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Blood pressure status and cardiovascular risk factors clustering: differences between Mongolian and Han among urban adults of Inner Mongolia in year 2014-survey

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Keywords: Cardiovascular diseases; Risk factors; Clustering; Blood pressure; Ethnic groups

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Abstract

Objectives: We aim to assess the ethnic differences in the clustering of CVD risk factors among adults with normal blood pressure, pre-hypertension and hypertension and to provide suggestions for prevention of hypertension and CVD in this respect.

Methods: 3227 individuals aged 20-80 years (2308 Han and 919 Mongolian) were selected using a multistage cluster sampling method from Inner Mongolia in 2014. Multivariate logistic regression was used to estimate the odds ratio (OR) and 95%CI of pre-hypertension and hypertension in Han and Mongolian stratified by 0, 1, 2 and ≥3 risk factors clustering, adjusted for age, gender and alcohol drinking. We conducted age direct standardization of CVD risk factors using the Sixth National Population Census in 2010.

Results: The adjusted odds ratio (95% confidence interval) of hypertension among 1, 2, and≥3 CVD risk factors for Mongolian compared with Han was 0.82 (0.57 to 1.18), 1.84 (1.18 to 2.86), and 1.56 (0.80 to 3.04), respectively. When consider hypertension as one of the CVD risk factors, the age-standardized prevalence showed that 93.21% of Mongolian males and 90.22% of Han males had at least one CVD risk factors. Clustering of 2 or 3 of these risk factors was noted in 28.90% or 38.30% of Han males, 26.19% or 39.79% of Mongolian males, 18.29% or 9.18% of Han females as well as 15.07% or 14.55% of Mongolian females, respectively. Males tend to have a higher prevalence of the 2 and ≥3 of CVD risk factors clustering when compared with females (P<0.05). The age-standardized prevalence of the clustering of ≥3 risk factors were significantly lower in the Han females than that in the Mongolian females (P=0.002).

Conclusions: These findings suggest that there may be a need to develop ethnic and gender specific and cost-effective strategies for preventing CVD in Mongolia.

Strengths and limitations of this study

It is unclear whether and to what extent there is clustering of these CVD risk factors in the two ethnic groups with pre-hypertension and hypertension. The present study shows for the first time that Mongolian was associated with a higher risk of hypertension in the ≥2 CVD risk factors when compared with Han adults.

Males tend to have a higher prevalence of the 2 and ≥3 CVD risk factors clustering when compared with females.

The age-standardized prevalence of the clustering of ≥3 risk factors was significantly lower in the Han females than that in the Mongolian females.

Still, some limitations should be considered. The progression from pre-hypertension to hypertension with CVD risk factors could not be precisely delineated.

In addition, the age-standardized prevalence of the clustering of CVD risk factors was not showed by normal blood pressure, pre-hypertension and hypertension due to the small sample.

INTRODUCTION

After cancer, cardiovascular disease (CVD) is the second most common cause of death worldwide accounting for > 17 million deaths[1]. Hypertension is one of the most important risk factors for the development of CVD [2 3]. By 2010, hypertension 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) proposed a new classification, pre-hypertension, in which people with a systolic BP of 120-139mmHg and/or a diastolic BP of 80-89 mmHg[4]. Studies have demonstrated that individuals with pre-hypertension are at increased risk for hypertension and cardiovascular disease [5-8]. The Inner Mongolia Autonomous Region is located in northern China, and Han and Mongolian constitute approximately 96% of the total population. The two ethnic groups have different genetic backgrounds, culture, customs and food consumption. Smoking, overweight or obesity, diabetes and dyslipidemia are well-established risk factors of CVD [9-11]. Several studies have noted the striking differences across ethnic groups in the clustering of these risk factors of the world [12-14]. However, it is unclear whether and to what extent there is clustering of these CVD risk factors in the two ethnic groups with pre-hypertension and hypertension. The present study was designed to evaluate ethnic differences in the clustering of CVD risk factors among adults with normal blood pressure, pre-hypertension and hypertension and to provide suggestions for prevention of hypertension and CVD.

METHODS

Study population

The China National Health Survey (CNHS) was conducted by the Chinese Academy of Medical Sciences for evaluate the Physiological Constant and Health Condition in Chinese. A cross-sectional study was performed in Bayan Nur, Xilingol League, Ulanqab and Hohhot, Inner Mongolia, China, in 2014. A sample aged 20-80 years was selected using a multistage cluster sampling method, which has been extensively described early [15]. Participants recruited including residents who had been living in Inner Mongolia for more than 1 year. Of the 3464 subjects aged 20-80 years, we excluded 179 subjects who were not Mongolian or Han and 58 subjects with missing values on baseline characteristics. Ultimately, the study population consisted of 3227 subjects. All participants provided written informed consent, the study was approved by the Institutional Review Board of the Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences.

Health survey

Data on demographic information, smoking, alcohol drinking and history of diseases were collected with unified questionnaires. Ethnicity was determined by the Subjects' ID card and categorized as Mongolian and Han people. Subjects were considered Mongolian or Han people if they and their parents were all of Mongolian or Han ethnicity. Cigarette smokers were defined as those who smoked at least one cigarette per day and lasting for at least 6 months. Smoking was defined as never smoker, or ever smoker if the subject was a current smoker or a former smoker. Drinking status was divided into two categories: never drinkers, or ever drinkers if the subject was a current drinker or a former drinker. Information on the personal history of hypertension, diabetes and dyslipidemia were also obtained.

Measurements

Height was measured to nearest 0.1 cm using fixed stadiometer and weight was measured by BIA (bioelectrical impendence analysis) with a commercially available body composition analyzer (BC-420, TANITA, Japan) to the nearest 0.1 kg in a standing position, with participants wearing light clothing. Body mass index (BMI) was calculated as the subject's weight in kg divided by the square of the subject's height

in metres. Sitting blood pressure was measured by trained research assistants following a standardized procedure using Omron digital blood pressure measuring device (Omron HEM-907, Japan). Blood samples were drawn after at least eight hours of overnight fasting and immediately processed, refrigerated and transported to the laboratory in Beijing, kept at −80 °C below zero before being analyzed. Fasting plasma glucose (FPG) and lipids, including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C), were assessed by General Hospital of Chinese PLA.

Definition of CVD risk factors

BMI was categorized according to the World Health Organization criteria, BMI<25 kg/m^2 is considered lean or healthy, BMI between 25 and 29 kg/m^2 is considered overweight, and BMI≥30 kg/m^2 is considered obese.

Pre-hypertension was defined as people with an average systolic blood pressure (SBP) of 120-139 mmHg and/or an average diastolic blood pressure (DBP) of 80-89mmHg. Hypertension was defined as an average (calculated from 3 measurements) SBP ≥140mmHg, and/or an average DBP ≥90mmHg, or self-reported diagnosis of hypertension.

Diabetes was defined according to the American Diabetes Association (ADA) 2009 criteria: FPG ≥ 7.0 mmol/L or/and a previous diagnosis of diabetes.

Dyslipidemia was defined as TC≥6.22mmol/L and/or TG≥2.26mmol/L and/or HDL-C<1.04mmol/L and/or LDL-C≥4.14mmol/l.

Statistical Analysis

The data are expressed as mean ± SD for continuous variables and percentage in each subgroup for categorical variables. The characteristics of the groups according to the blood pressure status in Mongolian and Han were compared using Chi-square test and t-test. For the parameters that exhibited skewed deviations (triglyceride levels), log-transformed variables were used. The proportions of 0, 1, 2 and ≥3 risk factors of CVD calculated for Han and Mongolian with normal blood pressure, pre-hypertension and hypertension was presented as percentage and 95% confidence interval (CI). Age and gender adjusted proportions of 0, 1, 2 and ≥3 risk factors of CVD were evaluated by the Logistic regression [16].

Multivariate logistic regression was used to estimate the odds ratio (OR) and 95%CI of pre-hypertension and hypertension in Han and Mongolian stratified by 0, 1, 2 and ≥3 risk factors clustering, adjusted for age, gender and alcohol drinking. In the analysis, stratified by risk factors, normal blood pressure, pre-hypertension and hypertension served as three levels of the dependent variable, and age, gender and alcohol drinking were independent variables. We conducted age direct standardization of CVD risk factors using the Sixth National Population Census in 2010. All *P* values of less than .05 were considered to be statistically significant with 2-sided alternative. All statistical analyses were performed using SAS software version 9.3.

RESULTS

The demographic data of the studied population are shown in Table 1. A total of 3227 individuals were included in the analysis, of which 919(28.48%) were Mongolian. When compared to the Han sample, the Mongolian sample were more likely to be alcohol drinkers and have higher HDL-C levels (all P<0.05). With in pre-hypertension and hypertension groups, the Mongolian sample were more likely to be overweight or obesity and have higher TC (all P<0.05). Mongolian with hypertension were more likely to have higher BMI, DBP and LDL-C (all P<0.05). Within Han adults, FPG, TG and dyslipidemia were higher than Mongolian in the population with normal blood pressure (all P<0.05), whereas LDL-C was lower (P<0.05). And the Han sample were more likely to be older in the population with pre-hypertension (P<0.05).

Table 1 Demographic characteristic of the study population with different blood pressure status

	Normal blood pressure(n=1407)			Pre-hypertension(n=896)			Hypertension(n=924)		
	Han(n=1009)	Mongolian(n=398)	P value	Han(n=664)	Mongolian(n=232)	P value	Han(n=635)	Mongolian(n=289)	P value
Mean Age, yrs	39.10±12.08	38.02±11.91	0.13	45.92±13.43	43.98±11.74	**0.04**	53.47±11.37	53.59±11.16	0.88
Male, n (%)	249(24.68)	89(22.36)	0.36	342(51.51)	123(53.02)	0.69	305(48.03)	145(50.17)	0.55
BMI, kg/m^2	22.93±3.23	23.19±3.38	0.18	24.91±3.76	25.43±3.64	0.07	26.46±3.64	27.18±4.18	**0.01**
Heart rate, beat/min	77.82±10.32	77.81±9.92	0.99	77.55±10.78	77.05±11.49	0.55	77.29±11.63	77.65±10.89	0.65
SBP, mmHg	108.20±7.21	107.50±7.98	0.17	126.10±6.49	125.20±6.33	0.08	140.90±15.02	141.30±15.30	0.77
DBP, mmHg	69.06±5.98	68.62±6.24	0.22	79.54±6.01	79.61±5.38	0.87	88.07±10.31	90.34±11.56	**0.005**
FPG, mmol/L	5.09±1.12	4.98±0.85	**0.04**	5.34±1.04	5.34±1.26	0.96	5.75±1.53	5.73±1.56	0.83
TC, mmol/L	4.57±0.98	4.65±0.90	0.14	4.92±0.98	5.07±0.92	**0.04**	5.07±1.02	5.37±1.04	**<0.001**
TG, mmol/L	1.23(1.19-1.27)	1.08(1.03-1.13)	**<0.001**	1.57(1.51-1.64)	1.48(1.37-1.60)	0.14	1.86(1.78-1.94)	1.83(1.72-1.95)	0.73
LDL-C, mmol/L	2.69±0.78	2.78±0.76	**0.04**	2.94±0.87	3.04±0.84	0.13	3.00±0.91	3.32±0.93	**<0.001**
HDL-C, mmol/L	1.37±0.34	1.46±0.36	**<0.001**	1.30±0.34	1.36±0.38	**0.01**	1.25±0.34	1.31±0.35	**0.02**
Smoking, n (%)	206(20.42)	78(19.60)	0.73	248(37.35)	96(41.38)	0.28	249(39.21)	105(36.33)	0.40
Alcohol Drinking, n (%)	335(33.20)	162(40.70)	**0.01**	311(46.84)	138(59.48)	**<0.001**	297(46.77)	162(56.06)	**0.01**
Overweight or obesity, n (%)	254(25.17)	119(29.90)	0.07	312(46.99)	134(57.76)	**0.004**	403(63.46)	208(71.97)	**0.01**
Dyslipidemia, n (%)	258(25.57)	76(19.10)	**0.01**	273(41.11)	87(37.50)	0.33	317(49.92)	153(52.94)	0.39
Diabetes, n (%)	26(2.58)	5(1.26)	0.13	45(6.78)	12(5.17)	0.39	94(14.80)	36(12.46)	0.34

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein-cholesterol; HDL-C, high-density lipoprotein-cholesterol. The data are expressed as the mean± sd., n (%) or geometric mean (95% confidence interval).

Table 2 presents the results of multiple logistic regression analysis of associations between potential CVD risk factors with pre-hypertension and hypertension in Mongolian and Han adults. Overweight or obesity was significantly associated with an increased risk of pre-hypertension and hypertension in both Mongolian and Han adults. Dyslipidemia was significantly associated with an increased risk of hypertension in both Mongolian and Han adults and within Mongolian adults, dyslipidemia was significantly associated with an increased risk of pre-hypertension. Within Han adults, diabetes was significantly associated with an increased risk of hypertension while smoking was significantly associated with a decreased risk of pre-hypertension.

Table 2 Factors associated with the prevalence of pre-hypertension and hypertension by multivariate logistic regression models

	Han		Mongolian	
CVD risk factors	Pre-hypertension OR(95%CI)	Hypertension OR(95%CI)	Pre-hypertension OR(95%CI)	Hypertension OR(95%CI)
Smoking	0.70(0.50-0.99) *	0.85(0.58-1.26)	0.92(0.54-1.55)	0.58(0.34-1.01)
Overweight or obesity	2.14(1.71-2.69) *	3.86(3.02-4.92) *	2.15(1.48-3.11) *	3.10(2.08-4.62) *
Dyslipidemia	1.16(0.91-1.46)	1.36(1.06-1.74) *	1.53(1.02-2.30) *	2.62(1.73-3.96) *
Diabetes	1.43(0.85-2.39)	2.34(1.44-3.82) *	1.60(0.53-4.81)	2.47(0.89-6.85)

Adjusted for age, gender, alcohol drinking, smoking, overweight or obesity, dyslipidemia and diabetes. * Compared with Normal blood pressure: P<0.05.

Overall, 33.62% of Han adults had no CVD risk factors, while the proportions of Mongolian adults were 30.14% and this difference was not statistically significant (P>0.05). Table 3 shows the proportions of 0, 1, 2 and ≥3 risk factors of CVD in Han and Mongolian populations with normal blood pressure, pre-hypertension and hypertension. The adjusted proportion of 0 CVD risk factor in Han adults was higher in the populations with normal blood pressure, whereas within normal blood pressure group, the unadjusted and adjusted proportions of 1 risk factors was higher in Mongolian adults (P<0.05). And the unadjusted and adjusted proportions of 2 risk factors was also higher in Mongolian adults (P<0.05).

Table 3 Comparison of proportional ratios (%) of different risk factors clustering among normal blood pressure, pre-hypertension and hypertension in Mongolian and Han adults

Blood pressure status	No. of risk factors clustering							
	0		1		2		≥3	
	Unadjusted	Adjusted[+]	Unadjusted	Adjusted[+]	Unadjusted	Adjusted[+]	Unadjusted	Adjusted[+]
Normal blood pressure								
Han	52.53(49.45-55.61)	29.59(25.41-34.13)	27.35(24.60-30.10)	32.36(28.94-35.98)	14.27(12.11-16.43)	17.62(14.90-20.72)	5.85(4.40-7.30)	5.86(4.24-8.05)
Mongolian	49.75(44.84-54.66)	24.27(19.48-29.80) *	35.18(30.48-39.87) *	42.03(36.55-47.71) *	10.80(7.75-13.85)	14.35(10.66-19.03)	4.27(2.28-6.26)	4.69(2.77-7.83)
Pre-hypertension								
Han	24.70(21.42-27.98)	22.93(19.55-26.71)	33.89(30.29-37.49)	33.57(29.94-37.40)	27.11(23.73-30.49)	24.80(21.46-28.47)	14.31(11.64-16.97)	9.71(7.39-12.67)
Mongolian	18.97(13.92-24.01)	17.11(12.58-22.85)	38.36(32.10-44.62)	38.37(32.10-45.04)	25.86(20.23-31.50)	23.44(18.26-29.57)	16.81(12.00-21.62)	11.52(7.90-16.51)
Hypertension								
Han	12.91(10.31-15.52)	12.12 (8.87-16.36)	32.76(29.11-36.41)	32.25(26.95-38.06)	31.50(27.88-35.11)	30.45(25.49-35.91)	22.83(19.57-26.10)	14.92(11.16-19.66)
Mongolian	12.11(8.35-15.87)	11.94(8.01-17.44)	27.34(22.20-32.47)	27.00(21.07-33.89)	38.41(32.80-44.02) *	37.10(30.46-44.27) *	22.15(17.36-26.93)	13.66 (9.55-19.16)

*Compared with Han: P<0.05; [+]Adjusted: adjusted for age and gender

Normal blood pressure group served as the control, the unadjusted and adjusted odds ratios (OR) of pre-hypertension and hypertension stratified by the number of risk factors clustering in Mongolian and Han were estimated in multivariate logistic analysis using multinomial logistic model, the OR and 95%CI are presented in Table 4. The adjusted OR showed that the prevalence of hypertension was 1.84 (95%CI: 1.18-2.86, P<0.05) times higher in Mongolian adults as compared to Han adults in the group with 2 risk factors.

Table 4 Adjusted odds ratios (95% confidence intervals) of cardiovascular risk factors clustering in pre-hypertension and hypertension

Ethnic group	Pre-hypertension				Hypertension			
	0 OR(95%CI)	1 risk factors OR(95%CI)	2risk factors OR(95%CI)	≥3risk factors OR(95%CI)	0 OR(95%CI)	1 risk factors OR(95%CI)	2risk factors OR(95%CI)	≥3risk factors OR(95%CI)
Unadjusted								
Han	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)
Mongolian	0.72(0.50-1.04)	0.78 (0.57-1.07)	1.12(0.71-1.75)	1.42(0.74-2.74)	1.14(0.75-1.75)	0.75(0.54-1.04)	1.86(1.23-2.81) *	1.53(0.83-2.83)
Adjusted[+]								
Han	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)
Mongolian	0.83(0.56-1.23)	0.80(0.58-1.11)	1.13(0.71-1.79)	1.43(0.73-2.81)	1.45(0.90-2.34)	0.82(0.57-1.18)	1.84(1.18-2.86) *	1.56(0.80-3.04)

[+]The odds ratios for ethnic grouping are adjusted for age, gender and alcohol drinking; *Compared with Han: P<0.05

When consider hypertension as one of the CVD risk factors, overall, 23.03%, 28.90%, and 38.30% of Han males and 27.51%, 26.19%, and 39.79% of Mongolian males had 1, 2, and≥3 of these risk factors, respectively. 26.36%, 18.29%, and 9.18% of Han females and 29.90%, 15.07%, and 14.55% of Mongolian females had 1, 2, and≥3 of these risk factors, respectively. Males tend to have a higher prevalence of the 2 and ≥3 of CVD risk factors clustering when compared with females (P<0.05). The age-standardized prevalence of the clustering of ≥3 risk factors were significantly lower in the Han females than in the Mongolian females (P=0.002) (Fig. 1).

DISCUSSION

This is the first study to report the ethnic differences in the clustering of CVD risk factors among adults with normal blood pressure, pre-hypertension and hypertension in Inner Mongolia. Our study found that HDL-C levels, TC, LDL-C and the proportion of overweight or obesity tend to be higher in Mongolian adults. FPG tend to be higher in Han adults. Ethnic differences in cardiovascular risk factors have previously been reported [17 18]. In a Swedish study among 107 immigrants aged 35-64 years, Turkish adults had higher TC levels than Swedish adults, and the higher HDL-C levels were observed more among children from African descent than among Dutch children[19]. Many studies have noted that there were ethnic differences in BP,FBG, BMI, TC, TG, LDL-C and HDL-C levels [12 18 20]. A study in Xinjiang in 2008 conducted that compared with Han adults the Mongolian adults aged > 30 years were more likely to have a higher TC, LDL-C, DBP, SBP, FBG and BMI[12]. Compared with a study of Inner Mongolia in 2003, the TC, TG, HDL-C, LDL-C, FBG and BMI of Mongolian adults were higher in our study. This may due to economic development and lifestyle changes [21].

Overweight or obesity was a risk factor of pre-hypertension and hypertension in both Mongolian and Han adults. BMI was an important risk factor of the pre-hypertension and hypertension. A cohort study conducted in US conducted that obesity was more likely to occur prior to hypertension [22]. Compared with the adults with normal blood pressure, dyslipidemia was associated with an increased risk of pre-hypertension in Mongolian adults. After a careful reanalysis of the high TC, high TG, low HDL-C, and high LDL-C ‘s effect on pre-hypertension, it appears that high TG was associated with an increased risk of pre-

hypertension in Mongolian adults, while high TC or high LDL-C was associated with an increased risk of pre-hypertension in Han adults. The majority of the dyslipidemia sample (58.02% in Han and 54.43% in Mongolian) with high TG. Within Han adults, diabetes was significantly associated with an increased risk of hypertension while smoking was significantly associated with a decreased risk of pre-hypertension. Studies have conducted that hypertension has been associated with incident diabetes[23] and insulin resistance has been associated with incident diabetes[24]. A study conducted in Mongolian in 2010 showed that among subjects with BMI<25 Kg/m^2, the adjusted DBP in all smokers were lower than that in non-smokers [25]. A large prospective cohort study in a nationally representative sample of 169871 Chinese adults from 1991 to 2000, the data also showed that male smokers had lower prevalence of hypertension than male non-smokers [26]. Many studies also suggested that smoking was positively associated with hypertension [27]. These finding implied that the association between smoking and hypertension was a complex issue, and the reason why among the Han adults, smokers have lower prevalence of pre-hypertension may due to the different genetic backgrounds, and a further study between the prevalence of pre-hypertension and ethnic specific genetic susceptibility is urgently needed to clarify the observation.

Mongolian adults with normal blood pressure had a higher proportion of clustering of 1 risk factors compared with Han adults, and Mongolian adults with hypertension had a higher proportion of clustering of 2 risk factors. These phenomenon may be due to the two ethnic groups have different culture, customs and food consumption, Mongolian tend to eat more animal fat and drink strong wine. After a careful reanalysis of the characteristics of the adults in the present study, it appears that the Mongolian adults had a higher proportion of overweight or obesity (with hypertension 71.97% and 63.46%, respectively) and drinking more alcohol (with hypertension 56.06% and 46.77%, respectively). The differences in Han and Mongolian groups with regard to the prevalence of CVD risk factors suggest that the necessary for the development of ethnic specific and CVD prevention programs to reduce the prevalence of CVD risk factors.

Another important finding was that the age-standardized prevalence of clustering of 1, 2, and ≥3 CVD risk factors in Mongolian and Han populations by gender. 90.22% of Han males and 93.21% of Mongolian

males had at least 1 CVD risk factors, which was similar to the study conducted in Beijing in 2007 (91.3%) [28]. But the ≥3 CVD risk factors in Han and Mongolian males were 38.30% and 39.79, respectively and were higher than that study (22.6%)[28]. The age may play an important role, older age were more likely to have the clustering of CVD risk factors. After reanalysis, we found the males' age in our study was younger than that study (46.23 *vs.* 52.8). This may due to the lifestyles' difference. The significant higher prevalence of the clustering of these CVD risk factors in men compared with women may be due to the fact that 73.55% of Han men versus 3.12% of Han women and 67.51% of Mongolian men versus 6.76% Mongolian women were smokers. The findings indicated that the prevention and control of CVD should emphasized men.

Limitations of our study are mainly those in epidemiological studies in general. Cross-sectional study does not allow for quantification of the importance of risk factor clustering in the incidence of CVD, which limits our ability to comment on causal relationships between the clustering of these risk factors and the incidence of CVD. Furthermore, the progression from pre-hypertension to hypertension with CVD risk factors could not be precisely delineated. In addition, the age-standardized prevalence of the clustering of CVD risk factors was not showed by normal blood pressure, pre-hypertension and hypertension due to the small sample.

In summary, our study found that several major CVD risk factors and their clustering appeared in the population of the present study. Although there was no difference between Han and Mongolian adults in the distribution of health resources, Mongolian tend to have a higher CVD risk factors clustering than Han adults. Mongolian was significantly associated with a higher risk of hypertension in the ≥2 CVD risk factors. The age-standardized prevalence of the clustering of ≥3 risk factors was significantly lower in the Han females than in the Mongolian females and the higher prevalence of the clustering of these CVD risk factors in men compared with women. These findings suggest that there may be a need to develop ethnic and gender specific and cost-effective strategies for preventing CVD in Mongolia.

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Authors' contributions

GL participated in the data collection and drafted the manuscript. GG, WW, HW, HG, YQ, GX, YL, BZ participated in the data collection. KW, FD, LP, GS participated in the design of the study and undertook statistical analyses. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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Competing interests

The authors declared that they have no competing interests.

Ethics approval

The study was approved by the Institutional Review Board of the Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences(NO.028-2013).

Provenance and peer review

Not commissioned; externally peer reviewed.

Data sharing statement

No additional data are available.

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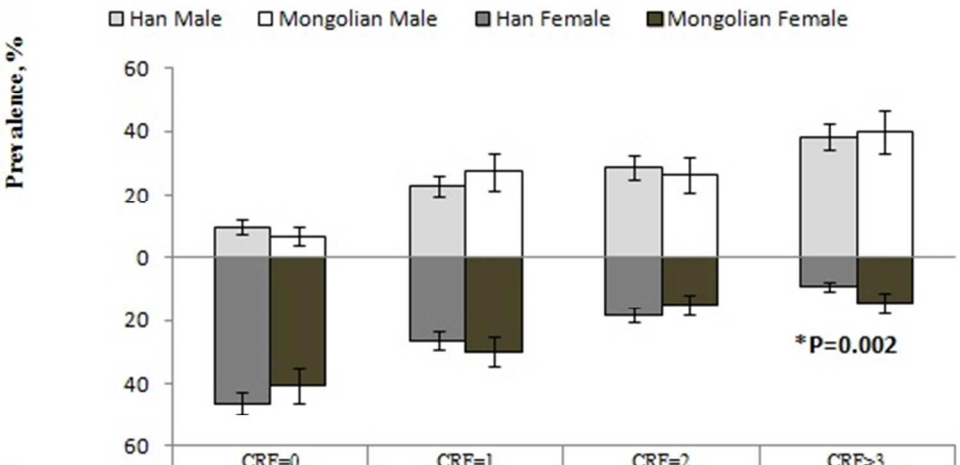
Figure legends

Fig.1 Age-standardized prevalence of major cardiovascular disease risk factors in Han and Mongolian adults by gender (%).



	CRF=0	CRF=1	CRF=2	CRF≥3
Han Male	9.78	23.03	28.90	38.30
Mongolian Male	6.79	27.51	26.19	39.79
Han Female	46.18	26.36	18.29	9.18
Mongolian Female	40.49	29.90	15.07	14.55

143x92mm (96 x 96 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-6
Bias	9	Describe any efforts to address potential sources of bias	4-6
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	4
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Results			Page No
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4
		(b) Give reasons for non-participation at each stage	4
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-8
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	*7-13*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-13
		(*b*) Report category boundaries when continuous variables were categorized	9-13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9-13
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The degree of high blood pressure and cardiovascular risk factors clustering: differences between Mongolian and Han among urban adults of Inner Mongolia: a cross-sectional study

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Keywords:	Cardiovascular diseases, Risk factors, Clustering, Blood pressure, Ethnic groups

The degree of high blood pressure and cardiovascular risk factors clustering: differences between Mongolian and Han among urban adults of Inner Mongolia: a cross-sectional study

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Keywords: Cardiovascular diseases; Risk factors; Clustering; Blood pressure; Ethnic groups

Running Title: Blood pressure status and cardiovascular risk factors clustering

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Abstract

Objectives: We aim 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 aged 20-80 years using a multistage cluster sampling method in Inner Mongolia, 2014. They were interviewed by standard questionnaires, and underwent anthropometric measurements and biochemical testing. Han and Mongolian were divided into optimal, pre-hypertension and hypertension groups based on blood pressure, respectively. Relationships between CVD risk factor clustering (with 0, 1, 2, and ≥3 CVD risk factors) and pre-hypertension and hypertension were analysed for all participants.

Results: Proportions of 2 and ≥3 CVD risk factor clustering in prehypertension and hypertension groups were consistently higher than that in the optimal group (bonferroni, P<0.0167). The odds ratio (OR) of prehypertension or hypertension increased as the number of CVD risk factors increased (P_{trend}<0.0001). In multivariate model, the adjusted OR of having 1, 2, and ≥3 CVD risk factors versus none risk factor was 1.95, 2.25 and 2.28 in Han, and 1.73, 2.83 and 3.69 in Mongolian for prehypertension; the adjusted OR were 3.15, 4.75 and 6.49 in Han , and 1.90, 5.29 and 8.13 in Mongolian for hypertension (all P<0.05). There was no significant heterogeneity between Han and Mongolian in either prehypertension or hypertension group (P>0.05). The age-standardized prevalence of ≥3 risk factor clustering was 38.30% in Han males and 39.79% in Mongolian males. The rate was significantly lower among Han females than that among Mongolian females (9.18% in Han females, 14.55% in Mongolian females, P=0.002).

Conclusions: These findings suggest that there was clustering of CVD risk factors in pre-hypertensive Han and Mongolian and 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 pre-hypertensive and hypertensive Han and Mongolian adults in Inner Mongolia, China.

To obtain gender and ethnic differences in CVD risk factors clustering, we conducted age direct standardization to the 2010 National Population Census to compare the clustering of CVD risk factors between Han and Mongolian by gender.

These findings suggest that there was clustering of CVD risk factors in pre-hypertensive Han and Mongolian and prehypertension may be a useful target for intervention.

As this was a cross-sectional study, progression from hypertension to diabetes or dyslipidemia could not be precisely delineated. After a careful analysis of the time of hypertension and diabetes diagnoses in 76 hypertensive patients with diabetes, we found that 74.67% (57/76) hypertension diagnoses were made before diabetes, and participants with hypertension diagnoses were at higher risk of diabetes than those without diagnoses of hypertension (OR=2.47, 95%CI: 1.69-3.61).

The age-standardized prevalence of CVD risk factor clustering was not shown by optimal, pre-hypertension and hypertension due to small sample sizes.

INTRODUCTION

Cardiovascular disease (CVD) is the major cause of deaths 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 pre-hypertension as systolic blood pressure (SBP) of 120-139mmHg and/or a diastolic blood pressure (DBP) of 80-89 mmHg [4], further understanding hypertension as a consecutive process from optimal to high blood pressure (BP). Studies have demonstrated that individuals with pre-hypertension are at increased risk for hypertension and CVD [5-8]. Current smoking, overweight or obesity, diabetes and dyslipidemia are well-established risk factors of CVD [9-11]. It has been demonstrated that hypertension is associated with increases in blood lipid levels [12-14] and diabetes [15-17]. Among the defined traditional CVD risk factors, hypertension is probably the one that is most conveniently measured and

easily controlled. However, it is unclear whether and to what extent there is clustering of the major CVD risk factors with pre-hypertension.

The Inner Mongolia Autonomous Region is located in Northern China, and Han and Mongolian constitute approximately 96% of the total population. The two ethnic groups have different genetic backgrounds, culture, customs and food consumption patterns. Several studies have noted the striking ethnic disparities in CVD risk factor clustering in China and overseas [18-20]. The present study was aimed to assess the clustering of CVD risk factors in Han and Mongolian with pre-hypertension or hypertension, which could provide evidence for CVD prevention in 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 program aiming to evaluate the Physiological Constant and Health Condition in Chinese people. A sample aged 20-80 years was selected using a multistage cluster sampling method, which has been extensively described previously [21]. 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.

Health survey / Measurements

Data on demographic information, smoking, alcohol drinking and history of diseases were collected with standard questionnaires. The ethnicity of participants was determined by their ID cards and their parents' ethnic status. Participants and their parents should be all Han or Mongolian. Drinking status was divided into two categories: never drinkers and ever drinkers (including current drinkers and former drinkers). Information on personal history of hypertension and diabetes were 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 BIA (bioelectrical impendence analysis) with a commercially available body composition analyzer (BC-420,

TANITA, Japan) when participants were in light clothes. Body mass index (BMI) was calculated as weight in kg divided by the square of height in metres. Sitting blood pressure was measured three times by trained research assistants following a standardized procedure using Omron digital blood pressure measuring device (Omron HEM-907, Japan). Blood samples were drawn after fasting overnight for at least eight hours and they 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 General Hospital of Chinese PLA.

Definitions

Blood pressure was divided into optimal BP, prehypertension and hypertension. Optimal BP was defined as an average systolic blood pressure (SBP) <120 mmHg and diastolic blood pressure (DBP) < 80 mmHg. Prehypertension was defined as an average SBP of 120-139 mmHg and/or DBP of 80-89mmHg [4]. Hypertension was defined as an average SBP ≥140mmHg, and/or DBP ≥90mmHg, or self-reported diagnosis of hypertension [22].

BMI was graded into lean or healthy (BMI<25 kg/m^2), overweight (BMI=25-29 kg/m^2), and obese (BMI≥30 kg/m^2) according to the World Health Organization criteria [23]. Diabetes was defined as FPG ≥7.0 mmol/L and/or a previous diagnosis of diabetes [24], and dyslipidemia was defined as TC≥6.22mmol/L and/or TG≥2.26mmol/L and/or HDL-C<1.04mmol/L and/or LDL-C≥4.14mmol/l [25]. Current smoking was determined when participants answered “yes” to the question “Do you smoke now?” and smoked ≥1 cigarette per day for at least 6 months [26].

Statistical Analysis

The data were expressed as mean ± SD for continuous variables and percentage for categorical variables. Chi-square test or one-way analyses of variance were used to compare characteristics among optimal BP, pre-hypertensive and hypertensive participants in each ethnic group in table 1.The bonferroni test was used for multiple comparisons. Variables with a skewed distribution (e.g., triglyceride levels), were log-transformed and their 95% confidence intervals (CI) were reported.

A multinomial logit analysis was performed to evaluate relationship between CVD risk factors (current smoking, BMI≥25 kg/m^2, dyslipidemia, diabetes) and pre-hypertension and hypertension in table2. Proportions of individuals with CVD risk factors clustering in optimal, pre-hypertensive and hypertensive groups were presented as percentage and 95% CI and they were analyzed with chi-square partition (CSP) method in table3.

A multinomial logit analysis was performed to explore relationships of pre-hypertension and hypertension with 1, 2 and ≥3 risk factors clustering after adjustment for age, gender and alcohol drinking in Han and Mongolian in table4. In the analysis, stratified by Han and Mongolian, optimal, pre-hypertension and hypertension served as three levels of the dependent variable, and age, gender, alcohol drinking and the number of CVD risk factors clustering were independent variables. The heterogeneity of associations among Han and Mongolian was evaluated by using Cochran Q test. Additionally, dose-response relationships between CVD risk factor clustering and pre-hypertension/hypertension were examined using the number of CVD risk factors as a continuous variable in multinomial logit models.

Age direct standardization of CVD risk factors to National 2010 Census was conducted in Han and Mongolian. Two-tailed *P* value of < 0.05 was considered statistically significant. All statistical analyses were performed using SAS software version 9.3 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Totally, 3464 participants were investigated. Fifty-eight participants were excluded for missing data and 179 participants were excluded since all the participants and their parents were not Mongolian or Han. Ultimately, a total of 3227 individuals were included for analysis, including 2308 (71.52%) Han and 919 (28.48%) Mongolian. When compared to the Han adults, the Mongolian was more likely to be alcohol drinkers (50.27% *vs.*40.86%), overweight or obesity (50.16% *vs.*41.98%) and have a higher BMI (25.01 *vs.*24.47), DBP (78.22 *vs.*77.31), TC (4.98 *vs.*4.81), LDL-C (3.02 *vs.*2.85) and HDL-C levels (1.39 *vs.*1.32) (all *P*<0.05). The prevalence of pre-hypertension and hypertension were 28.77% and 27.51% in Han, and 25.24% and 31.45% in Mongolian, respectively. The characteristics of Han were similar to those of Mongolian. Specifically, the mean age was highest in hypertension group than pre-hypertension and optimal BP groups (bonferroni, all

P<0.0167) in both Han and Mongolian. In each ethic group, the mean BMI, SBP, DBP, fasting glucose, TC, TG were consistently higher in participants with hypertension than those with pre-hypertension (bonferroni, all *P*<0.0167), and these variables were also higher in pre-hypertension group than those in the optimal BP group (bonferroni, all *P*<0.0167). HDL-C levels were lower in optimal BP than hypertension or prehypertension and there was no statistical difference between hypertension and prehypertension. The proportions of males in prehypertension and hypertension groups were considerably higher than that in optimal BP group (bonferroni, all *P*<0.0167). Compared with pre-hypertension and optimal groups, the proportions of overweight/obesity, dyslipidemia and diabetes were highest in hypertension group (bonferroni, *P*<0.0167). Alcohol drinking only differed between optimal BP and pre-hypertension/hypertension without statistical difference between prehypertension and hypertension. Ethnic disparities were observed in smoking status. The proportion of current smokers was higher in hypertension and pre-hypertension than optimal BP in Han, while the proportion in pre-hypertension was higher than optimal BP and hypertension as well in Mongolian (bonferroni, all *P*<0.0167) (Table 1).

Table 1 Demographic characteristic of the study population among optimal, pre-hypertension and hypertension in Mongolian and Han adults

Variables	Han(n=2308)			*P* value	Mongolian(n=919)			*P* value
	Optimal BP (n=1009)	Prehypertension (n=664)	Hypertension (n=635)		Optimal BP (n=398)	Prehypertension (n=232)	Hypertension (n=289)	
Mean Age, yrs	39.10±12.08	45.92±13.43[a]	53.47±11.37[bc]	<0.0001	38.02±11.91	43.98±11.74[a]	53.59±11.16[bc]	<0.0001
Male, n (%)	249(24.68)	342(51.51)[a]	305(48.03)[b]	<0.0001	89(22.36)	123(53.02)[a]	145(50.17)[b]	<0.0001
BMI, kg/m^2	22.93±3.23	24.91±3.76[a]	26.46±3.64[bc]	<0.0001	23.19±3.38	25.43±3.64[a]	27.18±4.18[bc]	<0.0001
SBP, mmHg	108.20±7.21	126.10±6.49[a]	140.90±15.02[bc]	<0.0001	107.50±7.98	125.20±6.33[a]	141.30±15.30[bc]	<0.0001
DBP, mmHg	69.06±5.98	79.54±6.01[a]	88.07±10.31[bc]	<0.0001	68.62±6.24	79.61±5.38[a]	90.34±11.56[bc]	<0.0001
FPG, mmol/L	5.09±1.12	5.34±1.04[a]	5.75±1.53[bc]	<0.0001	4.98±0.85	5.34±1.26[a]	5.73±1.56[bc]	<0.0001
TC, mmol/L	4.57±0.98	4.92±0.98[a]	5.07±1.02[bc]	<0.0001	4.65±0.90	5.07±0.92[a]	5.37±1.04[bc]	<0.0001
TG, mmol/L	1.23(1.19-1.27)	1.57(1.51-1.64)[a]	1.86(1.78-1.94)[bc]	<0.0001	1.08(1.03-1.13)	1.48(1.37-1.60)[a]	1.83(1.72-1.95)[bc]	<0.0001
LDL-C, mmol/L	2.69±0.78	2.94±0.87[a]	3.00±0.91[b]	<0.0001	2.78±0.76	3.04±0.84[a]	3.32±0.93[bc]	<0.0001
HDL-C, mmol/L	1.37±0.34	1.30±0.34[a]	1.25±0.34[b]	<0.0001	1.46±0.36	1.36±0.38[a]	1.31±0.35[b]	<0.0001
Current smoker, n (%)	174(17.24)	197(29.67)[a]	161(25.35)[b]	<0.0001	68(17.09)	71(30.60)[a]	60(20.76)[c]	0.0003
Alcohol Drinking, n (%)	335(33.20)	311(46.84)[a]	297(46.77)[b]	<0.0001	162(40.70)	138(59.48)[a]	162(56.06)[b]	<0.0001
Overweight or obesity, n (%)	254(25.17)	312(46.99)[a]	403(63.46)[bc]	<0.0001	119(29.90)	134(57.76)[a]	208(71.97)[bc]	<0.0001
dyslipidemia, n (%)	258(25.57)	273(41.11)[a]	317(49.92)[bc]	<0.0001	76(19.10)	87(37.50)[a]	153(52.94)[bc]	<0.0001
Diabetes, n (%)	26(2.58)	45(6.78)[a]	94(14.80)[bc]	<0.0001	5(1.26)	12(5.17)[a]	36(12.46)[bc]	<0.0001

Abbreviations: BP, blood pressure; BMI, body mass index; SBP, systolic ; DBP, diastolic blood pressure; FPG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein-cholesterol; HDL-C, high-density lipoprotein-cholesterol. The data are expressed as the mean± sd., n (%) or geometric mean (95% confidence interval).

a: denotes statistical significance between Optimal and Pre-hypertension (The bonferroni method was used for multiple comparisons);

b: denotes statistical significance between Optimal and Hypertension (The bonferroni method was used for multiple comparisons);

c: denotes statistical significance between Pre-hypertension and Hypertension (The bonferroni method was used for multiple comparisons).

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

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(0.57-1.09)	0.70(0.49-1.01)	0.76(0.45-1.27)	**0.54(0.31-0.93)** *
Overweight/obesity (yes vs. no)	**2.13(1.70-2.67)** *	**3.82(3.00-4.88)** *	**2.15(1.49-3.12)** *	**3.09(2.07-4.60)** *
Dyslipidemia (yes vs. no)	1.15(0.91-1.46)	**1.37(1.07-1.76)** *	**1.53(1.02-2.30)** *	**2.58(1.71-3.91)** *
Diabetes (yes vs. no)	1.44(0.86-2.42)	**2.36(1.45-3.85)** *	1.56(0.52-4.71)	2.41(0.87-6.71)

Adjusted for age, gender, and alcohol drinking in multivariate logistic regression model . * Compared to optimal BP: P<0.05; CVD risk factors were included in models with an enter method.

Overall, the proportion of having no CVD risk factors was 35.10% in Han and 31.56% in Mongolian without significant difference ($P>0.05$). Table 3 showed the comparisons of CVD risk factor clustering among optimal BP, pre-hypertension and hypertension in Han and Mongolian. In each ethnic group, the proportions of 2 and ≥3 CVD risk factor clustering were consistently higher in hypertensive or prehypertensive individuals than the ones with optimal BP (bonferroni, $P<0.0167$). Additionally, we observed that more hypertensive individuals had ≥3 CVD risk factor clustering than the prehypertensive ones in Han. In Mongolian, however, more hypertensive individuals had 2 CVD risk factor clustering than prehypertensive ones (bonferroni, all $P<0.0167$). There was no statistically significant difference between prehypertension and hypertension in Mongolian with ≥3 CVD risk factors.

Table 3 Comparisons of proportions (%) of different risk factors clustering among optimal BP, pre-hypertension and hypertension in Han and Mongolian

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

*: Compared with optimal BP P<0.0167; +: Compared with pre-hypertension P<0.0167

With optimal BP being reference, the adjusted odds ratios (OR) of pre-hypertension and hypertension associated with CVD risk factor clustering in Mongolian and Han were estimated in multinomial logistic models (Table 4). In both Han and Mongolian, the OR of pre-hypertension or hypertension increased with the increasing number of CVD risk factor clustering (P_{trend} <0.0001). Compared with no risk factors, the adjusted OR of pre-hypertension among 1, 2, and ≥3 CVD risk factors were 1.95, 2.25 and 2.28 for Han, and 1.73, 2.83 and 3.69 for Mongolian, respectively (all P<0.05). The adjusted OR of hypertension among 1, 2, and ≥3 CVD risk factors were 3.15, 4.75 and 6.49 for Han, and 1.90, 5.29 and 8.13 for Mongolian, respectively (all P<0.05). In prehypertension group, there was no significant heterogeneity between Han and Mongolian and there was no heterogeneity in hypertension group, either (both P>0.05).

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

No.of risk factors clustering	Pre-hypertension		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(1.51-2.52)	**<0.0001**	3.15(2.32-4.28)	**<0.0001**
2(n=509)	2.25(1.65-3.06)	**<0.0001**	4.75(3.38-6.69)	**<0.0001**
≥3(n=242)	2.28(1.48-3.52)	**0.0002**	6.49(4.11-10.24)	**<0.0001**
P for trend	**<0.0001**		**<0.0001**	
Mongolian				
0(n=290)	1.00(ref)		1.00(ref)	
1(n=322)	1.73(1.12-2.68)	**0.014**	1.90(1.15-3.12)	**0.0119**
2(n=220)	2.83(1.64-4.88)	**0.0002**	5.29(3.02-9.26)	**<0.0001**
≥3(n=87)	3.69(1.69-8.08)	**0.0011**	8.13(3.59-18.41)	**<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.

As hypertension was a well-known risk factor for CVD, we further combined hypertension with the CVD risk factors mentioned above to assess the overall prevalence of CVD risk factor clustering. In males, the prevalence of 1, 2, and ≥3 CVD risk factors were 23.03%, 28.90%, and 38.30% in Han and 27.51%, 26.19%, and 39.79% in Mongolian, respectively. In females, the prevalence of 1, 2, and ≥3 CVD risk factors were 26.36%, 18.29%, and 9.18% in Han and 29.90%, 15.07%, and 14.55% in Mongolian, respectively. With respect to gender, males tended to have a higher prevalence of 2 or ≥3 CVD risk factor clustering than females (P<0.05). The age-standardized prevalence of ≥3 risk factor clustering was significantly lower in Han females than Mongolian females (P=0.002).(Fig. 1).

DISCUSSION

The present study was the first one to assess CVD risk factor clustering in pre-hypertension and hypertension phases among Han and Mongolian population. We found that participants with pre-hypertension had higher levels of CVD risk factors like BMI, FPG, TC, TG and LDL-C than those with optimal BP. The pre-hypertensive participants also had lower levels of HDL-C than the counterparts with optimal BP. Additionally, participants with hypertension had higher levels of BMI, FPG, TC and TG than the pre-hypertensive ones in both Han and Mongolian. Such findings indicate that hypertension was a consecutive process from optimal to high blood pressure and pre-hypertension was an important intermediate phase to hypertension. Similar results were reported elsewhere. A cohort study conducted in Brazil showed that four in five individuals aged 40 to 49 years old with pre-hypertension would become hypertensive in 10 years [27]. Winegarden CR also reported that compared to "optimal (SBP<120 and DBP<80mmHg), the estimated RR for the subcategory: "normal" (SBP, 120-129 or DBP, 80-85mmHg) was 2.0 (95% CI: 1.6-2.6) and for "high normals" (SBP, 130-139 or DBP, 85-89mmHg), 2.9 (95% CI: 2.3-3.7)" [28]. When evaluating ethnic differences in CVD risk factors in the present study, we found that the Mongolian were more likely to have lipid disorder and be overweight or obese than the Han. They also had higher fasting glucose than the Han. Such ethnic differences had been reported in previous studies [29 30]. A cross-sectional study conducted in Xinjiang concluded that Mongolian adults aged > 30 years tended to have higher TC, LDL-C, FBG and BMI than Han adults[18]. Compared to a similar study in Inner Mongolia in 2003 [31], the 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 [32].

In addition, we found that the proportions of 2 and ≥3 CVD risk factors clustering were higher in the pre-hypertension group than the optimal BP group in Han and Mongolian. This is consistent with the study conducted in Beijing, 2007 [33], which suggested that the CVD risk factor clustering was common among people with pre-hypertension. A cohort of 4.1 million adults conducted in U.K showed that 20 mm Hg higher SBP and 10 mm Hg higher diastolic BP were associated with a 58% and a 52% higher risk of new-onset diabetes[34]. Recent Korean epidemiology study also demonstrated that individuals with pre-hypertension (HR: 1.27, 95%CI: 1.09-1.48) and hypertension (HR: 1.51, 95%CI: 1.29-1.76) were at higher risk of diabetes than optimal ones [35]. Moreover, data on diagnosis time of hypertension and diabetes (n=76) in our study showed that 74.67% (57/76) hypertension diagnoses were made before diabetes. And participants with hypertension diagnosis were at higher risk of being diabetic than

those without diagnosis (OR=2.47, 95%CI: 1.69-3.61) after adjustment for age, gender, BMI and alcohol drinking. All the evidence indicated that hypertension developed before diabetes. The pre-hypertensive participants had higher levels of TC, LDL-C, and TG and lower levels of HDL-C than the optimal ones [36]. Overweight or obesity was more likely to occur prior to hypertension [37] [38]. Meanwhile, BMI was also an important risk factor for CVD [39]. The association between smoking and hypertension was a complex issue. Several studies concluded the smokers had lower prevalence of hypertension [40] while other studies suggested smoking was positively associated with hypertension [41]. Despite the contradictory results, smoking was still a well-known risk factor of CVD [42]. In all, body weight reduction, tobacco cession and BP control in pre-hypertension phase are important ways to prevent hypertension, diabetes, and dyslipidemia, thus lowering the risk of developing cardiovascular diseases.

Furthermore, our study showed a dose-response relationship between the number of CVD risk factors and pre-hypertension and hypertension in Han and Mongolian. Specifically, the ORs of pre-hypertension or hypertension increased as the number of CVD risk factors increased in the two populations. This was consistent with the results of a survey conducted in in Beijing, 2007 [33]. These findings suggested that pre-hypertension may result in CVD risk factor clustering. As a modifiable condition, pre-hypertension may be a useful target for intervention. When analysing ethnic differences in CVD risk factor clustering, we found that Mongolian with optimal BP had a higher proportion of one risk factor clustering than Han, and hypertensive Mongolian had a higher proportion of two risk factor clustering than hypertensive Han. This may be due to different culture, customs and food consumption patterns between the two ethnic groups. Traditionally, Mongolians are accustomed to high intake of animal fat and drink strong wine. A careful reanalysis of the participants' characteristics in our study demonstrated that Mongolian had a higher proportion of overweight or obesity (71.97% and 63.46% in hypertension, respectively) than Han and they tended to drink more alcohol (56.06% and 46.77% in hypertension, respectively). Differences in prevalence of CVD risk factors between Han and Mongolian imply a need to develop tailored prevention programs targeted toward ethnic groups, therefore reducing the prevalence of CVD risk factors in general population.

Another important finding was the age-standardized prevalence of 1, 2, and ≥3 CVD risk factor clustering in Mongolian and Han populations. About 90.22% Han males and 93.21% Mongolian males had at least one CVD risk factors, which was similar to the study conducted in Beijing in 2007 (91.3%) [43]. But the proportions of ≥3 CVD risk factors in Han and Mongolian males were 38.30% and 39.79%, respectively, which were higher than the results in the latter study (22.6%) [43]. Due to the sharp difference in smoking rate (73.55% in Han men *vs.* 3.12% in Han women,

67.51% in Mongolian men *vs.* 6.76% in Mongolian women), men had greatly higher prevalence of CVD risk factor clustering than women. The age-standardized prevalence of the clustering of ≥3 risk factors in Han females was significantly lower than that in Mongolian females. These findings indicated 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. The progression from hypertension to diabetes or dyslipidemia could not be precisely delineated. Fortunately, the diagnosis time of hypertension and diabetes in our study showed that mostly hypertension were diagnosed before diabetes, and individuals with hypertension diagnosis were at higher risk of diabetes than those without hypertension diagnosis. All of these implied a temporal relationship between hypertension and diabetes. Moreover, due to small sample sizes, the age-standardized prevalence of CVD risk factor clustering was not displayed by optimal, pre-hypertension and hypertension.

In summary, several common CVD risk factors and their clustering were prevalent in Han and Mongolian population in Northern China. The clustering of CVD risk factors in pre-hypertension phase suggested that prehypertension should be a key stage for early intervention of CVD. More strategies should also be taken, including screening for individuals with prehypertension and effective management of some other common CVD risk factors. The ethnic and 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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Authors' contributions

GL participated in the data collection and drafted the manuscript. GG, WW, HW, HG, YQ, GX, YL, BZ participated in the data collection. KW, FD, LP, GS participated in the design of the study and undertook statistical analyses. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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Competing interests

None declared.

Ethics approval

The study was approved by the Institutional Review Board of the Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences (NO.028-2013).

Provenance and peer review

Not commissioned; externally peer reviewed.

Data sharing statement

No additional data are available.

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Figure legends

Fig.1 Age-standardized prevalence of major cardiovascular disease risk factors in Han and Mongolian adults by gender (%).

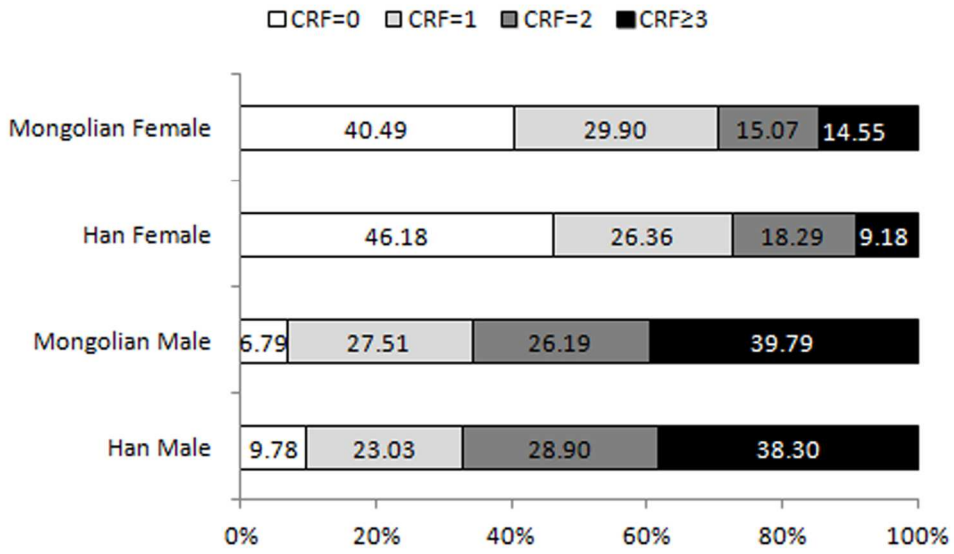

Fig.1 Age-standardized prevalence of major cardiovascular disease risk factors in Han and Mongolian adults by gender (%).

128x75mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-6
Bias	9	Describe any efforts to address potential sources of bias	4-6
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	4
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Results			Page No
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4
		(b) Give reasons for non-participation at each stage	4
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-8
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	*6-11*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	*6-11*
		(*b*) Report category boundaries when continuous variables were categorized	*6-11*
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	*6-11*
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	*6-11*
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	12-14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

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

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

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Keywords: Cardiovascular diseases; Risk factors; Clustering; Blood pressure; Ethnic groups

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ABSTRACT

Objectives: We aim 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 3,227 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 after adjusting for age, gender, and alcohol consumption. The differences between the ethnic groups were evaluated by multinomial logit analysis and stratified by risk factors.

Results: The clustering of 2 or ≥3 CVD risk factors in 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 1, 2, and ≥3 CVD risk factors versus no risk factors was 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 prehypertension or hypertension groups (P>0.05). The age-standardized 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% in Han women and 14.55% in Mongolian women, 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.
- These findings suggest that there was clustering of CVD risk factors in prehypertensive Han and Mongolian adults, and that prehypertension may be a useful target for intervention.
- 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-standardized 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 dyslipidemia 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 program aiming to evaluate the Physiological Constant and Health Condition in Chinese people. A sample of adults, ages 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.

Health survey / Measurements

Data on demographic information, smoking, alcohol drinking, and history of diseases were collected with standard questionnaires. 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 BIA (bioelectrical impendence analysis) with a commercially available body composition analyzer (BC-420, TANITA, Japan) when participants wore light clothes. Body mass index (BMI) was calculated as weight in kg divided by the square of height in meters. Sitting blood pressure was measured three times by trained research assistants following a standardized procedure using Omron digital blood pressure measuring device (Omron HEM-907, Japan). Blood samples were drawn after fasting overnight for at least 8 hours, and they 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 General Hospital of Chinese PLA.

Definitions

Blood pressure was divided into optimal BP, prehypertension, and hypertension. Optimal BP was defined as an average systolic blood pressure (SBP) <120 mmHg and diastolic blood pressure (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 World Health Organization criteria [25]. Diabetes was defined as fasting blood glucose (FPG) ≥7.0 mmol/L and/or a previous diagnosis of diabetes [26], and dyslipidemia 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 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 for categorical variables. Chi-square test or one-way analyses of variance were used to compare characteristics of optimal BP, prehypertensive and hypertensive participants in each ethnic group in Table 1. The Bonferroni test was used for multiple comparisons. Variables with a skewed distribution (e.g., triglyceride levels), were log-transformed and their 95% confidence intervals (CI) were reported.

A multinomial logit analysis was performed to evaluate the relationship between CVD risk factors (current smoking, BMI≥25 kg/m^2, dyslipidemia, diabetes) and prehypertension and hypertension in Table 2. Proportions of individuals with CVD risk factors clustering in optimal, prehypertensive and hypertensive groups were presented as percentage, and 95% CI and they were analyzed with chi-square partition (CSP) method in Table 3.

A multinomial logit analysis was performed to explore relationships of prehypertension and hypertension with 1, 2 and ≥3 risk factors clustering after adjustment for age, gender, and alcohol drinking in Han and Mongolian adults in Table 4. In the analysis, stratified by Han and Mongolian participants, optimal, 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. We also evaluated the differences between ethnic groups, stratified by risk factors, normal blood pressure, prehypertension, and hypertension, which served as three levels of dependent variables. Age, gender, and alcohol consumption were independent variables. The heterogeneity of associations between 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 standardization of CVD risk factors to National 2010 Census was conducted in 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).

RESULTS

In total, 3,464 participants were investigated. Of these, 58 participants were excluded for missing data, and 179 participants were excluded if their parents were not Mongolian or Han. Ultimately, a total of 3,227 individuals were included in analysis, including 2,308 (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 levels (1.39 *vs.* 1.32 mmol/L) (all P<0.05). The prevalence of prehypertension and hypertension was 28.77% and 27.51% in Han participants, and 25.24% and 31.45% in 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 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, 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, dyslipidemia, 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 Han participants, while the proportion of current smokers in the prehypertension group was higher than the optimal BP and hypertension groups in Mongolian participants (Bonferroni, all P<0.0167) (Table 1).

Table 1 Demographic characteristic of the study population among optimal, pre-hypertension and hypertension 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
Mean Age, yrs (mean ±sd)	39.10±12.08	45.92±13.43[a]	53.47±11.37[bc]	<0.0001	38.02±11.91	43.98±11.74[a]	53.59±11.16[bc]	<0.0001
Male, n (%)	249(24.68)	342(51.51)[a]	305(48.03)[b]	<0.0001	89(22.36)	123(53.02)[a]	145(50.17)[b]	<0.0001
BMI, kg/m^2 (mean± sd)	22.93±3.23	24.91±3.76[a]	26.46±3.64[bc]	<0.0001	23.19±3.38	25.43±3.64[a]	27.18±4.18[bc]	<0.0001
SBP, mmHg (mean± sd)	108.20±7.21	126.10±6.49[a]	140.90±15.02[bc]	<0.0001	107.50±7.98	125.20±6.33[a]	141.30±15.30[bc]	<0.0001
DBP, mmHg (mean± sd)	69.06±5.98	79.54±6.01[a]	88.07±10.31[bc]	<0.0001	68.62±6.24	79.61±5.38[a]	90.34±11.56[bc]	<0.0001
FPG, mmol/L (mean± sd)	5.09±1.12	5.34±1.04[a]	5.75±1.53[bc]	<0.0001	4.98±0.85	5.34±1.26[a]	5.73±1.56[bc]	<0.0001
TC, mmol/L (mean± sd)	4.57±0.98	4.92±0.98[a]	5.07±1.02[bc]	<0.0001	4.65±0.90	5.07±0.92[a]	5.37±1.04[bc]	<0.0001
TG, mmol/L (geometric mean, 95%CI)	1.23(1.19-1.27)	1.57(1.51-1.64)[a]	1.86(1.78-1.94)[bc]	<0.0001	1.08(1.03-1.13)	1.48(1.37-1.60)[a]	1.83(1.72-1.95)[bc]	<0.0001
LDL-C, mmol/L (mean± sd)	2.69±0.78	2.94±0.87[a]	3.00±0.91[b]	<0.0001	2.78±0.76	3.04±0.84[a]	3.32±0.93[bc]	<0.0001
HDL-C, mmol/L (mean± sd)	1.37±0.34	1.30±0.34[a]	1.25±0.34[b]	<0.0001	1.46±0.36	1.36±0.38[a]	1.31±0.35[b]	<0.0001
Current smoker, n (%)	174(17.24)	197(29.67)[a]	161(25.35)[b]	<0.0001	68(17.09)	71(30.60)[a]	60(20.76)[c]	0.0003
Alcohol Drinking, n (%)	335(33.20)	311(46.84)[a]	297(46.77)[b]	<0.0001	162(40.70)	138(59.48)[a]	162(56.06)[b]	<0.0001
Overweight or obesity, n (%)	254(25.17)	312(46.99)[a]	403(63.46)[bc]	<0.0001	119(29.90)	134(57.76)[a]	208(71.97)[bc]	<0.0001
dyslipidemia, n (%)	258(25.57)	273(41.11)[a]	317(49.92)[bc]	<0.0001	76(19.10)	87(37.50)[a]	153(52.94)[bc]	<0.0001
Diabetes, n (%)	26(2.58)	45(6.78)[a]	94(14.80)[bc]	<0.0001	5(1.26)	12(5.17)[a]	36(12.46)[bc]	<0.0001

Abbreviations: BP, blood pressure; BMI, body mass index; SBP, systolic ; DBP, diastolic blood pressure; FPG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein-cholesterol; HDL-C, high-density lipoprotein-cholesterol. The data are expressed as the mean± sd., n (%) or geometric mean (95% confidence interval).
a: denotes statistical significance between Optimal and Pre-hypertension (The bonferroni method was used for multiple comparisons);
b: denotes statistical significance between Optimal and Hypertension (The bonferroni method was used for multiple comparisons);
c: denotes statistical significance between Pre-hypertension and Hypertension (The bonferroni method was used for multiple comparisons).

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 Mongolian and Han adults (OR 2.13, 95% CI 1.70-2.67 for prehypertensive Han; OR 3.82, 95% CI 3.00-4.88 for hypertensive Han; OR 2.15, 95% CI 1.49-3.12 for prehypertensive Mongolian participants, OR 3.09, 95% CI 2.07-4.60 for hypertensive Mongolian participants, all P<0.05). Dyslipidemia was significantly associated with an increased risk of prehypertension and hypertension as well in Mongolian participants, but was only associated with hypertension in Han participants (P<0.05). In Han participants, those with diabetes experienced an increased risk of hypertension (P<0.05). In Mongolian participants, current smoking was significantly associated with a decreased risk of hypertension (P<0.05) (Table 2).

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(0.57-1.09)	0.70(0.49-1.01)	0.76(0.45-1.27)	**0.54(0.31-0.93) ***
Overweight/obesity (yes vs. no)	**2.13(1.70-2.67) ***	**3.82(3.00-4.88) ***	**2.15(1.49-3.12) ***	**3.09(2.07-4.60) ***
Dyslipidemia (yes vs. no)	1.15(0.91-1.46)	**1.37(1.07-1.76) ***	**1.53(1.02-2.30) ***	**2.58(1.71-3.91) ***
Diabetes (yes vs. no)	1.44(0.86-2.42)	**2.36(1.45-3.85) ***	1.56(0.52-4.71)	2.41(0.87-6.71)

Adjusted for age, gender, and alcohol drinking in multivariate logistic regression model . * Compared to optimal BP: P<0.05; CVD risk factors were included in models with an enter method.

Overall, the proportion of participants with no CVD risk factors was 35.10% in Han participants and 31.56% in 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 2 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 2 CVD risk factor clustering than prehypertensive participants (Bonferroni, all P<0.0167). There was no statistically significant difference between prehypertension and hypertension in Mongolian participants with ≥3 CVD risk factors. The proportions of 1 CVD risk factor clustering in the optimal BP group (P=0.0045) and 2 CVD risk factors clustering in the hypertension group (P=0.0236) were higher in Mongolian adults than in Han adults.

Table 3 Comparisons of proportions (%) of different risk factors clustering among optimal BP, pre-hypertension and hypertension in Han and Mongolian

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

*: Compared with optimal BP P<0.0167; +: Compared with pre-hypertension P<0.0167; a: Compared with Mongolian P<0.05 in optimal BP; b: Compared with Mongolian P<0.05 in prehypertension; c: Compared with Mongolian P<0.05 in hypertension;

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 1, 2, and ≥3 CVD risk factors were 1.95, 2.25, and 2.28 for Han participants, and 1.73, 2.83, and 3.69 for Mongolian participants, respectively (all P<0.05). The adjusted ORs of hypertension among 1, 2, and ≥3 CVD risk factors were 3.15, 4.75, and 6.49 for Han participants, and 1.90, 5.29, and 8.13 for Mongolian participants, respectively (all P<0.05). In the prehypertension group, there was no significant heterogeneity between Han and Mongolian participants, and there was no heterogeneity in the hypertension group (both P>0.05).

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

No.of risk factors clustering	Pre-hypertension		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(1.51-2.52)	**<0.0001**	3.15(2.32-4.28)	**<0.0001**
2(n=509)	2.25(1.65-3.06)	**<0.0001**	4.75(3.38-6.69)	**<0.0001**
≥3(n=242)	2.28(1.48-3.52)	**0.0002**	6.49(4.11-10.24)	**<0.0001**
P for trend	**<0.0001**		**<0.0001**	
Mongolian				
0(n=290)	1.00(ref)		1.00(ref)	
1(n=322)	1.73(1.12-2.68)	**0.014**	1.90(1.15-3.12)	**0.0119**
2(n=220)	2.83(1.64-4.88)	**0.0002**	5.29(3.02-9.26)	**<0.0001**
≥3(n=87)	3.69(1.69-8.08)	**0.0011**	8.13(3.59-18.41)	**<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.

As hypertension was 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 1, 2, and ≥3 CVD risk factors were 23.03%, 28.90%, and 38.30% in Han participants, and 27.51%, 26.19%, and 39.79% in Mongolian participants, respectively. In women, the prevalences of 1, 2, and ≥3 CVD risk factors were 26.36%, 18.29%, and 9.18% in Han participants, and 29.90%, 15.07%, and 14.55% in Mongolian participants, respectively. With respect to gender, men tended to have a higher prevalence of either 2 or ≥3 CVD risk factor clustering than women (P<0.05). The age-standardized prevalence of ≥3 risk factor clustering was significantly lower in Han women than Mongolian women (P=0.002) (Fig. 1).

DISCUSSION

Our study found that participants with prehypertension had higher levels of CVD risk factors like BMI, 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 blood pressure, and that prehypertension is an important intermediate phase before hypertension. A cohort study conducted in Brazil showed that four in five individuals with prehypertension, ages 40 to 49 years old, would be fully hypertensive within 10 years [29]. Winegarden CR 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: 1.6-2.6), and for "high normal" values (SBP, 130-139 mmHg or DBP, 85-89 mmHg) was 2.9 (95% CI: 2.3-3.7) [30]. In addition, the proportions of 2 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 factors 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 United Kingdom 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: 1.09–1.48) and hypertension (HR: 1.51, 95% CI: 1.29–1.76) had a higher risk of developing diabetes than those with optimal blood pressure [33]. A careful reanalysis of diagnosis times for hypertension and diabetes (n=76) in our study showed that 74.67% (57/76) of hypertension diagnoses were made prior to diabetes diagnoses. Moreover, participants with hypertension diagnoses had a higher risk of developing diabetes than those without a hypertension diagnosis (OR=2.47, 95% CI: 1.69–3.61) after adjustment for age, gender, BMI, and alcohol consumption. 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 blood pressure 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 JNC 7 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 dyslipidemia 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 dyslipidemia, thus lowering their risk of developing CVD.

When evaluating ethnic differences in CVD risk factors, we found that Mongolian participants were more likely to have a lipid disorder and be overweight or obese than 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 analyzing ethnic differences in CVD risk factor clustering, we found that Mongolian participants with optimal BP had a higher proportion of 1 risk factor clustering than Han participants, and hypertensive Mongolian participants had a higher proportion of 2 risk factors 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 reanalysis of the participants' characteristics in our study demonstrated that Mongolian participants had a higher proportion of overweight or obese participants (71.97% and 63.46% in hypertension, respectively) than 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 programs targeting ethnic groups, and therefore reducing the prevalence of CVD risk factors in the general population.

Another important finding was the age-standardized prevalence of 1, 2, and ≥3 CVD risk factor clustering in Mongolian and Han populations. About 90.22% Han men and 93.21% 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-standardized 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-standardized prevalence of CVD risk factor clustering was not displayed by optimal, prehypertension, and hypertension groupings.

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 suggest 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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Authors' contributions

GL participated in the data collection and drafted the manuscript. GG, WW, HW, HG, YQ, GX, YL, BZ participated in the data collection. KW, FD, LP, GS participated in the design of the study and undertook statistical analyses. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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Competing interests

None declared.

Ethics approval

The study was approved by the Institutional Review Board of the Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences (NO.028-2013).

Provenance and peer review

Not commissioned; externally peer reviewed.

Data sharing statement

No additional data are available.

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Figure legends

Fig.1 Age-standardized prevalence of major cardiovascular disease risk factors in Han and Mongolian adults by gender (%).

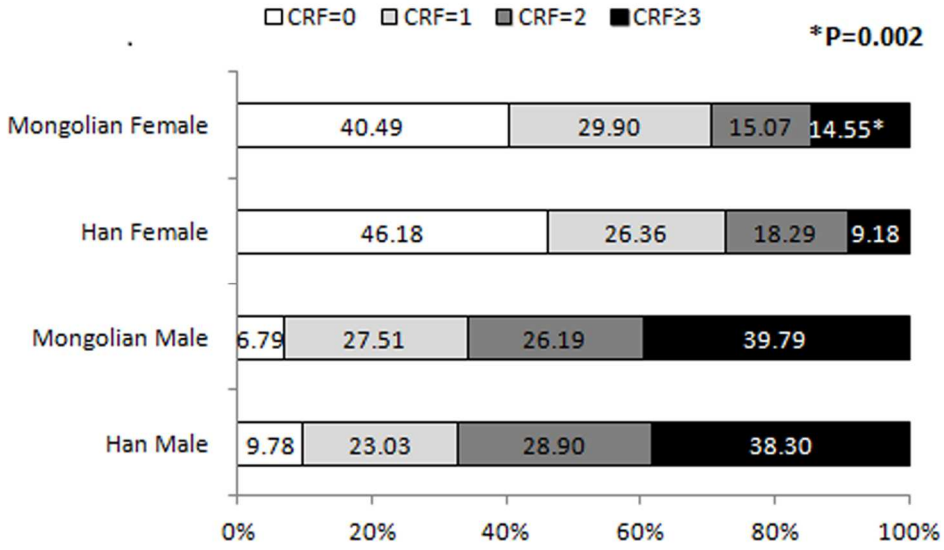

Fig.1 Age-standardized prevalence of major cardiovascular disease risk factors in Han and Mongolian adults by gender (%).

129x76mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-6
Bias	9	Describe any efforts to address potential sources of bias	4-6
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	4-5
		(*c*) Explain how missing data were addressed	6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Results			Page No
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	*6-10*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	*6-10*
		(*b*) Report category boundaries when continuous variables were categorized	*6-10*
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	*6-10*
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	*6-10*
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	11-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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

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Secondary Subject Heading:	Cardiovascular medicine, Public health
Keywords:	Cardiovascular diseases, Risk factors, Clustering, Blood pressure, Ethnic groups

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

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Keywords: Cardiovascular diseases; Risk factors; Clustering; Blood pressure; Ethnic groups

Running Title: Blood pressure status and cardiovascular risk factors clustering

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ABSTRACT

Objectives: We aim 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 3,227 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 Cochran Q test. The differences between the ethnic groups in the proportions of risk factors was test with χ^2 test.

Results: The clustering of 2 or ≥3 CVD risk factors in 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 1, 2, and ≥3 CVD risk factors versus no risk factors was 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 prehypertension or hypertension groups. The age-standardized 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 the people who trained interviewers checks on responses of 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-standardized 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 dyslipidemia 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 program aiming to evaluate the Physiological Constant and Health Condition in Chinese people. A sample of adults, ages 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, 3,464 participants were investigated. Of these, 58 participants were excluded for missing data, and 179 participants were excluded if their parents were not Mongolian or Han. Ultimately, a total of 3,227 individuals were included in analysis, including 2,308 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 the people who trained interviewers checks on responses of 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 BIA (bioelectrical impendence analysis) with a commercially available body composition analyzer (BC-420, TANITA, Japan) when participants wore light clothes. Body mass index (BMI) was calculated as weight in kg divided by the square of height in meters. Sitting blood pressure was measured three times by trained research assistants following a standardized procedure using Omron digital blood pressure measuring device (Omron HEM-907, Japan). Blood samples were drawn after fasting overnight for at least 8 hours, and they 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 General Hospital of Chinese People's Liberation Army (PLA).

Definitions

Blood pressure was divided into optimal BP, prehypertension, and hypertension. Optimal BP was defined as an average systolic blood pressure (SBP) <120 mmHg and diastolic blood pressure (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 World Health Organization criteria [25]. Diabetes was defined as fasting blood glucose (FPG) ≥7.0 mmol/L and/or a previous diagnosis of diabetes [26], and dyslipidemia 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 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% confidence intervals (CI). Chi-square test or one-way analyses of variance were used to compare characteristics of optimal BP, prehypertensive and hypertensive participants in each ethnic group in Table 1. The Bonferroni test was used for multiple comparisons. Variables with a skewed distribution (e.g., triglyceride 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 smoking, BMI≥25 kg/m^2, dyslipidemia, diabetes) and prehypertension and hypertension in Table 2. Proportions of individuals with CVD risk factors clustering in optimal, prehypertensive and hypertensive groups were presented as percentage, and 95% CI and they were analyzed with chi-square partition (CSP) method, the differences between the ethnic groups in the proportions of risk factors was test with χ^2 test in Table 3.

A multinomial logit analysis was performed to explore relationships of prehypertension and hypertension with 1, 2 and ≥3 risk factors clustering after adjustment for age, gender, and alcohol drinking in Han and Mongolian adults in Table 4. In the analysis, stratified by Han and Mongolian participants, optimal, 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 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 standardization of CVD risk factors to National 2010 Census was conducted in 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).

RESULTS

A total of 3,227 individuals were included in analysis, including 2,308 (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 levels (1.39 *vs.* 1.32 mmol/L) (all $P<0.05$). The prevalence of prehypertension and hypertension was 28.77% and 27.51% in Han participants, and 25.24% and 31.45% in 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 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, 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, dyslipidemia, 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 Han participants, while the proportion of current smokers in the prehypertension group was higher than the optimal BP and hypertension groups in Mongolian participants (Bonferroni, all $P<0.0167$) (Table 1).

Table 1 Demographic characteristic of the study population among optimal, pre-hypertension and hypertension 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
Mean Age, yrs (mean ±sd)	39.10±12.08	45.92±13.43[a]	53.47±11.37[bc]	<0.0001	38.02±11.91	43.98±11.74[a]	53.59±11.16[bc]	<0.0001
Male %(95%CI)	24.68(22.02-27.34)	51.51 (47.70-55.31)[a]	48.03 (44.15-51.92)[b]	<0.0001	22.36(18.27-26.46)	53.02 (46.60-59.44)[a]	50.17 (44.41-55.94)[b]	<0.0001
BMI, kg/m^2 (mean± sd)	22.93±3.23	24.91±3.76[a]	26.46±3.64[bc]	<0.0001	23.19±3.38	25.43±3.64[a]	27.18±4.18[bc]	<0.0001
SBP, mmHg (mean± sd)	108.20±7.21	126.10±6.49[a]	140.90±15.02[bc]	<0.0001	107.50±7.98	125.20±6.33[a]	141.30±15.30[bc]	<0.0001
DBP, mmHg (mean± sd)	69.06±5.98	79.54±6.01[a]	88.07±10.31[bc]	<0.0001	68.62±6.24	79.61±5.38[a]	90.34±11.56[bc]	<0.0001
FPG, mmol/L (mean± sd)	5.09±1.12	5.34±1.04[a]	5.75±1.53[bc]	<0.0001	4.98±0.85	5.34±1.26[a]	5.73±1.56[bc]	<0.0001
TC, mmol/L (mean± sd)	4.57±0.98	4.92±0.98[a]	5.07±1.02[bc]	<0.0001	4.65±0.90	5.07±0.92[a]	5.37±1.04[bc]	<0.0001
TG, mmol/L (geometric mean, 95%CI)	1.23(1.19-1.27)	1.57(1.51-1.64)[a]	1.86(1.78-1.94)[bc]	<0.0001	1.08(1.03-1.13)	1.48(1.37-1.60)[a]	1.83(1.72-1.95)[bc]	<0.0001
LDL-C, mmol/L (mean± sd)	2.69±0.78	2.94±0.87[a]	3.00±0.91[b]	<0.0001	2.78±0.76	3.04±0.84[a]	3.32±0.93[bc]	<0.0001
HDL-C, mmol/L (mean± sd)	1.37±0.34	1.30±0.34[a]	1.25±0.34[b]	<0.0001	1.46±0.36	1.36±0.38[a]	1.31±0.35[b]	<0.0001
Current smoker %(95%CI)	17.24 (14.91-19.58)	29.67 (26.19-33.14)[a]	25.35 (21.97-28.74)[b]	<0.0001	17.09 (13.39-20.78)	30.60 (24.67-36.53)[a]	20.76 (16.09-25.44)[c]	0.0003
Alcohol Drinking %(95%CI)	33.20 (30.30-36.11)	46.84 (43.04-50.63)[a]	46.77 (42.89-50.65)[b]	<0.0001	40.70 (35.88-45.53)	59.48 (53.17-65.80)[a]	56.06 (50.33-61.78)[b]	<0.0001
Overweight or obesity %(95%CI)	25.17 (22.50-27.85)	46.99 (43.19-50.78)[a]	63.46 (59.72-67.21)[bc]	<0.0001	29.90 (25.40-34.40)	57.76 (51.40-64.11)[a]	71.97 (66.79-77.15)[bc]	<0.0001
Dyslipidemia %(95%CI)	25.57 (22.88-28.26)	41.11 (37.37-44.86)[a]	49.92 (46.03-53.81)[bc]	<0.0001	19.10 (15.23-22.96)	37.50 (31.27-43.73)[a]	52.94 (47.19-58.70)[bc]	<0.0001
Diabetes %(95%CI)	2.58 (1.60-3.55)	6.78 (4.87-8.69)[a]	14.80 (12.04-17.57)[bc]	<0.0001	1.26 (0.16-2.35)	5.17 (2.32-8.02)[a]	12.46 (8.65-16.26)[bc]	<0.0001

Abbreviations: BP, blood pressure; BMI, body mass index; SBP, systolic ; DBP, diastolic blood pressure; FPG, fasting blood glucose; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein-cholesterol; HDL-C, high-density lipoprotein-cholesterol. The data are expressed as the mean± sd., % (95%CI)or geometric mean (95% confidence interval).
a: denotes statistical significance between Optimal and Pre-hypertension (The bonferroni method was used for multiple comparisons);
b: denotes statistical significance between Optimal and Hypertension (The bonferroni method was used for multiple comparisons);
c: denotes statistical significance between Pre-hypertension and Hypertension (The bonferroni method was used for multiple comparisons).

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 Mongolian and Han adults (OR 2.13, 95% CI 1.70-2.67 for prehypertensive Han; OR 3.82, 95% CI 3.00-4.88 for hypertensive Han; OR 2.15, 95% CI 1.49-3.12 for prehypertensive Mongolian participants, OR 3.09, 95% CI 2.07-4.60 for hypertensive Mongolian participants, all P<0.05). Dyslipidemia was significantly associated with an increased risk of prehypertension and hypertension as well in Mongolian participants, but was only associated with hypertension in Han participants (P<0.05). In Han participants, those with diabetes experienced an increased risk of hypertension (P<0.05). In Mongolian participants, current smoking was significantly associated with a decreased risk of hypertension (P<0.05) (Table 2).

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(0.57-1.09)	0.70(0.49-1.01)	0.76(0.45-1.27)	**0.54(0.31-0.93) ***
Overweight/obesity (yes vs. no)	**2.13(1.70-2.67) ***	**3.82(3.00-4.88) ***	**2.15(1.49-3.12) ***	**3.09(2.07-4.60) ***
Dyslipidemia (yes vs. no)	1.15(0.91-1.46)	**1.37(1.07-1.76) ***	**1.53(1.02-2.30) ***	**2.58(1.71-3.91) ***
Diabetes (yes vs. no)	1.44(0.86-2.42)	**2.36(1.45-3.85) ***	1.56(0.52-4.71)	2.41(0.87-6.71)

Adjusted for age, gender, and alcohol drinking in multivariate logistic regression model . * Compared to optimal BP: P<0.05; CVD risk factors were included in models with an enter method.

Overall, the proportion of participants with no CVD risk factors was 35.10% in Han participants and 31.56% in 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 2 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 2 CVD risk factor clustering than prehypertensive participants (Bonferroni, all P<0.0167). There was no statistically significant difference between prehypertension and hypertension in Mongolian participants with ≥3 CVD risk factors. The proportions of 1 CVD risk factor clustering in the optimal BP group (P=0.0045) and 2 CVD risk factors clustering in the hypertension group (P=0.0236) were higher in Mongolian adults than in Han adults.

Table 3 Comparisons of proportions (%) of different risk factors clustering among optimal BP, pre-hypertension and hypertension in Han and Mongolian

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

*: Compared with optimal BP P<0.0167; +: Compared with pre-hypertension P<0.0167; a: Compared with Mongolian P<0.05 in optimal BP; b: Compared with Mongolian P<0.05 in prehypertension; c: Compared with Mongolian P<0.05 in hypertension;

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 1, 2, and ≥3 CVD risk factors were 1.95, 2.25, and 2.28 for Han participants, and 1.73, 2.83, and 3.69 for Mongolian participants, respectively (all P<0.05). The adjusted ORs of hypertension among 1, 2, and ≥3 CVD risk factors were 3.15, 4.75, and 6.49 for Han participants, and 1.90, 5.29, and 8.13 for Mongolian participants, respectively (all P<0.05). In the prehypertension group, there was no significant heterogeneity between Han and Mongolian participants, and there was no heterogeneity in the hypertension group (both P>0.05).

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

No.of risk factors clustering	Pre-hypertension		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(1.51-2.52)	**<0.0001**	3.15(2.32-4.28)	**<0.0001**
2(n=509)	2.25(1.65-3.06)	**<0.0001**	4.75(3.38-6.69)	**<0.0001**
≥3(n=242)	2.28(1.48-3.52)	**0.0002**	6.49(4.11-10.24)	**<0.0001**
P for trend	**<0.0001**		**<0.0001**	
Mongolian				
0(n=290)	1.00(ref)		1.00(ref)	
1(n=322)	1.73(1.12-2.68)	**0.014**	1.90(1.15-3.12)	**0.0119**
2(n=220)	2.83(1.64-4.88)	**0.0002**	5.29(3.02-9.26)	**<0.0001**
≥3(n=87)	3.69(1.69-8.08)	**0.0011**	8.13(3.59-18.41)	**<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.

As hypertension was 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 1, 2, and ≥3 CVD risk factors were 23.03%, 28.90%, and 38.30% in Han participants, and 27.51%, 26.19%, and 39.79% in Mongolian participants, respectively. In women, the prevalences of 1, 2, and ≥3 CVD risk factors were 26.36%, 18.29%, and 9.18% in Han participants, and 29.90%, 15.07%, and 14.55% in Mongolian participants, respectively. With respect to gender, men tended to have a higher prevalence of either 2 or ≥3 CVD risk factor clustering than women (P<0.05). The age-standardized prevalence of ≥3 risk factor clustering was significantly lower in Han women than Mongolian women (P=0.002) (Fig. 1).

DISCUSSION

Our study found that participants with prehypertension had higher levels of CVD risk factors like BMI, 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 blood pressure, and that prehypertension is an important intermediate phase before hypertension. A cohort study conducted in Brazil showed that four in five individuals with prehypertension, ages 40 to 49 years old, would be fully hypertensive within 10 years [29]. Winegarden CR 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: 1.6-2.6), and for "high normal" values (SBP, 130-139 mmHg or DBP, 85-89 mmHg) was 2.9 (95% CI: 2.3-3.7) [30]. In addition, the proportions of 2 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 factors 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 United Kingdom 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: 1.09–1.48) and hypertension (HR: 1.51, 95% CI: 1.29–1.76) had a higher risk of developing diabetes than those with optimal blood pressure [33]. A careful reanalysis of diagnosis times for hypertension and diabetes (n=76) in our study showed that 74.67% (57/76) of hypertension diagnoses were made prior to 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 blood pressure 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 JNC 7 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 dyslipidemia 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 dyslipidemia, thus lowering their risk of developing CVD.

When evaluating ethnic differences in CVD risk factors, we found that Mongolian participants were more likely to have a lipid disorder and be overweight or obese than 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 analyzing ethnic differences in CVD risk factor clustering, we found that Mongolian participants with optimal BP had a higher proportion of 1 risk factor clustering than Han participants, and hypertensive Mongolian participants had a higher proportion of 2 risk factors 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 reanalysis of the participants' characteristics in our study demonstrated that Mongolian participants had a higher proportion of overweight or obese participants (71.97% and 63.46% in hypertension, respectively) than 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 programs targeting ethnic groups, and therefore reducing the prevalence of CVD risk factors in the general population. Another important finding was the age-standardized prevalence of 1, 2, and ≥3 CVD risk factor clustering in Mongolian and Han populations. About 90.22% Han men and 93.21% 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-standardized 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-standardized prevalence of CVD risk factor clustering was not displayed by optimal, prehypertension, and hypertension groupings. Finally, this study was conducted only in Inner Mongolia, so the study's findings can not 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 suggest 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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Authors' contributions

GL participated in the data collection and drafted the manuscript. GG, WW, HW, HG, YQ, GX, YL, BZ participated in the data collection. KW, FD, LP, GS participated in the design of the study and undertook statistical analyses. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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Competing interests

None declared.

Ethics approval

The study was approved by the Institutional Review Board of the Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences (NO.028-2013).

Provenance and peer review

Not commissioned; externally peer reviewed.

Data sharing statement

No additional data are available.

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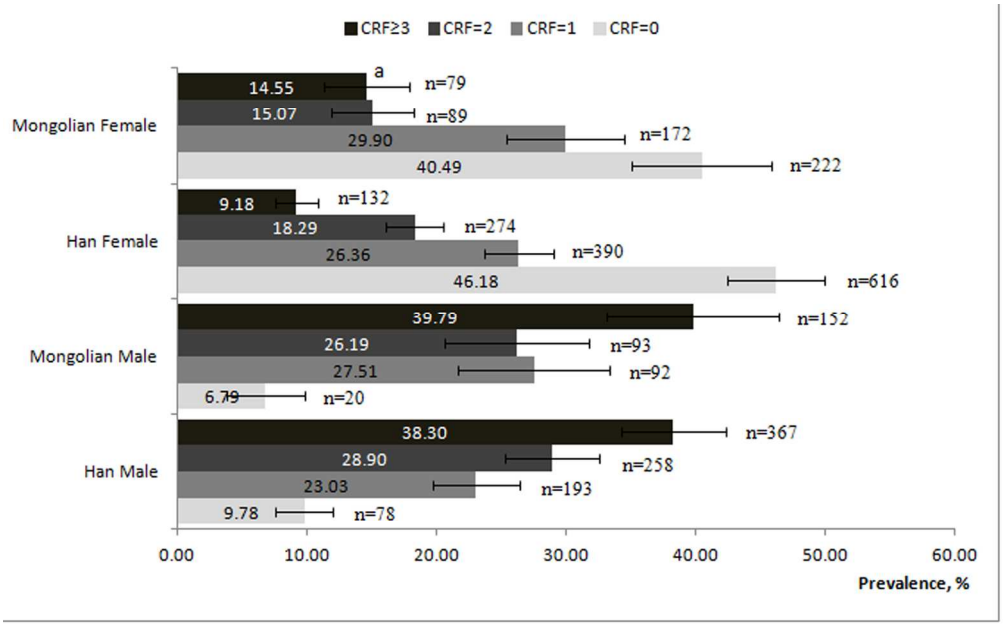
Figure legends

Fig.1 Age-standardized prevalence of major cardiovascular disease risk factors in Han and Mongolian adults by gender (%).

a. The difference in the age-standardized prevalence of ≥3 risk factor clustering between Han women and Mongolian women (P=0.002).



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179x111mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	4
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	

Results			Page No
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-7
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	*7*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	*8-10*
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.