Public Health Nutrition: 23(9), 1543–1554 doi:10.1017/S136898001900301X

Diet quality is associated with reduced risk of hypertension among Inner Mongolia adults in northern China

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Submitted 25 February 2019: Final revision received 6 June 2019: Accepted 2 July 2019; First published online 5 November 2019

Abstract

Objective: The present study investigated the association between dietary patterns and hypertension applying the Chinese Dietary Balance Index-07 (DBI-07).
Design: A cross-sectional study on adult nutrition and chronic disease in Inner Mongolia. Dietary data were collected using 24 h recall over three consecutive days and weighing method. Dietary patterns were identified using principal components analysis. Generalized linear models and multivariate logistic regression models were used to examine the associations between DBI-07 and dietary patterns, and between dietary patterns and hypertension.
Setting: Inner Mongolia (*n* 1861).
Participants: A representative sample of adults aged ≥18 years in Inner Mongolia.
Results: Four major dietary patterns were identified: 'high protein', 'traditional northern', 'modern' and 'condiments'. Generalized linear models showed higher factor scores in the 'high protein' pattern were associated with lower DBI-07 (βLBS = −1·993, βHBS = −0·206, βDQD = −2·199; all $P < 0·001$); the opposite in the 'condiments' pattern (βLBS = 0·967, βHBS = 0·751, βDQD = 1·718; all $P < 0·001$). OR for hypertension in the highest quartile of the 'high protein' pattern compared with the lowest was 0·374 (95 % CI 0·244, 0·573; $P_{trend} < 0·001$) in males. OR for hypertension in the 'condiments' pattern was 1·663 (95 % CI 1·113, 2·483; $P_{trend} < 0·001$) in males, 1·788 (95 % CI 1·155, 2·766; $P_{trend} < 0·001$) in females.
Conclusions: Our findings suggested a higher-quality dietary pattern evaluated by DBI-07 was related to decreased risk for hypertension, whereas a lower-quality dietary pattern was related to increased risk for hypertension in Inner Mongolia.

Keywords
Hypertension
Principal components analysis
Dietary patterns
Dietary quality
Chinese Diet Balance Index-07

Hypertension is a global public health issue. The total number of adults with hypertension reached 1·13 billion worldwide in 2015, up from 0·594 billion in 1975, and low- and middle-income countries contributed most to this increase[1]. The hypertension prevalence rate in China is increasing. A survey by Wang *et al.* in 2014 showed that the national adjusted hypertension prevalence rate was 29·6 %[2], which was higher than that in 2002 (18 %)[3]. Hypertension is an independent disease and an important risk factor for cardiovascular and cerebrovascular diseases. An investigation by the WHO on causes of death showed that about 17 million people die of CVD each year (which constitute about one-third of the total deaths); of all the cardiovascular causes of death, 47 % comprised heart disease and 54 % comprised stroke owing to hypertension[4,5].

Dietary factors are closely related to the development of hypertension. A diet containing vegetables, fruits and low amounts of salt and fat helps to prevent or reduce hypertension. Excessive Na consumption is a risk factor for hypertension. Researchers are paying increasing attention to the

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association between dietary patterns and disease. The Mediterranean dietary pattern can lower hypertension[6] and chronic heart failure[7]. The Western dietary pattern is significantly associated with increased risk of maturity-onset CHD and stroke. Among different dietary patterns, the Dietary Approaches to Stop Hypertension (DASH) dietary pattern is generally recognized as an effective way to prevent and control hypertension. However, the DASH diet is not wholly appropriate for China, as it features fruits, vegetables, whole grains, other mineral-rich foods, low saturated fat consumption and low Na consumption[8]. The traditional dietary pattern in China[9], particularly in northern China, is characterized by high consumption of wheat and starch and low consumption of protein products such as pork, beef, poultry, aquatic products and dairy products. This diet is very different from the DASH dietary pattern. In addition, the DASH dietary pattern focuses only on the effect of specific foods and nutrients on hypertension and does not consider the effect of overall dietary quality.

Located in northern China, Inner Mongolia is a minority community containing forty-nine ethnic groups, including the Han nationality and the Mongol nationality. Different ethnic groups have different genetic characteristics and food culture. Inner Mongolia has high prevalence rates for metabolic diseases related to nutrition, such as hypertension[10]. To address the relationship between diet and hypertension in Inner Mongolia, the association between dietary patterns and the prevalent risks of hypertension was explored in the present study. Chinese Dietary Balance Index-07 (DBI-07) scores were used to evaluate the quality of the main dietary patterns.

Methods

Study design

The present study was a surveillance survey of chronic disease and nutrition in Chinese adults in Inner Mongolia in 2015. The survey was conducted across eight monitoring sites in Inner Mongolia. Participants comprised residents of urban, farming, pastoral and forest areas, and from different age and ethnic groups. The cross-sectional study investigated dietary and non-dietary factors: general demographics, lifestyle, hypertension prevalence rate, dietary behavioural habits and daily food intake, by multistage-stratified cluster-random sampling among those aged ≥18 years.

The survey was approved by the Ethical Committee of the National Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention. All participants provided written informed consent before the start of the investigation.

Dietary data collection

A 24 h recall and weighing method over three consecutive days was used to collect dietary data. This dietary survey was recommended by the Chinese Dietary Guidelines for chronic disease and nutrition surveillance in Chinese adults, and aimed to know about the residents' intakes of nutrients and foods. Every household member (aged 2 years or over) was investigated. In the 24 h recalls, participants recalled and described all food and alcohol consumption for three consecutive days. Information about consumption of condiments such as salt and soya sauce, and cooking oil, was collected using a weighing method. Condiments purchased and wasted were also recorded.

Drinking frequency, type (liquor with high alcohol content, liquor with low alcohol content, beer, yellow rice wine, rice wine, wine) and average drinking amount were measured. The average daily alcohol consumption was calculated according to the Manual of Chinese Chronic Disease and Nutrition Surveillance Survey[11]. Participant height and weight were directly measured by trained and evaluated workers. Blood and urine samples were also collected. The laboratory director organized the quality-control sample assessment at a field laboratory.

Chinese Dietary Balance Index-07

The Chinese DBI-07 is a method for evaluating dietary structure and quality based on the Chinese Dietary Guidelines, which consists of seven components: (i) cereals; (ii) vegetables and fruits; (iii) dairy products, soyabeans and soyabean products; (iv) animal foods; (v) condiments and alcohol; (vi) dietary variety; and (vii) drinking-water[12,13]. The DBI-07 evaluation of intake quality for different foods is based on the consumption patterns of individuals with different energy intakes. A score of 0 for each component indicates that the recommended intake has been met. Positive scores (0 to 12) are used to evaluate excessive intake of alcoholic beverages and condiments that should be reduced or limited according to the guidelines. Negative scores (−12 to 0) are used to evaluate insufficient intakes of vegetables and fruits, dairy products, soyabeans and soyabean products, food variety and drinking-water that should be consumed sufficiently or in quantity according to the guidelines. Both positive and negative scores are used to evaluate intake of cereals (−12 to 12) and animal foods (−12 to 8), which should be consumed in appropriate amounts according to the guidelines. To reflect the different nutritional needs of people with different energy consumption, the scores for cereals, vegetables, fruit, dairy products, soyabeans and soyabean products, animal foods and condiments are based on seven energy intake levels. Twelve food subgroups are used to evaluate the food variety recorded by the DBI-07: (i) rice and rice products; (ii) wheat and wheat products; (iii) corns, coarse grains, starchy roots and their products; (iv) dark-coloured vegetables; (v) light-coloured vegetables; (vi) fruits; (vii) soyabeans and soyabean products; (viii) dairy products; (ix) livestock meat and meat products; (x) poultry; (xi) eggs; and (xii) fish and shellfish. If food intake amounts meet the lowest recommended amounts, the

Public Health Nutrition

score for this subgroup is 0; if not, −1. The lowest recommended intake amounts are 5 g for soyabeans and soyabean products and 25 g for other food subgroups. The score for food variety ranges from −12 to 0. An indicator of dietary quality is calculated from the scores on different parts of the DBI-07.

The higher-bound score (HBS) is calculated by adding all positive scores as an indicator of excessive food intake. The lower-bound score (LBS) is calculated by adding the absolute values of all negative scores as an indicator of insufficient food intake. Diet quality distance (DQD) is calculated by adding the absolute values of both positive and negative scores. The possible ranges for total score, HBS, LBS and DQD scores are −72 to 44, 0 to 32, 0 to 72 and 0 to 84, respectively. Each indicator is divided into five levels for convenience: (i) 'no problem' (a score of 0); (ii) 'almost no problem' (less than 20 % of the total score); (iii) 'low level' (20–40 % of the total score); (iv) 'moderate level' (40–60 % of the total score); and (v) 'high level' (>60 % of the total score). The total score of each DBI-07 component is divided by the total score of LBS, HBS and DQD to assess their contribution rate and how much each food subgroup affects dietary quality (see online supplementary material, Supplemental Table S1).

Definition of hypertension

The main outcome indicator was hypertension. Meeting one of the following conditions was considered to indicate hypertension. The first condition was self-reported hypertension; that is, having a diagnosis of hypertension and currently receiving hypertension treatment[14]. The second condition was field-measured hypertension, assessed as the average of three blood pressure measurements carried out by trained investigators and defined as average systolic blood pressure ≥140 mmHg and/or average diastolic blood pressure ≥90 mmHg.

Other variables

Age was categorized as follows: <35, 35–44, 45–54, 55–64 and ≥65 years. Participant household registration place was categorized as urban or rural. Based on regional characteristics, ethnicity groups were categorized as Han, Mongolian or other minorities (i.e. all minorities living in Inner Mongolia except Han and Mongolian). Educational level was categorized as low (primary school or lower), medium (junior high school) or high (senior high school and above). Marital status was categorized as married, unmarried or widowed/divorced.

Smoking status was categorized as non-smoker (never having smoked previously), ex-smoker (previously smoked but has quit) or current smoker (has smoked at least 1 cigarette/d for more than 1 year and smokes now).

Physical activity was assessed by the questionnaire, which addressed three activity categories with twenty-six items: twenty items on physical activity state, four items on resting state and two items on sleeping state. The items asked participants what kind of activities they engaged in, the frequency of activities per week and the total time spent on activities per day. Physical activities were scored using the weighting procedure recommended by the Physical Activity Guidelines for Americans[15].

BMI was categorized as three groups according to the recommended standard issued by a working group on obesity in China[16]. BMI was categorized as normal or underweight (BMI < 23·9 kg/m^2), overweight (BMI = 24·0–27·9 kg/m^2) or obese (BMI ≥ 28·0 kg/m^2). The normal and underweight categories were combined into one as there were too few people in the standard underweight category.

Statistical analysis

Continuous variables were shown as means and standard deviations. ANOVA was used for group comparisons. Categorical variables were expressed as numbers and percentages and were analysed using the χ^2 test.

Principal components analysis was used to derive food patterns based on the twenty-nine food groups. The varimax rotation (orthogonal rotation) was used to extract factor loadings. Factors were selected based on their eigenvalues (>1·00). The number of dietary patterns was determined based on scree plots, reasonability of food combination and variance contribution rate. Factor scores for each pattern were calculated by adding the coefficient of the factor loading and the standardized daily intake amounts of every kind of food that was related to each pattern. Dietary patterns were defined according to absolute factor loading values >0·2 for each factor on different food types. Dietary patterns were named by combining the food composition characteristics of the dietary pattern with the main food types included. Based on quartiles, factor scores were classified into four groups, quartiles Q1, Q2, Q3 and Q4, in ascending order of factor scores. The higher the score, the more consistent the individual dietary intake condition and dietary pattern were; the lower the score, the less likely the individual dietary intake condition fitted the dietary pattern.

Using generalized linear models, LBS, HBS, DQD being the dependent variables and dietary patterns being the independent variable, the quality of dietary patterns was evaluated after adjusting for other confounders. Multivariate logistic regression models were used to examine the association between dietary patterns and hypertension. The 'Forward: LR' method was used to select independent variables. With $\alpha = 0{\cdot}05$ as the significance level, $P \leq 0{\cdot}05$ was considered statistically significant. The statistical software package IBM SPSS Statistics version 19.0 was used for all analyses.

Results

Participant characteristics

A total of 1861 participants were included in the present study: 889 (47·77 %) men and 972 (52·23 %) women. The

mean age was 52·5 years. Of participants, 914 (49·11 %) were hypertension patients, 463 were male (52·08 %) and 451 were female (46·40 %). A total of 58·41 % of participants were from rural areas and 18·21 % were minorities; 45·89 % had primary school education or no formal education. Among the participants, the rate of excessive drinking was 3·39 %; 587 (31·54 %) and 109 (5·86 %) were identified as current smokers and ex-smokers, respectively; and 762 (41·41 %) were more likely partake in no exercise or inadequate exercise. The sex differences in marital status, weight control, salt control, dyslipidaemia and uric acid were significant ($P < 0·05$; see online supplementary material, Supplemental Table S2).

Dietary patterns

Four major dietary patterns, named the 'high protein' pattern, 'traditional northern' pattern, 'modern' pattern and 'condiments' pattern, were extracted (see online supplementary material, Supplemental Fig. S1). The total variance of these four dietary patterns was 27·754 %; the variance contribution rates were 9·017, 6·908, 6·645 and 5·184 %, respectively. Sex-specific dietary patterns are shown in Supplemental Tables S3 and S4 (Supplemental Figs S2 and S3). According to the variance, the order of the four major dietary patterns extracted was different between males and females, but the characteristics of food composition and the kinds of main foods in the four dietary patterns were basically the same. The 'high protein' pattern was characterized by milk tea and tea, fried wheat products, beef and mutton, milk and dairy products. The 'traditional northern' pattern represented a typical traditional diet: high intakes of starchy roots and products, pork, pickled vegetables/dried vegetables and corns. The 'modern' pattern featured the intake of various vegetables, fresh fruits, nuts and other foods. The 'condiments' pattern was characterized by high intakes of salt, animal oils, various condiments and various alcoholic beverages (Table 1).

Table 1 Factor loadings of each dietary pattern found among Inner Mongolia adults (n 1861), northern China, 2015

Food group	'High protein' pattern	'Traditional northern' pattern	'Modern' pattern	'Condiments' pattern
Milk tea and tea	0·795	–	–	–
Fried wheat products	0·727	–	–	–
Beef/mutton	0·627	–	–	–
Dairy products	0·416	–	–	–
Milk	0·371	–	–	–
Potato	–	0·780	–	–
Dried vegetables, pickles	–	0·729	–	–
Pork	–	0·651	–	–
Corn and other cereals	–	0·198	–	–
Desserts, snacks, snack foods	–	0·120	–	–
Vegetables	–	–	0·562	–
Soyabeans	–	–	0·545	–
Wheat flour	–	–	0·495	–
Fresh fruits	–	–	0·458	–
Aquatic product	–	–	0·427	–
Eggs	–	–	0·425	–
Algae	–	–	0·346	–
Vegetable oil	–	–	0·254	–
Processed meat	–	–	0·241	–
Starch and sugar	–	–	0·236	–
Beverages	–	–	0·114	–
Nuts	–	–	0·105	–
Salt	–	–	–	0·654
Animal oil	–	–	–	0·607
Condiments	–	–	–	0·528
Rice	–	–	–	0·468
Alcohol	–	–	–	0·318
Animal giblets	–	–	–	0·180
Cake	–	–	–	−0·131
Variance (%)	9·017	6·908	6·465	5·184

Characteristics of dietary patterns

Table 2 shows the demographic characteristics of the four dietary patterns. The sex difference was significant in the distribution of the percentage in Q1 and Q4 of the 'high protein' pattern scores. There was an ascending trend for males and a declining trend for females ($P_{trend} = 0·002$). Of those showing the 'high protein' pattern, participants were younger, had higher educational levels, showed greater weight control and a higher percentage were in Q4. Most of the participants in Q4 (67·39 %) showed the 'high protein' pattern and engaged in adequate physical activity. Increasing factor scores were associated with a higher percentage of overweight and obese participants ($P_{trend} = 0·002$) and a lower percentage of hypertension patients ($P_{trend} = 0·012$).

Participants with higher adherence to the 'traditional northern' pattern were from urban areas and were of Han nationality. Most were married, unlike those with low factor scores. There was a sex difference in the distribution of the percentages in Q1 and Q4 of the 'traditional northern' pattern; there was an ascending trend for males and a declining trend for females ($P_{trend} = 0·001$). The proportion of participants in Q4 decreased with increasing age ($P_{trend} = 0·012$); the ≥65 years group had the lowest percentage (16·01 %). Non-smokers showing the 'traditional northern' pattern were more likely to have low factor scores. There was an ascending trend from Q1 to Q4 in the percentages of participants who controlled their salt intake, but hypertension patients showed the opposite trend.

Participants with higher adherence to the 'modern' pattern were male and from urban areas. They were younger than those who had low factor scores on the 'modern' pattern. Fewer older participants were in Q4 ($P < 0·01$); those aged ≥65 years had the lowest percentage (15·03 %). Participants from other minorities had the highest percentage in Q4 (41·18 %). An ascending trend in the percentage in Q4 was observed as education level increased ($P < 0·01$). Participants with high factor scores on the 'modern' pattern

Table 2 Participant characteristics according to the lowest (Q1) and highest quartile (Q4) of each dietary pattern found among Inner Mongolia adults (*n* 1861), northern China, 2015

	'High protein' pattern					'Traditional northern' pattern					'Modern' pattern					'Condiments' pattern				
	Q1		Q4			Q1		Q4			Q1		Q4			Q1		Q4		
	n	%	*n*	%	P_{trend}	*n*	%	*n*	%	P_{trend}	*n*	%	*n*	%	P_{trend}	*n*	%	*n*	%	P_{trend}
Sex																				
Men	195	21·93	237	26·66	0·002	205	23·06	253	28·46	0·001	204	22·95	245	27·56	0·004	226	25·42	246	27·67	0·175
Women	270	27·78	228	23·46		261	26·85	212	21·81		262	26·95	221	22·74		240	24·69	220	22·63	
Place of residence																				
Urban	164	21·19	161	20·80	0·892	165	21·32	216	27·91	<0·001	117	15·12	304	39·28	<0·001	234	30·23	123	15·89	<0·001
Rural	301	27·69	304	27·97		301	27·69	249	22·91		349	32·11	162	14·90		232	21·34	343	31·55	
Age group (years)																				
<35	53	27·89	42	22·11	<0·001	51	26·84	54	28·42	0·012	42	22·11	74	38·95	<0·001	51	26·84	51	26·84	<0·001
35–44	75	23·73	124	39·24		78	24·68	88	27·85		67	21·20	102	32·28		64	20·25	92	29·11	
45–54	135	25·23	131	24·49		121	22·62	141	26·36		125	23·36	141	26·36		106	19·81	149	27·85	
55–64	126	24·51	114	22·18		134	26·07	133	25·88		145	28·21	103	20·40		142	27·63	123	23·93	
≥65	76	24·84	54	17·65		82	26·80	49	16·01		87	28·43	46	15·03		103	33·66	51	16·67	
Ethnicity																				
Han	354	23·26	336	22·08	0·010	357	23·46	419	27·53	<0·001	360	23·65	407	26·74	<0·001	405	26·61	379	24·90	0·072
Mongolian	88	32·47	115	42·44		92	33·95	37	13·65		97	35·79	31	11·44		44	16·24	74	27·31	
Other minority	23	33·82	14	20·59		17	25·00	9	13·24		9	13·24	28	41·18		17	25·00	13	19·12	
Education level																				
Low	248	29·04	198	23·19	0·001	217	25·41	234	27·40	0·553	301	35·25	123	14·40	<0·001	176	20·61	241	28·22	<0·001
Medium	138	23·75	148	25·47		150	25·82	133	22·89		116	19·97	166	28·57		151	25·99	144	24·78	
High	79	18·54	119	27·93		99	23·24	98	23·00		49	11·50	177	41·55		139	32·63	81	19·01	
Marital status																				
Married	425	24·63	436	25·28	0·530	417	24·17	442	25·62	0·001	428	24·81	440	25·51	0·026	427	24·75	444	25·74	0·140
Single	12	25·00	12	25·00		17	35·42	12	25·00		9	18·75	17	35·42		13	27·08	8	16·67	
Widowed/divorced	25	30·49	15	18·29		30	36·59	10	12·20		25	30·49	9	10·98		25	30·49	14	17·07	
Physical activity																				
None	46	10·02	21	4·57	0·003	71	15·37	25	5·46	<0·001	75	16·20	25	5·43	0·045	87	18·83	28	6·11	<0·001
Inadequate	156	33·99	129	28·04		153	33·12	99	21·62		119	25·70	167	36·30		144	31·17	118	25·76	
Adequate	257	55·99	310	67·39		238	51·52	334	72·93		269	58·10	268	58·26		231	50·00	312	68·12	
Smoking status																				
Current smoker	147	25·04	138	23·51	0·943	137	23·34	180	30·66	0·003	154	26·24	145	24·7	0·292	136	23·17	176	29·98	<0·001
Ex-smoker	26	23·85	26	23·85		21	19·27	33	30·28		26	23·85	34	31·19		23	21·10	36	33·03	
Non-smoker	292	25·06	301	25·84		308	26·44	252	21·63		286	24·55	287	24·64		307	26·35	254	21·80	
Weight control																				
No	425	25·98	403	24·63	0·026	416	25·43	406	24·82	0·276	443	27·08	378	23·11	<0·001	407	24·88	417	25·49	0·159
Yes	465	17·86	465	27·68		50	22·32	59	26·34		22	9·82	88	39·29		58	25·89	49	21·88	
Salt control																				
No	306	25·93	316	26·78	0·740	339	28·73	260	22·03	<0·001	358	30·34	213	18·05	<0·001	284	24·07	290	24·58	0·596
Yes	159	23·35	149	21·90		127	18·65	205	30·10		108	15·86	253	37·15		182	26·73	176	25·84	
BMI																				
Underweight/normal	207	28·67	158	21·88	0·002	182	25·21	183	25·35	0·962	202	27·98	157	21·75	0·004	179	24·79	195	27·01	0·024
Overweight	176	23·25	204	26·95		188	24·83	195	25·76		187	24·70	205	27·08		182	24·04	195	25·76	
Obese	70	20·17	102	29·39		86	24·78	85	24·50		72	20·75	98	28·24		94	27·09	68	19·60	

Table 2 *Continued*

	'High protein' pattern					'Traditional northern' pattern					'Modern' pattern					'Condiments' pattern				
	Q1		Q4			Q1		Q4			Q1		Q4			Q1		Q4		
	n	%	*n*	%	P_{trend}	*n*	%	*n*	%	P_{trend}	*n*	%	*n*	%	P_{trend}	*n*	%	*n*	%	P_{trend}
Hypertension																				
No	206	21·75	250	26·40	0·012	230	24·29	261	27·56	0·022	229	24·18	260	27·46	0·070	255	26·93	225	23·76	0·046
Yes	259	28·34	215	23·52		236	25·82	204	22·32		237	25·93	206	22·54		211	23·09	241	26·37	
Diabetes																				
No	419	24·62	433	25·44	0·249	421	24·74	431	25·32	0·173	431	25·32	419	24·62	0·281	423	24·85	436	25·62	0·082
Yes	46	28·93	32	20·13		45	28·30	34	21·38		35	22·01	47	29·56		43	27·04	30	18·87	
Dyslipidaemia																				
No	295	27·39	253	23·49	0·009	275	25·53	270	25·07	0·655	285	26·46	243	22·56	0·005	257	23·86	284	26·37	0·055
Yes	170	21·68	212	27·04		191	24·36	195	24·87		181	23·09	223	28·44		209	26·66	182	23·21	
Uric acid																				
No	414	25·17	410	24·92	0·563	402	24·44	409	24·86	0·658	420	25·53	401	24·38	0·105	408	24·80	414	25·17	0·440
Yes	51	23·61	55	25·46		64	29·63	56	25·93		46	21·30	65	30·09		58	26·85	52	24·07	
Hypertension history																				
No	285	25·18	286	25·27	0·942	310	27·39	238	21·02	<0·001	310	27·39	241	21·29	<0·001	296	26·15	276	24·38	0·077
Yes	180	24·69	179	24·55		156	21·40	227	31·14		156	21·40	225	30·86		170	23·32	190	26·06	

engaged in adequate physical activity and many did not control their weight.

Participants with higher adherence to the 'condiments' pattern were ethnic Mongolian males from rural areas. They had lower education levels, most were aged 35–54 years and they were more likely to smoke. An ascending trend in the percentage in Q4 was associated with an increased level of physical activity ($P_{trend} < 0·001$). The percentage of people who controlled their salt intake and the percentage of hypertension patients increased from Q1 to Q4.

Nutrient and energy intakes by dietary pattern

Table 3 compares nutrient intakes in the four dietary patterns by sex. In the 'high protein' pattern, the intake of Ca was highest in males and females. Additionally, the percentage of energy from protein was also higher. However, the percentage of energy from dinner was lowest. Among the four dietary patterns, intakes of nutrients such as total fat and K were highest in the 'traditional northern' pattern in both sexes. In the 'modern' pattern, the intake of carbohydrates was highest in both males and females. Additionally, the percentage of energy from carbohydrates was also higher. Among the four dietary patterns, Na intake and the percentage of the energy from dinner were highest in the 'condiments' pattern in both sexes. However, the intakes of Ca and dietary fibre were lowest. The food consumption in the four dietary patterns by sex is shown in the online supplementary material, Supplemental Table S5.

Quality evaluation of food intake using Dietary Balance Index-07 scores

The distribution of dietary quality among Inner Mongolian adults is shown in the online supplementary material, Supplemental Table S6. In the total population, moderate- and high-level dietary imbalance accounted for 79·64 %. Among them, the distribution of LBS indicated that 26·90 % of the participants had high level of inadequate intakes, and the distribution of HBS indicated that 1·10 % of the participants had high level of excessive intakes. The mean scores of LBS, HBS and DQD were 37·54, 4·73 and 42·26, respectively. Participants with hypertension had higher scores in LBS and DQD.

Quality evaluation of dietary patterns using Dietary Balance Index-07 scores

The quality of the 'high protein' pattern was higher as evaluated by DBI-07. Participants with higher factor scores in the 'high protein' pattern had lower DBI-07 scores: LBS ($\beta = -1·993$; 95 % CI −2·362, −1·625; $P < 0·001$), HBS ($\beta = -0·206$; 95 % CI −0·381, −0·030; $P = 0·021$) and DQD ($\beta = -2·199$; 95 % CI −2·598, −1·801; $P < 0·001$). The quality of the 'condiments' pattern was lower. Participants with higher factor scores in the 'condiments pattern' had higher DBI-07 scores: LBS ($\beta = 0·967$; 95 % CI 0·570, 1·364;

Table 3 Sex-specific nutrient and energy intakes according to the lowest (Q1) and highest quartile (Q4) of each dietary pattern found among Inner Mongolia adults (*n* 1861), northern China, 2015

	'High protein' pattern					'Traditional northern' pattern					'Modern' pattern					'Condiments' pattern				
	Q1		Q4			Q1		Q4			Q1		Q4			Q1		Q4		
	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	SD	*P*	Mean	SD	Mean	sd	*P*
Males																				
Energy (kJ/d)	6669·80	3765·14	9617·30	4629·93	<0·001	8535·99	7557·56	9725·12	3798·24	<0·001	6253·78	3226·95	11 208·81	6575·45	<0·001	6870·09	3148·29	10 783·61	7252·80	<0·001
Energy (kcal/d)	1594·12	899·89	2298·59	1106·58	<0·001	2040·15	1806·30	2324·36	907·80	<0·001	1494·69	771·26	2678·97	1571·57	<0·001	1641·99	752·46	2566·59	1733·46	<0·001
Energy intake from dinner (%)	40·00	12·77	33·72	9·79	<0·001	33·76	12·33	36·80	10·20	<0·001	33·92	12·52	34·98	10·15	0·460	30·78	10·86	38·26	11·46	<0·001
Total fat (g/d)	54·89	38·40	83·71	53·88	<0·001	55·01	33·09	95·73	63·25	<0·001	61·56	58·52	81·85	47·26	<0·001	56·48	40·11	84·07	59·24	<0·001
Carbohydrate (g/d)	197·25	75·75	285·83	118·53	<0·001	223·86	123·23	287·64	121·54	<0·001	186·74	65·74	321·37	134·02	<0·001	227·18	101·60	272·75	127·40	<0·001
Protein (g/d)	36·57	16·68	75·40	31·31	<0·001	47·22	24·56	68·72	32·26	<0·001	41·91	26·13	73·17	29·73	<0·001	48·60	24·32	58·87	30·46	<0·001
Energy intake from carbohydrates (%)	53·76	13·27	51·39	10·37*	0·109	51·09	13·58	50·79	11·85*	<0·001	54·20	12·67	51·51	12·14*	0·099	56·65	9·91	47·57	13·81*	<0·001
Energy intake from fat (%)	30·71	14·08	32·44	10·32†	0·235	28·30	12·20	35·81	13·11†	<0·001	32·93	13·40	29·37	10·58	0·017	29·89	10·17	31·68	14·42†	0·333
Energy intake from protein (%)	9·90	2·92	13·61	3·72†	<0·001	11·33	4·40	11·93	3·32	0·115	11·27	3·18	12·02	3·61†	0·082	11·95	2·50	10·41	4·16	<0·001
Fibre (g/d)	5·97	3·78	9·00	4·98	<0·001	5·88	3·49	10·15	5·53	<0·001	5·59	4·12	11·22	4·89	<0·001	7·40	5·40	7·87	4·21	0·667
Ca (mg/d)	186·77	93·70	390·28	192·71	<0·001	300·79	170·91	336·08	189·45	<0·001	236·84	203·18	385·88	145·10	<0·001	313·72	138·81	277·82	157·12	0·070
K (g/d)	0·85	0·43	1·74	0·78	<0·001	1·04	0·55	1·86	0·75	<0·001	1·10	0·80	1·80	0·68	<0·001	1·19	0·66	1·44	0·76	0·001
Na (g/d)	4·24	2·74	5·41	4·60	0·006	5·97	5·81	5·30	4·30	0·002	5·65	5·54	4·81	2·96	0·196	3·44	1·76	8·06	6·28	<0·001
Na:K	6·08	4·63	3·42	2·85	<0·001	6·90	8·70	3·15	2·79	<0·001	6·86	8·58	2·92	1·85	<0·001	3·55	2·23	7·24	8·41	<0·001
Females																				
Energy (kJ/d)	5520·37	2375·63	8099·43	3651·54	<0·001	5626·02	3011·85	9181·75	3556·48	<0·001	5600·74	3187·33	8669·46	3818·11	<0·001	5780·95	2266·05	8006·96	4017·94	<0·001
Energy (kcal/d)	1319·40	567·79	1935·81	872·74	<0·001	1344·65	719·85	2194·49	850·02	<0·001	1338·61	761·79	2072·05	912·55	<0·001	1381·68	541·60	1913·71	960·31	<0·001
Energy intake from dinner (%)	39·35	12·08	32·71	9·09	<0·001	33·36	11·61	36·44	10·12	0·018	34·21	12·77	35·17	9·59	0·589	29·03	10·00	36·54	9·64	<0·001
Total fat (g/d)	55·67	41·63	79·10	63·83	<0·001	51·63	29·13	95·50	65·74	<0·001	59·23	65·47	75·06	38·69	<0·001	48·77	28·96	86·12	67·71	<0·001
Carbohydrate (g/d)	166·41	62·57	239·01	112·34	<0·001	167·96	70·80	267·62	120·34	<0·001	161·72	60·61	270·38	125·94	<0·001	191·70	76·66	218·56	94·88	<0·001
Protein (g/d)	33·71	15·44	62·93	28·95	<0·001	40·49	22·60	60·95	29·16	<0·001	36·49	20·78	64·35	29·68	<0·001	40·56	17·73	50·83	27·80	<0·001
Energy intake from carbohydrates (%)	53·08	12·93	50·36	10·27*	0·002	52·15	11·31	50·11	12·73*	<0·001	52·96	13·93	52·48	10·20*	0·892	56·37	9·74	48·37	12·66*	<0·001
Energy intake from fat (%)	35·19	14·09	35·33	11·01†	0·036	34·11	11·37	37·62	14·07†	<0·001	34·79	14·78	33·11	10·60†	0·442	30·80	10·12	38·87	14·06†	<0·001
Energy intake from protein (%)	10·53	2·93	13·47	3·57†	<0·001	12·28	3·56	11·31	3·18	0·007	11·32	3·24	12·65	3·04†	<0·001	11·86	2·54	10·96	3·52	<0·001
Fibre (g/d)	6·10	3·93	8·09	5·11	<0·001	5·68	3·96	9·79	5·95	<0·001	5·02	3·56	11·14	5·63	<0·001	6·87	4·95	7·69	4·83	0·014
Ca (mg/d)	181·16	99·99	363·75	187·76	<0·001	282·30	177·55	327·07	203·76	<0·001	231·24	207·12	361·72	149·27	<0·001	282·41	135·15	279·57	189·57	0·030
K (g/d)	0·85	0·45	1·55	0·77	<0·001	0·96	0·56	1·78	0·75	<0·001	0·98	0·68	1·70	0·71	<0·001	1·07	0·59	1·36	0·75	<0·001
Na (g/d)	4·30	2·57	5·30	4·57	0·005	5·54	5·14	5·29	3·51	0·006	5·25	4·99	4·44	2·61	0·096	3·24	1·75	8·42	6·27	<0·001
Na:K	6·22	4·87	3·80	3·02	<0·001	6·94	7·92	3·42	2·75	<0·001	6·81	7·72	2·83	1·71	<0·001	3·76	2·47	7·89	8·26	<0·001

*Compared with Q1, the mean ± SD is lower than the reference range.
†Compared with Q1, the mean ± SD is higher than the reference range.

Table 4 Generalized linear models* of dietary quality according to indicators of the Chinese Dietary Balance Index-07 (DBI-07) for each dietary pattern found among Inner Mongolia adults (*n* 1861), northern China, 2015

	LBS			HBS			DQD		
	β	95 % CI	*P*	*β*	95 % CI	*P*	*β*	95 % CI	*P*
'High protein' pattern	−1·993	−2·362, −1·625	<0·001	−0·206	−0·381, −0·030	0·021	−2·199	−2·598, −1·801	<0·001
'Traditional northern' pattern	−0·690	−1·084, −0·295	0·001	1·567	1·398, 1·735	<0·001	0·877	0·451, 1·308	<0·001
'Modern' pattern	−4·882	−5·255, −4·508	<0·001	0·739	0·540, 0·937	<0·001	−4·143	−4·574, −3·712	<0·001
'Condiments' pattern	0·967	0·570, 1·364	<0·001	0·751	0·570, 0·933	<0·001	1·718	1·293, 2·143	<0·001

LBS, lower-bound score; HBS, higher-bound score; DQD, diet quality distance.
*Model adjusted for sex, age, place of residence, educational level, marital status, nationality, salt intake control, smoking status, weight control, BMI, hypertension, abnormal blood lipids and other variables.

$P < 0·001$), HBS ($\beta = 0·751$; 95 % CI 0·570, 0·933; $P < 0·001$) and DQD ($\beta = 1·718$; 95 % CI 1·293, 2·143; $P < 0·001$). Higher adherence to the 'traditional northern' pattern was with lower LBS and higher HBS and DQD, and higher adherence to the 'modern' pattern was with lower LBS, DQD and higher HBS, respectively, which indicates diet quality was lower (Table 4). The results of evaluation of dietary quality in the different dietary patterns are shown in the online supplementary material, Supplemental Table S7.

Association between dietary patterns and hypertension

The 'high protein' pattern showed statistically significant inverse associations with hypertension in males, but no associations in females. In males, after adjusting for demographic and behavioural characteristics, the OR for hypertension in the highest quartile compared with the lowest was 0·406 (95 % CI 0·268, 0·615; $P_{trend} = 0·001$); after further adjustment for BMI, the OR still less than 1, 0·374 (95 % CI 0·244, 0·573; $P_{trend} < 0·001$). The 'condiments' pattern showed statistically significant positive associations with hypertension both in males and females. In males, after adjusting for demographic and behavioural characteristics and BMI, the OR for hypertension in the highest quartile compared with the lowest was 1·663 (95 % CI 1·113, 2·483; $P_{trend} = 0·005$). In females, after adjusting for demographic and behavioural characteristics, the OR for hypertension in the highest quartile compared with the lowest quartile was 1·634 (95 % CI 1·067, 2·502; $P_{trend} = 0·037$). After further adjustment for BMI, the OR increased to 1·788 (95 % CI 1·155, 2·766; $P_{trend} = 0·015$). No associations between other dietary patterns and hypertension were observed (Tables 5 and 6).

Discussion

The prevalence of hypertension was 49·11 % in Inner Mongolia, which is higher than the rate reported in northern China[17] and a national survey[2]. Lower diet quality as evaluated by DBI-07 was prominent in Inner Mongolia. Epidemiological evidence shows that the risk of hypertension is associated with sociodemographic, lifestyle, behavioural, genetic and dietary factors[18,19], especially closely with dietary quality. The present cross-sectional study aimed to explore the association between the risk of hypertension and dietary quality as evaluated by the Chinese DBI-07 in Inner Mongolia in 2015.

Many studies[20,21] have suggested that the DASH dietary pattern can prevent and control hypertension. The DASH diet mainly recommends the consumption of whole-wheat bread, spinach salad, olive oil, aquatic products and other foods. Inner Mongolia is located in northern China, and for geographical and economic reasons, residents consume small amounts of fresh vegetables and fruit. Although the consumption of fresh vegetables and fruit has increased in recent years, consumption remains lower than the recommended amount. A food culture that features meat as the main component still exists among local residents. Additionally, a large amount of alcohol consumption is associated with an increased risk of hypertension for males, particularly Asians, which is also a major feature in Inner Mongolia. Therefore, the DASH dietary pattern is not appropriate for evaluating the dietary quality of people in Inner Mongolia. Ultimately, we chose the Chinese DBI-07 to evaluate the dietary quality of residents in Inner Mongolia. Distinct from the DASH dietary pattern, the DBI-07 considers the effect of alcohol consumption. Moreover, the DBI-07 is based on the recommended amounts of various foods from the Dietary Guidelines for Chinese Residents. The DBI-07 evaluated the quality of different food intakes based on the consumption patterns of individuals with different energy intake needs. Compared with the recommended intakes of the Chinese Dietary Guidelines (2016)[22], the lower quality diet of Inner Mongolia residents was serious, especially the inadequate intakes.

The characteristics of food composition and the kinds of main foods in each of the four dietary patterns extracted were basically the same by sex. Therefore, we named them as 'high protein' pattern, 'traditional northern' pattern, 'modern' pattern and 'condiments' pattern in both sexes. And the cumulative variance of these four dietary patterns was 27·754 %, which is close to that found in other research[23,24].

Table 5 Association of dietary patterns with hypertension across quartiles (Q) of dietary pattern scores in male Inner Mongolia adults (*n* 889), northern China, 2015

		Q1	Q2		Q3		Q4		
		n, % or OR	*n*, % or OR	95 % CI	*n*, % or OR	95 % CI	*n*, % or OR	95 % CI	P_{trend}
'High protein' pattern	Cases (*n*)	127	98	–	132	–	106	–	–
	Proportion (%)	65·13	45·58	–	54·55	–	44·73	–	–
	Model 1	1·000	0·448	0·301, 0·668	0·643	0·436, 0·947	0·433	0·293, 0·640	0·001
	Model 2	1·000	0·384	0·250, 0·589	0·566	0·373, 0·859	0·391	0·257, 0·595	0·001
	Model 3	1·000	0·380	0·248, 0·581	0·511	0·334, 0·781	0·406	0·268, 0·615	0·001
	Model 4	1·000	0·408	0·264, 0·630	0·511	0·334, 0·781	0·374	0·244, 0·573	<0·001
'Traditional northern' pattern	Cases (*n*)	110	112	–	129	–	112	–	–
	Proportion (%)	50·64	53·59	–	58·11	–	44·27	–	–
	Model 1	1·000	0·997	0·678, 1·467	1·198	0·817, 1·756	0·686	0·474, 0·993	0·081
	Model 2	1·000	0·961	0·639, 1·445	1·215	0·812, 1·819	0·686	0·463, 1·016	0·066
	Model 3	1·000	0·978	0·648, 1·475	1·217	0·811, 1·826	0·705	0·474, 1·048	0·153
	Model 4	1·000	1·047	0·687, 1·598	1·263	0·834, 1·912	0·677	0·452, 1·014	0·094
'Modern' pattern	Cases (*n*)	103	113	–	124	–	123	–	–
	Proportion (%)	50·49	53·30	–	54·39	–	50·20	–	–
	Model 1	1·000	1·119	0·762, 1·645	1·169	0·801, 1·707	0·989	0·682, 1·433	0·967
	Model 2	1·000	1·220	0·812, 1·831	1·236	0·824, 1·852	1·185	0·789, 1·780	0·442
	Model 3	1·000	1·206	0·803, 1·810	1·129	0·756, 1·687	1·074	0·722, 1·598	0·841
	Model 4	1·000	1·139	0·752, 1·727	1·128	0·749, 1·701	0·956	0·635, 1·440	0·799
'Condiments' pattern	Cases (*n*)	107	105	–	119	–	132	–	–
	Proportion (%)	47·35	50·97	–	56·40	–	53·66	–	–
	Model 1	1·000	1·156	0·792, 1·687	1·439	0·987, 2·098	1·288	0·897, 1·849	0·106
	Model 2	1·000	1·150	0·769, 1·718	1·564	1·044, 2·344	1·584	1·070, 2·346	0·009
	Model 3	1·000	1·205	0·806, 1·799	1·619	1·083, 2·421	1·718	1·160, 2·545	0·003
	Model 4	1·000	1·102	0·729, 1·666	1·496	0·992, 2·254	1·663	1·113, 2·483	0·005

Data were analysed using multivariable-adjusted logistic regression.
Model 1: crude model.
Model 2: adjusted for age place of residence, ethnicity, marital status, educational level, family history and dyslipidaemia.
Model 3: additionally adjusted for smoking status, physical activity, weight control and salt control.
Model 4: additionally adjusted for BMI.

The 'high protein' pattern was characterized by milk tea and tea, fried wheat products, beef and mutton, milk and dairy products. The LBS, HBS and DQD indicators of DBI-07 showed a descending trend as the factor scores increased in the 'high protein' pattern. The dietary intake of meat and dairy products, and the intakes of nutrients such as protein and Ca, were higher than in the other dietary patterns. The energy intake at dinner was lower than for the other patterns. Male participants who mainly adhered to the 'high protein' pattern had a lower risk of hypertension, while in females the 'high protein' pattern was not significantly associated with hypertension. The possible reason is that intakes of protein and Ca, which benefited to control blood pressure[25,26], were lower in females than in males. In addition, the 'high protein' pattern in the present study was not the main dietary pattern in females, but the 'traditional northern' pattern. Other authors[27,28] also showed that a dietary pattern high in protein was associated with a reduced risk of hypertension. Although the intake of meat is a risk factor for hypertension[29–31], our study did not show that the 'high protein' dietary pattern with consumption of beef and mutton was a risk factor for hypertension after adjusting for confounders. On one hand, the fat content of beef and mutton is lower than that of pork[32], and the other hand, dairy products are rich in protein and Ca. The high intake of protein makes people feel full quickly, which helps to eat less high-energy foods and improves the whole dietary quality to reduce blood pressure[25,33]. Moreover, Ca contributes to reduce the incidence of obesity through shifting the energy balance, thereby reducing the risk of suffering hypertension[26]. A notable feature of the 'high protein' dietary pattern was the high intake of milk tea and tea; of them, tea has a positive effect on blood pressure and blood lipids[34].

The 'condiments' pattern was characterized by high intakes of salt, animal oil, condiments and alcoholic beverages. The LBS, HBS and DQD indicators of DBI-07 showed an ascending trend as the factor scores increased. In the 'condiments' pattern, the dietary intake of oil and salt was higher than the recommended intake, and the dietary intake of vegetables, eggs and dairy was lower than the recommended intake. Participants had a higher risk of hypertension in the 'condiments' pattern. Factor score in the 'condiments' pattern was positively correlated with waist and lipid-related indicators, and thus it was also positively correlated with the prevalence of hypertension[35,36]. It is worth noting that the intake of alcohol in the 'condiments' dietary pattern is much higher than in the other three dietary patterns. Long-term excessive intake of alcohol is an independent risk factor for hypertension[37,38]. Participants with higher adherence to the 'condiments'

Table 6 Association of dietary patterns with hypertension across quartiles (Q) of dietary pattern scores in female Inner Mongolia adults (*n* 972), northern China, 2015

		Q1	Q2		Q3		Q4		
		n, % or OR	*n*, % or OR	95 % CI	*n*, % or OR	95 % CI	*n*, % or OR	95 % CI	P_{trend}
'High protein' pattern	Cases (*n*)	132	116	–	94	–	109	–	–
	Proportion (%)	48·89	46·40	–	41·96	–	47·81	–	–
	Model 1	1·000	0·905	0·641, 1·277	0·756	0·529, 1·080	0·958	0·673, 1·363	0·559
	Model 2	1·000	0·746	0·502, 1·109	0·640	0·425, 0·963	1·136	0·755, 1·709	0·839
	Model 3	1·000	0·746	0·502, 1·109	0·640	0·425, 0·963	1·136	0·755, 1·709	0·839
	Model 4	1·000	0·675	0·448, 1·015	0·570	0·375, 0·868	0·992	0·654, 1·504	0·677
'Traditional northern' pattern	Cases (*n*)	126	133	–	100	–	92	–	–
	Proportion (%)	48·28	51·95	–	41·15	–	43·40	–	–
	Model 1	1·000	1·159	0·820, 1·636	0·749	0·731, 1·223	0·821	0·571, 1·182	0·081
	Model 2	1·000	0·957	0·647, 1·417	0·698	0·467, 1·041	0·749	0·493, 1·140	0·069
	Model 3	1·000	0·957	0·647, 1·417	0·698	0·467, 1·041	0·749	0·493, 1·140	0·069
	Model 4	1·000	1·002	0·670, 1·499	0·698	0·463, 1·051	0·782	0·511, 1·198	0·097
'Modern' pattern	Cases (*n*)	134	120	–	114	–	83	–	–
	Proportion (%)	51·15	47·43	–	48·31	–	37·56	–	–
	Model 1	1·000	0·862	0·610, 1·218	0·893	0·628, 1·269	0·575	0·399, 0·827	0·007
	Model 2	1·000	0·774	0·524, 1·142	0·867	0·573, 1·302	0·694	0·449, 1·072	0·159
	Model 3	1·000	0·774	0·524, 1·142	0·867	0·573, 1·302	0·694	0·449, 1·072	0·159
	Model 4	1·000	0·765	0·514, 1·137	0·845	0·558, 1·280	0·650	0·417, 1·015	0·097
'Condiments' pattern	Cases (*n*)	104	123	–	115	–	109	–	–
	Proportion (%)	43·33	47·49	–	45·46	–	49·55	–	–
	Model 1	1·000	1·183	0·831, 1·168	1·109	0·764, 1·555	1·284	0·889, 1·854	0·106
	Model 2	1·000	1·353	0·903, 2·026	1·312	0·871, 1·976	1·634	1·067, 2·502	0·037
	Model 3	1·000	1·353	0·903, 2·026	1·312	0·871, 1·976	1·634	1·067, 2·502	0·037
	Model 4	1·000	1·403	0·928, 2·120	1·382	0·910, 2·098	1·788	1·155, 2·766	0·015

Data were analysed using multivariable-adjusted logistic regression.
Model 1: crude model.
Model 2: adjusted for age, place of residence, ethnicity, marital status, educational level, family history and dyslipidaemia.
Model 3: additionally adjusted for smoking status, physical activity, weight control and salt control.
Model 4: additionally adjusted for BMI.

pattern had the highest HBS for alcohol consumption and the highest risk of hypertension. Dietary salt and Na intakes were also the highest in the 'condiments' dietary pattern. Salt consumption is associated with hypertension[39,40]. Long-term excessive intake of salt reduces the ability of the kidneys to process salt[41], leading to impairments of endothelial function, left ventricular relaxation, electric repolarization, endothelium dysfunction[42], and subsequent vascular sclerosis[43], resulting in primary hypertension by affecting Na loadings.

The 'traditional northern' pattern was characterized by high intakes of starch and sugar, pork, pickled vegetables/dried vegetables and corns; the dietary intake of cereals and meat was higher than the recommended intake, and the intakes of nutrients such as total fat and Na were also higher than recommended. The 'modern' pattern was characterized by the intakes of various vegetables, fresh fruits, nuts and other foods; the dietary intake of carbohydrates and Na was higher than the recommended intake, and intakes of the nutrients dietary fibre and Ca were lower than those recommended. In the 'traditional northern' pattern, the HBS and DQD indicators of DBI-07 ascended with increasing factor scores, although the LBS showed a descending trend. In the 'modern' pattern, HBS showed an ascending trend as the factor scores increased, even though LBS and DQD showed a descending trend. In our study, no association was found with hypertension.

Excessive intake of salt and alcohol is related to the development of hypertension[44–47]. In our study, salt consumption was excessive in the four major dietary patterns, as assessed by DBI-07. For those participants with higher factor scores in the 'traditional northern' pattern and the 'modern' pattern, although they have no higher Na intake as factor scores increased compared with the 'high protein' pattern and the 'condiments' pattern, we did not find they were related to a lower risk of hypertension. The 'condiments' pattern had the highest intake of alcohol compared with the other three dietary patterns and showed a risk factor for hypertension. And the alcohol consumption in the 'high protein' pattern was higher than in the 'traditional northern' pattern. However, participants had a lower risk of hypertension if they mainly followed the 'high protein' pattern. Based on the excessive salt intake in the four major dietary patterns, and the higher alcohol consumption in the 'high protein' pattern than in the 'traditional northern' pattern, only the 'high protein' dietary pattern indicated a reduced hypertension risk, we suggest that the quality of dietary pattern evaluated by DBI-07 may explain the important part effect on hypertension. Evidence to support this assumption comes from a Japanese study[37], which

indicated that the higher the dietary quality and the more high quality diet, the lower the hypertension risk.

There is a close relationship between BMI and hypertension[48]. The present study focused on the relationship between the quality of dietary patterns and hypertension. In males, after adjusting for BMI, the OR of the 'high protein' pattern with higher quality and risk of hypertension changed from 0·406 (95 % CI 0·268, 0·615) to 0·374 (95 % CI 0·244, 0·573). In females, after adjusting for BMI, the OR of the 'condiments' pattern with lower quality and risk of hypertension changed from 1·634 (95 % CI 1·067, 2·502) to 1·788 (95 % CI 1·155, 2·766). After adjusting for BMI, the dietary quality was still the primary factor for hypertension.

Sociodemographic features generally affect people's dietary pattern and quality[49]. Our study mainly evaluated the relationship between the quality of current dietary patterns and hypertension. Therefore, demographic characteristics were only used as confounders for adjustment. We did not explore further their effect on the relationship between dietary patterns and hypertension in the present study.

The present study was cross-sectional. Despite effective methods of quality control, a certain amount of bias (including selection bias, information bias and other types of bias) is unavoidable and may have affected the representativeness of the sample and results. Although the study demonstrated a relationship between excessive/insufficient food intake and hypertension, and between dietary patterns and hypertension, causal relationships cannot be assumed. The findings offer some insights into the aetiology of the association between dietary patterns and hypertension; however, long-term follow-up studies are needed to determine if there is a causal relationship between these factors.

Conclusions

In summary, four major dietary patterns were identified; the 'high protein' pattern (a higher-quality dietary pattern as evaluated by DBI-07) was related to a decreased prevalent risk of hypertension, while the 'condiments' pattern (a lower-quality dietary pattern as evaluated by DBI-07) was related to an increased prevalent risk of hypertension.

Acknowledgements

Acknowledgements: The authors sincerely express appreciation to all the participants and to local colleagues. They thank Diane Williams, PhD, from Liwen Bianji, Edanz Group China (www.liwenbianji.cn/ac), for editing the English text of a draft of this manuscript. *Financial support:* This study was supported by Inner Mongolia Science and Technology Project (Intelligent Health Monitoring and Modern Medical Information System Development Based on Internet of Things Technology). The funder had no role in the design, analysis or writing of this article. *Conflict of interest:* None declared. *Authorship:* X.W. and P.W. conceived and designed the protocol. X.W. and A.L. conducted the statistical analysis and prepared the manuscript. M.D., J.W., W.W. and Y.Q. contributed to data collection. H.Z., D. Liu, X.N., L.J., R.S., D. Liang and R.W. participated in cleaning and analysing the data. X.W. and A.L. produced the final revised manuscript. P.W. reviewed the paper and approved its final version. All authors were involved in interpreting results, editing the manuscript for content and approved the final version of the manuscript. *Ethics of human subject participation:* This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethical Committee of the National Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention. Written informed consent was provided by participants before the start of the investigation.

Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S136898001900301X

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