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ARTICLE

Hypertension prevalence, awareness, treatment, and control in northeast China: a population-based cross-sectional survey

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Abstract

Hypertension has been recognized as a major risk factor for cardiovascular disease. We aimed to analyze the current prevalence, awareness, treatment, and control of hypertension in northeast China. This cross-sectional survey adopted the multistage stratified random cluster sampling method to obtain a representative sample of adults aged 40 years or older in the general population of northeast China. Hypertension was defined as a systolic blood pressure (SBP) ≥ 140 mm Hg, or diastolic blood pressure (DBP) ≥ 90 mm Hg, or self-reported use of antihypertensive medications in the last 2 weeks irrespective of BP. Altogether 4052 participants were included with weighted prevalence of hypertension of 57.3%. Among them, 47.4% were aware of their condition; 78.8% took antihypertensive medication, but only 10.2% had their blood pressure controlled. Individuals who were overweight/obesity, with dyslipidemia, or diabetes were at a higher risk of hypertension; these people also more likely to be aware of their condition. Subjects with a personal history of stroke were more inclined to receive antihypertensive medication, but that did not necessarily translate to well-controlled hypertension. Moreover, dyslipidemia (OR = 0.600; 95% CI: 0.375, 0.960) were associated with poor hypertension control. Subjects using combination of antihypertensive medications (OR = 2.924; 95% CI: 1.606, 5.325) or with a family history of coronary heart disease were more likely to have their blood pressure controlled. Our study identified a high prevalence of hypertension in northeast China. Although awareness and treatment rates improved over the last decade, the control rate remained disproportionately and unacceptably low.

Introduction

Hypertension has long been recognized as a worldwide public-health challenge and particularly as a major risk factor for cardiovascular disease and premature death [1, 2]. It was also considered to be the largest contributor to global disability-adjusted life-years in 2015 3]. It is estimated that the proportion of the global adult hypertensive population will increase to 29%, with an estimated 1.56 billion hypertensive individuals in the world by 2025. Most of this increase can be attributed to economically developing regions in the world 4].

With rapid economic development and demographic transitions characterized by striking reductions in fertility and child mortality and increases in life expectancy in the past few decades, the major causes of morbidity and mortality in China have shifted from primarily infectious diseases to chronic, particularly cardiovascular, diseases 5]. As the most important modifiable risk factor for cardiovascular diseases, the age-standardized prevalence of hypertension is declining in higher income countries, whereas low-income and middle-income countries are encountering an increasing burden of hypertension; [2, 6] this is true for China 7].

Although there are several studies on the prevalence of hypertension in northeast China in recent years [8, 9], only limited studies on the influencing factors associated with the awareness, treatment, and control of hypertension have been undertaken. This gap in knowledge is an impediment to develop targeted health policies for the prevention and

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control of hypertension in this area. The 2015–2016 China National Stroke Screening Survey includes these data and remains the latest cross-sectional survey in northeast China. Using the data from this study, we aimed the following: (1) provide the updated data for the prevalence, awareness, treatment, and control of hypertension in northeast China and (2) investigate the influence factors associated with hypertension among adults aged 40 years and above in this area.

Patients and Methods

Data source and study participants

The China National Stroke Screening Survey was an ongoing stroke surveillance program among residents in China 10]. The details of this study in northeast China and methods have been reported elsewhere 11]. It was conducted from January to March 2016, and supervised by National Center for Stroke Control and Prevention. The most important reason for choosing this period of time was to increase response rate and reduce sample selection bias, in order to make the study sample best representative of the adults aged 40 years or older in this area because many migrant workers living in this area would return home during this period of time for Spring Festival with their families.

This cross-sectional survey adopted the multistage stratified random cluster sampling method to select representative samples. In the first stage, 30 villages and 10 towns were randomly selected from 308 villages (rural) and 14 towns (urban) in Dehui City using probability proportional to size (PPS) sampling. In the second stage, 5 villagers' groups or communities were sampled from both rural and urban strata using PPS. Finally, 1 adult resident aged 40 years or older was randomly selected from each household of the selected villagers' groups or communities. Respondents who were unwilling to participate in the survey or judged to very frail were excluded. 4100 permanent residents 40 years and older who had lived in Dehui City of Jilin province for >6 months volunteered to participate in the survey, with an excellent response rate being 92.2%. Ethics approval was obtained from the Human Ethics and Research Ethics committees of the First Hospital of Jilin University, and informed consent was obtained from all participants during recruitment. For the purpose of the present analysis, 48 subjects were excluded due to missing values. Finally, a total of 4052 people were included in the present analysis.

Screening protocol and assessment criteria

All participants were assessed at a central survey site in their area. All adult individuals completed a questionnaire-based interview, physical and clinical examinations.

The questionnaire included information about stroke history, demographic information, and the presence of risk factors. The physical examination involved the measurement of height, weight, neck, waist and hip circumference, and resting blood pressure. Height and weight were measured according to the standardized protocol, with the participants wearing light clothing and without shoes. Blood pressure was measured by trained practitioners using an automatic OMRON sphygmomanometer (OMRON HEM-7200, Kyoto, Japan). Two consecutive measures were taken on the right arm supported at the heart level on seated participants after 20 min of rest, and we took the average of the readings. A blood sample was drawn from the participant's antecubital vein in the morning after an overnight fast (at least 8 h) for measuring fasting blood glucose (FBG), total cholesterol (TC), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C), and the sample was uniformly measured by Changchun Kingmed Center for Clinical Laboratory Co., Ltd. Supplementary Table S1 presents detailed assessment criteria for other stroke-related factors, including hypertension, diabetes, dyslipidemia, overweight or obesity, physical inactivity, smoking, drinking, etc. referred in this study (Supplementary Table S1).

Diagnostic criteria

Hypertension was defined as an average systolic blood pressure (SBP) of 140 mm Hg or greater, or an average diastolic blood (DBP) of 90 mm Hg or greater, or self-reported diagnosis. Participants who took anti-hypertensive drugs in the last 2 weeks were also considered as having hypertension, regardless of the level of blood pressure measured at the time of the study.

Hypertension awareness was defined as self-reported previous diagnosis before the present survey. Hypertension treatment was defined as the self-reported use of medication for the management of hypertension during the previous 2 weeks. The control rate of hypertension referred to the proportion among those treated who had an average systolic and diastolic blood pressure of <140/90 mm Hg at the screening camp.

Statistical analysis

The estimations and comparisons of rates were weighted to the standard population in the 6th National General Investigation in Dehui City of Jilin province in 2010, which was the most recent Chinese population census. Complex weighted computation was used to adjust for differing response proportions, selection probabilities, and deviations in the sample compared with the standard population, particularly in terms of gender (male or female), age groups

Table 1 General characteristics of participants according to hypertension status

Characteristics	Overall ($n = 4052$)	Hypertension ($n = 2335$)	Normal ($n = 1717$)	p value
Age (years)	54.85 ± 9.30	56.72 ± 9.23	52.30 ± 8.77	< 0.001[a]
Gender (male)	1619 (40.0)	1042 (44.6)	577 (33.6)	< 0.001[b]
Region				0.404[b]
Urban, *n* (%)	2067 (51.0)	1178 (50.4)	889 (51.8)	
Rural, *n* (%)	1985 (49.0)	1157 (49.6)	828 (48.2)	
Education, *n* (%)				< 0.001[b]
Primary school and below	1446 (35.7)	904 (38.7)	542 (31.6)	
Junior middle school	1696 (41.9)	965 (41.3)	731 (42.6)	
Senior middle school	537 (13.3)	278 (11.9)	259 (15.1)	
College and above	373 (9.2)	188 (8.1)	185 (10.8)	
Dyslipidemia, *n* (%)	2570 (63.4)	1668 (71.4)	902 (52.5)	< 0.001[b]
Diabetes, *n* (%)	441 (10.9)	340 (14.6)	101 (5.9)	< 0.001[b]
Overweight/obesity, *n* (%)	1239 (30.6)	908 (38.9)	331 (19.3)	< 0.001[b]
Physical inactivity, *n* (%)	902 (22.3)	568 (24.3)	334 (19.5)	< 0.001[b]
Personal history of stroke, *n* (%)	292 (7.2)	242 (10.4)	50 (2.9)	< 0.001[b]
Family history of stroke, *n* (%)	1397 (34.5)	869 (37.2)	528 (30.8)	< 0.001[b]
Personal history of coronary heart disease, *n* (%)	272 (6.7)	218 (9.3)	54 (3.1)	< 0.001[b]
Family history of coronary heart disease, *n* (%)	1011 (25.0)	617 (26.4)	394 (22.9)	0.011[b]
Family history of hypertension, *n* (%)	1573 (38.8)	1049 (44.9)	524 (30.5)	< 0.001[b]
Fruit consumption, *n* (%)				0.730[b]
≥ 5 days per week	3580 (88.4)	2055 (88.0)	1525 (88.8)	
3–4 days per week	433 (10.7)	213 (9.1)	146 (8.5)	
≤ 2 days per week	641 (15.8)	67 (2.9)	46 (2.7)	
Smoker				0.754[b]
Yes	2027 (50.0)	1173 (50.2)	854 (49.7)	
No	2025 (50.0)	1162 (49.8)	863 (50.3)	
Alcohol consumption, *n* (%)				< 0.001[b]
Never	2978 (73.5)	1644 (70.4)	1334 (77.7)	
Light/Moderate drinking	641 (15.8)	367 (15.7)	274 (16.0)	
Heavier drinking	433 (10.7)	324 (13.9)	109 (6.3)	
SBP (mm Hg)	141.02 ± 21.69	154.28 ± 18.22	122.98 ± 9.70	< 0.001[a]
DBP (mm Hg)	88.78 ± 11.81	95.48 ± 10.20	79.66 ± 6.56	< 0.001[a]
TG CHOHDLLDL (mmol/L)				
TC	5.40 ± 1.16	5.53 ± 1.18	5.22 ± 1.11	< 0.001[a]
TG	2.06 ± 1.76	2.32 ± 2.04	1.71 ± 1.20	< 0.001[a]
LDL-C	2.13 ± 0.81	2.17 ± 0.81	2.08 ± 0.79	< 0.001[a]
HDL-C	1.25 ± 0.24	1.24 ± 0.24	1.27 ± 0.26	< 0.001[a]
FBG (mmol/L)	5.32 ± 1.65	5.52 ± 1.82	5.05 ± 1.35	< 0.001[a]
Neck circumference (cm)	34.23 ± 3.28	34.91 ± 3.33	33.31 ± 2.97	< 0.001[a]
Waist circumference (cm)	85.60 ± 9.25	87.96 ± 8.97	82.38 ± 8.65	< 0.001[a]
Hip circumference (cm)	96.21 ± 8.54	98.19 ± 8.36	93.51 ± 8.03	< 0.001[a]
Hypertension awareness, *n* (%)	—	1170 (50.1)[c]	—	—
Hypertension treatment, *n* (%)	—	910 (77.8)[c]	—	—
Hypertension control, *n* (%)	—	100 (11.0)[c]	—	—

DBP diastolic blood pressure, FBG, fasting blood-glucose, *HDL-C* high-density lipoprotein cholesterol; *LDL-C* low-density lipoprotein cholesterol; *SBP* systolic blood pressure, *TC* total cholesterol; *TG* triglyceride

[a]Mann–Whitney–Wilcoxon test

[b]χ^2 test

[c]On the basis of the surveyed raw data. Hypertension awareness was defined as self-reported previous diagnosis before the present survey among all of the hypertensive participants. Hypertension treatment was defined as the self-reported use of medication for the management of hypertension during the previous 2 weeks among those who were aware of their hypertension condition. The control rate of hypertension referred to the proportion among those who were treated with medication.

(40–49 years, 50–59 years, 60–69 years, 70– years), and place of residence (rural or urban area). Quantitative variables were presented as means ± SD and compared using Student's t test (normal distribution parameters) or Mann–Whitney–Wilcoxon test (non-normal distribution parameters). Categorical variables were presented as proportions and compared using the Rao–Scott-χ^2 test. Finally, the associated influence factors for the prevalence, awareness, treatment, and control of hypertension were analyzed through multivariate binary logistic regression using the surveyed raw data. All statistical analyses were performed using IBM SPSS 17.0 (SPSS Inc., New York, NY, USA). Statistical significance was set at $p < 0.05$.

Results

General characteristics between participants with and those without hypertension

A total of 4052 participants were included for analysis, including 2335 hypertensive patients (mean age, 56.72 ± 9.23 years) and 1717 normotensive participants (mean age, 52.30 ± 8.77 years). Of the 4052 study subjects, nearly half were from the urban region (51.0%), and 40.0% were men.

Demographic and clinical characteristics of the analyzed subjects according to the hypertension status are provided in Table 1. Compared with participants without hypertension, the hypertension group was usually older and had a higher proportion of males. Dyslipidemia, diabetes, overweight/obesity, physical inactivity, personal and family history of stroke and coronary heart disease, and family history of hypertension were more frequent ($p < 0.001$, except $p = 0.011$ for family history of coronary heart disease) in the hypertension group. In addition, the hypertension group had higher TC, TG, LDL-C, and lower HDL-C ($p < 0.001$, except $p = 0.001$ for LDL-C) than the normotension group; they also had higher FBG level, and higher neck, waist, and hip circumferences than those of the non-hypertension group (all $p < 0.001$).

Prevalence, Awareness, treatment, and control of hypertension and their associated factors

As shown in Table 2, the overall adjusted prevalence of hypertension was 57.3%. Among the hypertensive participants, 47.4% were aware of their conditions. Of the affected individuals who were aware of their condition, 78.8% had received hypotensive drugs, but only 10.2% of those who had taken antihypertensive agents now had normal blood pressure. The prevalence, awareness, treatment, and control of hypertension in northeast China by demographic characteristics, such as age, gender, and region, were presented in detail in Table 2.

In a multivariate binary logistic regression analysis, prevalence, awareness, treatment, and control of hypertension were used as dependent variables, the parameters (Table 2) that were significantly associated with prevalence, awareness, treatment, and control of hypertension in univariate analysis ($p < 0.1$, except for age, gender, and region) were used as independent variables respectively.

After adjusting for potential confounders, multiple logistic regression analysis (Table 3) suggests that the prevalence of hypertension was significantly associated with increasing age, and there was a significant association between gender and the prevalence of hypertension, with men (OR = 1.391; 95% CI: 1.169, 1.656) more likely to have hypertension. In addition, subjects with dyslipidemia (OR = 1.704; 95% CI: 1.476, 1.968), or diabetes (OR = 1.755; 95% CI: 1.376, 2.253) had a higher risk for hypertension. And participants with a personal history of stroke or coronary heart disease, or a family history of hypertension were more likely to have hypertension compared to those without a history of these conditions. However, subjects with education level of junior (OR = 0.819; 95% CI: 0.680, 0.985) or senior (OR = 0.628; 95% CI: 0.481, 0.820) middle school were less likely to have hypertension than those with education level of primary school and below.

As shown in Table 4, increasing age was significantly associated with the awareness of hypertension, and men were less likely to be aware of their conditions. Participants who were overweight/obesity or those with dyslipidemia or diabetes tended to be more aware of their conditions than those otherwise. In addition, subjects with a personal history of coronary heart disease (OR = 2.263; 95% CI: 1.619, 3.164) or stroke (OR = 1.212; 95% CI: 1.003, 1.465), or family history of hypertension (OR = 2.445; 95% CI: 2.026, 2.951), were more inclined to be aware of their conditions compared with those who had no personal or family history.

Table 5 indicates that respondents aged 70– (OR = 1.857; 95% CI: 1.054, 3.270) were more inclined to receive treatment for hypertension than group 40–49 years. As shown by the findings of hypertension awareness, male subjects were unlikely to take hypotensive drugs for their hypertension conditions than female. Participants living in urban areas (OR = 1.758; 95% CI: 1.317, 2.348) were more likely to report drug treatment than those living in rural areas. Subjects with a personal history of stroke (OR = 1.637; 95% CI: 1.044, 2.567) were more inclined to receive treatment than otherwise.

Proportions of different drug classes among hypertension patients using anti-hypertensive drugs overall and by demographic characteristics were shown in Supplementary Table S2. Of all the hypertensives receiving drug therapy, 90.8% (95% CI: 88.2–92.8%) were using monotherapy (one of the western drugs or traditional Chinese medicine), and only 9.2% (95% CI: 7.2–11.8%) were using combination

Table 2 Prevalence, awareness, treatment and control of hypertension in northeast China

Category	Subcategory	Prevalence Rate (95% CI)	Awareness Rate (95% CI)	Treatment Rate (95% CI)	Control Rate (95% CI)
Total		57.3 (55.5–59.2)	47.4 (44.9–49.8)	78.8 (75.8–81.5)	10.2 (8.1–12.7)
Age	40–49	47.1 (43.8–50.4)	37.4 (32.9–42.2)	71.4 (63.8–78.0)	10.6 (6.3–17.4)
	50–59	58.6 (55.7–61.5)	46.5 (42.7–50.3)	80.3 (75.6–84.2)	12.7 (9.1–17.5)
	60–69	68.5 (65.3–71.6)	56.7 (52.6–60.7)	81.6 (77.2–85.3)	10.1 (7.1–14.2)
	70–	74.1 (68.0–79.3)	59.2 (51.7–66.3)	83.5 (74.8–89.6)	5.3 (2.0–13.1)
	p value	< 0.001	< 0.001	0.026	0.239
Gender	Male	60.7 (57.8–63.5)	42.2 (38.7–45.7)	72.4 (67.3–77.0)	8.7 (5.7–13.0)
	Female	53.9 (51.5–56.3)	53.2 (50.0–56.4)	84.5 (81.2–87.4)	11.3 (8.7–14.6)
	p value	< 0.001	< 0.001	< 0.001	0.277
Region	Urban	59.2 (57.0–61.4)	49.5 (46.5–52.5)	71.3 (67.3–75.0)	10.3 (7.8–13.5)
	Rural	56.7 (54.3–59.0)	46.6 (43.5–49.7)	81.6 (77.7–85.0)	10.1 (7.6–13.4)
	p value	0.121	0.192	< 0.001	0.940
Education	Primary school and below	60.7 (57.9–63.5)	49.1 (45.4–52.7)	82.7 (78.2–86.4)	8.1 (5.6–11.5)
	Junior middle school	54.0 (51.0–56.9)	45.3 (41.4–49.2)	76.0 (70.9–80.5)	12.9 (9.1–18.0)
	Senior middle school	53.9 (48.9–58.8)	44.3 (37.8–51.1)	69.9 (60.9–77.6)	11.9 (6.4–21.0)
	College and above	56.5 (51.0–61.8)	49.7 (41.7–57.7)	70.5 (59.8–79.3)	12.7 (6.6–23.1)
	p value	0.001	0.316	0.007	0.133
Dyslipidemia	Yes	64.7 (62.4–66.9)	50.4 (47.5–53.3)	78.9 (75.4–82.0)	14.4 (9.8–20.7)
	No	45.3 (42.3–48.3)	40.3 (36.0–44.7)	78.5 (72.3–83.6)	8.7 (6.6–11.5)
	p value	< 0.001	< 0.001	0.896	0.035
Diabetes	Yes	74.8 (69.6–79.3)	61.7 (55.4–67.7)	84.6 (77.6–89.7)	10.5 (6.0–17.6)
	No	55.1 (53.1–57.1)	44.9 (42.3–47.5)	77.5 (74.1–80.5)	10.1 (7.9–12.8)
	p value	< 0.001	< 0.001	0.063	0.910
Physical inactivity	Yes	66.2 (62.2–69.9)	56.1 (51.0–61.0)	78.2 (72.1–83.4)	9.2 (6.0–13.9)
	No	55.4 (53.3–57.5)	45.1 (42.4–47.8)	79.0 (75.5–82.1)	10.5 (8.0–13.5)
	p value	< 0.001	< 0.001	0.821	0.618
Smoking	Yes	56.6 (54.1–59.0)	49.1 (45.6–52.7)	80.6 (76.6–84.1)	9.8 (7.2–13.2)
	No	58.5 (55.8–61.2)	46.2 (43.0–49.5)	76.1 (71.6–80.2)	10.7 (7.7–14.7)
	p value	0.297	0.233	0.122	0.706
Overweight/obesity	Yes	72.4 (69.3–75.3)	55.9 (52.0–59.8)	80.6 (76.1–84.5)	9.5 (6.7–13.2)
	No	50.5 (48.2–52.8)	41.8 (38.8–44.9)	77.3 (73.2–80.9)	10.8 (8.0–14.5)
	p value	< 0.001	< 0.001	0.257	0.557
Fruit consumption	≤ 2 d/w	59.5 (49.3–68.9)	58.3 (45.0–70.5)	87.1 (69.3–95.3)	9.5 (3.5–23.4)
	3-4 d/w	58.3 (51.9–64.4)	37.0 (29.4–45.3)	80.7 (65.7–90.2)	11.7 (4.9–25.5)
	≥ 5 d/w	57.1 (55.1–59.1)	47.9 (45.3–50.5)	78.2 (75.0–81.0)	10.1 (7.9–12.8)
	p value	0.851	0.015	0.483	0.936
Alcohol consumption	Never	55.1 (53.0–57.3)	49.9 (47.0–52.8)	82.5 (79.3–85.3)	10.8 (8.5–13.8)
	Light/moderate drinking	55.0 (50.3–59.6)	41.9 (36.0–48.1)	70.3 (60.9–78.3)	9.8 (4.5–19.8)
	Heavier drinking	73.1 (67.8–77.9)	43.3 (37.0–49.8)	71.2 (62.0–79.0)	7.0 (3.5–13.3)
	p value	< 0.001	0.027	0.002	0.565
Like to eat salted food	Yes	59.1 (56.2–62.0)	50.3(46.6–54.1)	80.1 (75.5–84.0)	11.4 (8.2–15.6)
	No	55.9 (53.5–58.3)	54.6 (51.4–57.7)	77.6 (73.6–81.2)	9.0 (6.7–12.2)
	p value	0.096	0.090	0.397	0.308
Personal history of stroke	Yes	59.2 (57.0–61.4)	73.4 (66.4–79.5)	85.2 (78.0–90.4)	18.3 (9.2–33.1)
	No	56.7 (54.3–59.0)	44.3 (41.8–46.9)	77.6 (74.2–80.6)	20.2 (15.4–26.0)
	p value	< 0.001	< 0.001	0.052	0.777
Family history of stroke	Yes	62.7 (59.6–65.8)	53.2 (49.1–57.2)	77.6 (72.7–81.9)	7.8 (4.3–13.7)
	No	54.6 (52.3–56.9)	44.0 (41.0–47.0)	79.6 (75.8–83.0)	10.7 (8.4–13.5)
	p value	< 0.001	< 0.001	0.495	0.326

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Category	Subcategory	Prevalence Rate (95% CI)	Awareness Rate (95% CI)	Treatment Rate (95% CI)	Control Rate (95% CI)
Personal history of coronary heart disease	Yes	78.2 (71.5–83.6)	70.4 (62.6–77.2)	86.0 (78.3–91.2)	19.3 (11.9–29.7)
	No	55.9 (54.0–57.8)	45.2 (42.7–47.7)	77.8 (74.5–80.7)	8.7 (6.8–11.1)
	p value	< 0.001	< 0.001	0.046	0.003
Family history of coronary heart disease	Yes	60.5 (56.8–64.2)	54.9 (50.1–59.6)	79.5 (73.6–84.3)	15.1 (10.7–20.9)
	No	56.3 (54.2–58.4)	44.8 (42.0–47.6)	78.5 (75.0–81.7)	8.1 (6.0–10.8)
	p value	0.055	< 0.001	0.774	0.007
Family history of hypertension	Yes	67.6 (64.6–70.4)	60.2 (56.6–63.8)	77.7 (73.4–81.4)	12.3 (9.3–16.1)
	No	51.6 (49.2–53.9)	37.9 (34.8–41.1)	80.1 (75.8–83.9)	7.7 (5.2–11.2)
	p value	< 0.001	< 0.001	0.394	0.048

The data were presented as weighted prevalence (95% confidence intervals). *p* values were calculated with the Rao–Scott–χ^2 test

CI confidence interval

therapy (two or more western drugs or traditional Chinese medicine and western drugs). In addition, the proportion comparisons between total monotherapy and combination therapy showed no significant differences by age group, gender, and residence (all $p > 0.05$).

Table 6 provides the data showing that subjects aged 70 and above (OR = 0.334; 95% CI: 0.116, 0.957) were less likely to control their hypertension at normal levels than those in age group 40–49 years; and dyslipidemia (OR = 0.600; 95% CI: 0.375, 0.960) was associated with poor control of hypertension. However, subjects using combination of antihypertensive medications compared with that of using monotherapy (OR = 2.924; 95% CI: 1.606, 5.325) or with a family history of coronary heart disease (OR = 1.698; 95% CI: 1.083, 2.664) were more likely to control their hypertension at <140/90 mm Hg.

Discussion

Findings from the population-based cross-sectional survey in northeast China indicated that more than half (57.3%) of adult participants aged 40 years and older were hypertensive. Of these individuals, 47.4% hypertensive subjects were aware of their condition. Although nearly 80% of individuals who were aware of their hypertensive status were receiving antihypertensive medication, blood pressure control was achieved in only 1 in 10 of these individuals.

After entering the 21st century, the first nation-wide study, 2002 China National Nutrition and Health Survey (NNHS) indicated that the overall adjusted prevalence of hypertension in Chinese adults who were 18 years of age and above in 2002 was 18%, with 12% vs. 6%, 28% vs. 29%, and 50% vs. 52% in the age groups of 18–44 years, 45–59 years, and 60 and above years, respectively, in men and women 12]. Our present findings for the overall adjusted prevalence of hypertension was 57.3%, with 47.1, 58.6, 68.5, 74.1% in the age groups of 40–49, 50–59, 60–69, and 70 and above years, respectively. These prevalence rates were much higher than the 2002 NNHS data; however, there was an agreement between the NNHS study and the present findings that the overall prevalence rate was significantly greater for men than for women. These prevalence rates in each age group over 40 years were also significantly higher than the baseline survey of China Kadoorie Biobank Study conducted from June 2004 to August 2009 [13], reporting the adjusted prevalence of hypertension in Chinese adults in the age groups of 40–49, 50–59, 60–69, and 70–74 years old at entry were 22.1, 36.1, 50.7, and 58.4%, respectively. The hypertension prevalence rates reported in our cross-sectional survey in each age group over 40 years were also prominently higher than that reported by the China National Survey of Chronic Kidney Disease, done from 2007 to 2010 [14]; this demonstrated that the adjusted prevalence of hypertension in the age groups of 18–44, 45–59, and 60 and above years were 17.5, 40.1, and 58.2%, respectively. Data collected in 2011-2012 from the China Health and Retirement Longitudinal Study (CHARLS) national study showed that the adjusted prevalence of hypertension in Chinese adults aged 45 years or older in the groups of 50 and below, 50–59, 60–69, 70–79, and 80 and above years were 21.8, 33.8, 26.7, 13.5, and 4.2%, respectively 15]. Another most recent nationally representative survey including 174,621 adults aged 18 years and above from 31 provinces in China between 2013 and 2014, as part of the China Chronic Disease and Risk Factors Surveillance (CCDRFS) survey 16], reported the adjusted prevalence of hypertension in Chinese adults in the groups of 40–49, 50–59, 60–69, and over 70 years were 19.9, 33.8, 48.0, and 61.1%, respectively. Although disparity in sampling design and eligible ages may lead to the variation when estimating prevalence level, the aforementioned epidemiological surveys taken together indicated that the prevalence of hypertension in northeast China was higher than the China national average in the corresponding age group. The prevalence of hypertension in our study was

Table 3 Multivariate logistic regression analyses on influence factors for prevalence of hypertension

Category	Subcategory	Fully adjusted OR (95% CI)	Wald χ^2 value	p value
Age (years)	40–49	1.00 (referent)		
	50–59	1.679 (1.421–1.984)	37.005	< 0.001
	60–69	2.40 (2.006–2.968)	79.738	< 0.001
	70–	3.512 (2.571–4.796)	62.356	< 0.001
Gender	Female	1.00 (referent)		
	Male	1.391 (1.169–1.656)	13.825	< 0.001
Region	Rural	1.00 (referent)		
	Urban	1.339 (1.161–1.543)	16.184	< 0.001
Education	Primary school and below	1.00 (referent)		
	Junior middle school	0.819 (0.680–0.985)	4.477	0.034
	Senior middle school	0.628 (0.481–0.820)	11.657	0.001
	College and above	0.756 (0.555–1.030)	3.150	0.076
Overweight/obesity	No	1.00 (referent)		
	Yes	2.320 (1.980–2.719)	108.177	< 0.001
Physical inactivity	No	1.00 (Referent)		
	Yes	1.197 (1.007–1.424)	4.150	0.042
Dyslipidemia	No	1.00 (referent)		
	Have	1.704 (1.476–1.968)	52.797	< 0.001
Diabetes	No	1.00 (referent)		
	Have	1.755 (1.367–2.253)	19.502	< 0.001
Personal history of stroke	No	1.00 (referent)		
	Yes	2.298 (1.652–3.196)	24.405	< 0.001
Personal history of coronary heart disease	No	1.00 (referent)		
	Yes	2.103 (1.516–2.916)	19.849	< 0.001
Family history of hypertension	No	1.00 (referent)		
	Have	2.135 (1.710–2.666)	44.886	< 0.001
Alcohol consumption	Never	1.00 (referent)		
	Light/moderate drinking	0.993 (0.803–1.227)	0.005	0.945
	Heavier drinking	2.061 (1.566–2.713)	26.607	< 0.001

Method: enter: age, gender, region; forward-conditional: overweight/obesity, education, dyslipidemia, diabetes, physical inactivity, alcohol consumption, like to eat salted food, personal history of stroke, personal history of coronary heart disease, family history of stroke, family history of coronary heart disease, family history of hypertension

CI confidence interval, *OR* odds ratio

also relatively higher than some regional surveys reported in northern, southern, and central China in recent years, such as Inner Mongolia [17] (28.64, 21.16, and 15.29% in the age groups of 40–49, 50–59, and 60–80 years old, respectively), Zhejiang [18] (17.2, 34.3, and 57.7% in the age groups of 40–49, 50–59, and 60 and above years, respectively), and Henan [19] (22.4, 40.5, 56.4, and 66.3% in the age groups of 35–44, 45–54, 55–64 and 65–74 years old, respectively). However, it is lower than that in Xinjiang, which is located in northwest China [20] (41.0, 61.0, 77.6, and 88.6% in the age groups of 40–49, 50–59, 60–69, and 70 and above years, respectively). Relatively slower economic development and urbanization could be one of the major causes for such a high prevalence of hypertension in northeast China, and a previous study indicated that low socioeconomic status was associated with higher prevalence of hypertension 21]. Another explanation for the particularly high prevalence could be that residents living in the cold northeastern regions consume significantly more sodium than do southerners, which could affect blood pressure 22]. Furthermore, this difference is possibly due to the different lifestyles and dietary habits in northeast China 11]. The cold weather in northeast China limits people's outdoor physical activity during the long winter, consequently increasing the risk of overweight or obesity and related metabolic abnormalities, such as dyslipidemia and

Table 4 Multivariate logistic regression analyses on influence factors for awareness of hypertension

Category	Subcategory	Fully adjusted OR (95% CI)	Wald χ^2 value	p value
Age(years)	40–49	1.00 (referent)		
	50–59	1.600 (1.271–2.015)	16.003	< 0.001
	60–69	2.284 (1.786–2.920)	43.367	< 0.001
	70–	2.382 (1.686–3.368)	24.177	< 0.001
Gender	Female	1.00 (referent)		
	Male	0.699 (0.584–0.836)	15.407	< 0.001
Region	Rural	1.00 (referent)		
	Urban	1.171 (0.978–1.403)	2.949	0.086
Overweight/obesity	No	1.00 (referent)		
	Yes	1.749 (1.452–2.108)	34.557	< 0.001
Dyslipidemia	No	1.00 (referent)		
	Have	1.265 (1.038–1.543)	5.413	0.020
Diabetes	No	1.00 (referent)		
	Have	1.385 (1.071–1.790)	6.165	0.013
Fruit consumption	≤ 2d/w	1.00 (referent)		
	3-4d/w	0.442 (0.240–0.814)	6.868	0.009
	≥ 5d/w	0.687 (0.400–1.180)	1.849	0.174
Personal history of coronary heart disease	No	1.00 (referent)		
	Yes	2.263 (1.619–3.164)	22.847	< 0.001
Personal history of stroke	No	1.00 (referent)		
	Yes	1.212 (1.003–1.465)	3.955	0.047
Family history of hypertension	No	1.00 (referent)		
	Yes	2.445 (2.026–2.951)	86.722	< 0.001

Method: enter: age, gender, region; forward-conditional: overweight/obesity, dyslipidemia, diabetes, physical inactivity, alcohol consumption, fruit consumption, personal history of stroke, personal history of coronary heart disease, family history of stroke, family history of coronary heart disease, family history of hypertension

CI confidence interval, *OR* odds ratio

diabetes. These conditions also contributed to the high prevalence of hypertension.

It was also found that the influencing factors for hypertension in our study were increasing age, gender, living in urban areas, overweight/obesity, physical inactivity, and family history of hypertension. This was partly consistent with many other previous studies [12, 14–16]. Our study also showed that highly educated people usually had a lower rate of hypertension than those with low education levels. This finding was consistent with several other studies [23–25]. It may reflect that factors associated with hypertension are similar among different ethnicities. In addition, individuals with dyslipidemia or diabetes, and subjects with a personal history of stroke or coronary heart disease, were more likely to have hypertension. This reminds health practitioners that people with underlying chronic disease such as dyslipidemia and diabetes, or a history of cardiovascular disease, are at higher risk for hypertension and should thus be given close attention and careful monitoring. Therefore, studies to improve early detection and intervention of hypertension will become increasingly important. In a population-based cross-sectional study, Wang et al. [26] reported that galactosylation of immunoglobulin G is moderately associated with pre-hypertension and hypertension, and certain types of IgG N-glycan traits (sialylation, core fucosylation, and bisecting N-GlcNAc) are associated with hypertension. They may act as reliable biomarkers to detect people predisposed to hypertension in the early stage.

To reduce the cardiovascular disease burden in China, the prevention and treatment of hypertension with a goal of reducing prevalence and substantially increasing awareness, treatment, and control levels should be a public health priority. Overall, of those individuals with hypertension in our study, 47.4% were aware of their condition; of those who were aware of their condition, 78.8% were being treated. Awareness and treatment rates of hypertension were higher among women compared with men, regardless of age group or residential area. The awareness rate was nearly doubled compared with NNHS study, in which the overall awareness of hypertension was significantly greater for

Table 5 Multivariate logistic regression analyses on influence factors for treatment of hypertension

Category	Subcategory	Fully adjusted OR (95% CI)	Wald χ^2 value	*p* value
Age(years)	40–49	1.00 (referent)		
	50–59	1.346 (0.926–1.957)	2.424	0.120
	60–69	1.401 (0.956–2.053)	2.988	0.084
	70–	1.857 (1.054–3.270)	4.592	0.032
Gender	Female	1.00 (referent)		
	Male	0.579 (0.436–0.769)	14.233	< 0.001
Region	Rural	1.00 (referent)		
	Urban	1.758 (1.317–2.348)	14.622	< 0.001
Personal history of stroke	No	1.00 (referent)		
	Yes	1.637 (1.044–2.567)	4.612	0.032

Method: enter: age, gender, region; forward-conditional: education, diabetes, alcohol consumption, fruit consumption, personal history of stroke, personal history of coronary heart disease

CI confidence interval, *OR* odds ratio

women than for men 12]; however, the treatment rate was similar to that observed in our study. The awareness and treatment rates of hypertension in our present study were also higher than in many previous surveys such as the China Kadoorie Biobank Study [13] (30.5% awareness rate, 46.4% treatment rate) and the CHARLS survey conducted between June 2011 and March 2012 [15] (37.3% awareness rate, 21.1% treatment rate). The awareness rate in our survey was also relatively higher than the CCDRFS survey conducted from 2013 to 2014 16]; however, the treatment rate was lower than that observed in this study (31.9% awareness rate, 82.9% treatment rate). By contrast, among those treated in our survey, only 10.2% had their hypertension controlled. This rate was even lower than the national survey in 2002 12]. As shown in our survey, the awareness and treatment rates of hypertension increased with age. The aforementioned epidemiological surveys indicated that the awareness and treatment rates of hypertension have improved after combined efforts of public health practitioners and professionals in the last decade. In this aspect, Shao et al. [27] did a first attempt to map the medical care ecology of Beijing urban population, which would be useful for highlighting health care system reform, the formulation of better health care policy and improving medical education to meet the expanding demands of the people. Beyond that, Wang et al. [28] had developed a questionnaire-suboptimal health status questionnaire-25 (SHSQ-25), which could be used as an effective instrument for predictive, preventive and personalized medicine, and would enable clinicians and public health workers to predict an individual's predisposition, such as pre-hypertension in order to provide targeted preventive measures before the actual onset of the disease. However, the awareness and control rates in northeast China were still under the global average 29], and markedly below those of high-income countries 6], such as the US [74.4% (95% CI: 68.6%-79.4%) awareness and 46.5% (95% CI: 41.1%-51.9%) control rate in 2009 to 2010] [30] and Canada [82.5% (95% CI: 78.5%-86.0%) awareness and 79.0% (95% CI: 71.3%-86.7%) treatment in 2009] 31].

Our present findings also showed that subjects who were overweight/obesity or those with dyslipidemia or diabetes tended to be more aware of their hypertension than those without these conditions. Moreover, subjects with a personal history of stroke were more inclined to be aware of and receive treatment for hypertension; and, participants with a personal history of coronary heart disease were also more likely to be aware of and control their hypertension (< 140/90 mm Hg). Several studies have suggested that those who have a history of a cardiovascular event often pay close attention to their health, and are particularly concerned about cardiovascular disease risk factors, including hypertension. Moreover, these patients are more probably to comply with treatment with antihypertensive drugs for their hypertension [32, 33]. As our study showed, of all the hypertensives receiving drug therapy, 90.8% (95% CI: 88.2–92.8%) were using monotherapy, and only 9.2% (95% CI: 7.2–11.8%) were using combination therapy, and subjects using combination of antihypertensive medications compared with that of using monotherapy (OR = 2.924; 95% CI: 1.606, 5.325) were more likely to control their hypertension at less than 140/90 mm Hg. This result was in accordance with the PURE China investigation, reporting that few hypertensive individuals received more than one class of drugs, even when their blood pressure was not controlled with a single drug 34]. This current situation in southeast China may explain why control rates were unacceptably low in the hypertensive participants in our study.

Our study had some limitations. First, we used the surveillance definition of hypertension. Blood pressure was measured in a single visit (although two measurements were taken at that visit); and it is known that the overall prevalence of white-coat hypertension in the general population is 10–15% 35]. Thus, its value, as well as the prevalence of

Table 6 Multivariate logistic regression analyses on influence factors for control of hypertension

Category	Subcategory	Fully adjusted OR (95% CI)	Wald χ^2 value	*p* value
Age(years)	40–49	1.00 (Referent)		
	50–59	0.884 (0.482–1.622)	0.158	0.691
	60–69	0.777 (0.414–1.457)	0.621	0.431
	70–	0.334 (0.116–0.957)	4.172	0.041
Gender	Female	1.00 (referent)		
	Male	0.633 (0.392–1.021)	3.516	0.061
Region	Rural	1.00 (referent)		
	Urban	1.092 (0.702–1.697)	0.152	0.697
Dyslipidemia	No	1.00 (referent)		
	Yes	0.600 (0.375–0.960)	4.535	0.033
Antihypertensive medication use	Irregular	1.00 (referent)		
	Regular	1.428 (0.892–2.285)	2.203	0.138
Antihypertensive medication use	Monotherapy	1.00 (referent)		
	Combination	2.924 (1.606–5.325)	12.304	0.016
Family history of hypertension	No	1.00 (referent)		
	Yes	1.168 (0.733–1.860)	0.428	< 0.001
Family history of coronary heart disease	No	1.00 (referent)		
	Yes	1.698 (1.083–2.664)	5.315	0.021

Method: enter: age, gender, region; forward-conditional: dyslipidemia, antihypertensive medication use (irregular or regular), antihypertensive medication use (monotherapy or combination), family history of coronary heart disease, family history of hypertension

CI confidence interval, *OR* odds ratio

hypertension based partly on the measured blood pressure, may have been overestimated. However, there was a systematic review and meta-analysis of prospective studies concluding that white-coat hypertension was also associated with long-term risks of cardiovascular diseases and total mortality compared with normotension 35]. Second, the factor of hypertension-related dietary habits such as salt intake was based on dietary recall instead of a 24-h urinary sodium excretion test. Finally, because our study was a cross-sectional survey, we could not establish cause-and-effect relationships between the observed associations.

Conclusions

In conclusion, our results showed a high prevalence of hypertension among adults aged 40 years and above in northeast China. Although awareness and treatment of hypertension improved over the last decade, the control rate of hypertension remained disproportionately and unacceptably low among hypertensive individuals. Faced with this epidemiological transition, we need innovative strategies that consider the influencing factors to prevent and control hypertension, including promoting healthier diets and lifestyles, reducing inappropriate use of antihypertensive drugs, and strengthening the primary care system.

What is known about topic?

- Hypertension has been recognized as a major preventable risk factor for cardiovascular disease.
- Limited studies on the influencing factors associated with the awareness, treatment, and control of hypertension have been undertaken so far in northeast China.
- Knowledge about this information is crucial for informing hypertension prevention and control strategies.

What this study adds?

- This study showed a high prevalence of hypertension in northeast China.
- Although awareness and treatment rates improved over the last decade, the control rate remained disproportionately and unacceptably low.
- We need innovative strategies that consider the influencing factors to prevent and control hypertension, including promoting healthier diets and lifestyles, reducing inappropriate use of antihypertensive drugs, and strengthening the primary care system.

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Compliance with Ethical Standards

Conflict of interest The authors declare no conflict of interest.

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