in Mongolian women), men had a much higher prevalence of CVD risk factor clustering than women. The age-standardised prevalence of the clustering of ≥3 risk factors in Han women was significantly lower than that in Mongolian women. These findings indicate that men and Mongolian women should be the targeted population for CVD prevention and control.

Our study's limitations were mainly the unclear temporal relationships between CVD risk factors and hypertension, which is due to the inherent weakness of cross-sectional studies, and has been heatedly debated in epidemiological studies. A prospective cohort study needs to be completed to further assess the direction of prehypertension, hypertension, and CVD risk factors in Inner Mongolia. Furthermore, several important confounding factors associated with CVD, such as nutrition and physical activity, were not evaluated in the present study. Moreover, because of small sample sizes, the age-standardised prevalence of CVD risk factor clustering was not displayed by optimal BP, prehypertension, and hypertension groupings. Finally, this study was conducted only in Inner Mongolia, so the study's findings cannot be representative of all Chinese adults, and further research is needed.

In summary, several common CVD risk factors and their clustering were prevalent in the Han and Mongolian populations in Northern China. The clustering of CVD risk factors in prehypertensive patients suggests that prehypertension should be a key stage for early intervention of CVD. More strategies should also be developed, including screening of individuals with prehypertension and effective management of other common CVD risk factors. The gender disparities in CVD risk factor clustering suggest that targeted and cost-effective strategies for preventing CVD should be developed in Inner Mongolia.

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