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Epidemiological status quo of hypertension in elderly population: an investigation conducted in Changchun, Jilin Province, China

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Abstract

Objectives: To investigate the epidemiological status quo of hypertension in the elderly population in Changchun, China, and provide a reference for the prevention and control strategies of hypertension in this region.

Design: A cross-sectional study in 10 districts in Changchun as a part of a comprehensive project in Northeast China.

Participants and setting: A total of 6,846 participants who were ≥60 years old were selected using a random sampling method.

Main outcome measures: The epidemiological status quo of hypertension.

Results: The prevalence of hypertension in Changchun was 52.9%, of which 87.7% had been diagnosed with hypertension before the study, 69.5% were currently taking antihypertensive medications, and 67.2% had effective blood pressure control. Obesity, widowed, history of diseases, and family history of hypertension were risk factors of hypertension; people who were obesity, had a personal history of heart coronary disease, or a family history of hypertension were more likely to recognize their prevalence of hypertension; but people with a history of diabetes, hyperlipidemia, or a family history of hypertension were not easy to control blood pressure within the normal range. Among people taking antihypertensive medications, 92.6% used a single drug, and calcium channel blockers (CCB) was the most commonly used antihypertensive medications in monotherapy.

Conclusion: The prevalence of hypertension in the elderly population in Changchun, China is lower than the national average, and the awareness, treatment, and control of

hypertension are at a higher level, indicating that the prevention and control of hypertension in local health organizations in Changchun have been achieved. However, in the use of antihypertensive medications, the combined use of drugs is relatively low, suggesting that the guidance and education of scientific medication are required for strengthening.

Strengths and limitations of this study

1. This study investigated the epidemiological status quo of hypertension by assessing the prevalence, awareness, treatment, and control of hypertension in elderly population in China.

2. A large number of participants were included in the study.

3. The data in this study were based on self-reported questionnaires, so the accuracy of the reported results cannot be determined.

4. The temporality of the association cannot be determined because of the cross-sectional nature of the design of this study.

Introduction

Hypertension afflicts about 1.5 billion people globally, generating $370 billion of economic burden [1, 2]. A national survey performed from 2003 to 2012 has shown that the prevalence of hypertension continues to increase, and the risk factors of hypertension are also increasing in China [3]. In 2012, the prevalence of hypertension among the population over the age of 18 was 23.2% in China: 46.9% knew about their conditions, 40.7% received antihypertensive medications, and 15.3% controlled blood pressure among patients with hypertension [4]. Hypertension has been one of the leading risk factors of mortality in China.

The status quo is different in different regions in China, although the status quo of patients with hypertension, including awareness, treatment, and control, has increased in recent years [5, 6, 7]. Previous regional studies on hypertension mainly focused on the more developed southeast coast. Jilin Province is located in the northeast of China, and the winter in Jilin Province is cold and long. Changchun, the capital of Jilin Province, has been a heavy industry city since 1949, impacting a special environment and lifestyle for Changchun people [8]. Blood pressure increases steadily with age, leading to that hypertension is more common in people over the age of 60 years with the increasing of aging [9]. However, there are few studies focusing on the elderly in China. We, in this study, investigated the epidemiological status quo of hypertension by assessing the prevalence, awareness, treatment, and control of hypertension in elderly population in China.

Methods

1. Study design and enrollment of participants

The Comprehensive Project of Paradigm for Major Chronic Disease Prevention and Control Technology in Northeast China was conducted from July 1, 2019 to Oct 31, 2019 to investigate major chronic non-communicable disease prevention and control technology in Northeast China. This study was approved by the Ethics Committee of China Medical University. Data from 11,119 participants were inspected, indicating that the quality of the data was generally high because data from less than 0.3% of participants were missing. We, according to the principle of random sampling, randomly selected 10 districts as the survey locations in Changchun, Jilin Province, China. Thereafter, we performed this survey, with the help of the staff of the community health centers. We enrolled 6,871 participants according to the following criteria: (1) over the age of 60 years, (2) with registered permanent residence (a record officially identifying area residents), and (3) living in Changchun for more than 6 months. Each participant filled out a questionnaire, provided a written informed consent, and was performed a physical examination. After participants with incomplete information were removed, 6,846 participants were remained in this study.

2. Data collection

The questionnaire was designed by the Comprehensive Demonstration Research Project Group of Major Chronic Noncommunicable Disease Prevention and Control

Technology in Northeast China, and staff collecting information from eligible participants was trained by the Project Group. The questionnaire included the basic characteristics of the participants (age, sex, ethnicity, place of residence, marital status, education level, occupation, and annual income), health behaviors (smoking, drinking, and physical exercise), history of diseases (hypertension, diabetes, hyperlipidemia, coronary heart disease, and stroke), and medication history. The staff performed anthropometric measurements, including height, weight, and blood pressure. The blood pressure was measured twice on the right upper arm of the participants after sitting for 5 minutes using electronic sphygmomanometers. The sphygmomanometers and weight scales were calibrated by the Bureau of Quality and Technical Supervision before use.

3. Variable definition

According to 2018 Chinese Guidelines for the Management of Hypertension [10], hypertension was defined as a mean systolic blood pressure (SBP) ≥140 mm Hg and/or a mean diastolic blood pressure (DBP) ≥90 mm Hg, or self-reported use of antihypertensive medications in the past 2 weeks. Stage 2 or stage 3 hypertension was defined as SBP ≥160 mm Hg and/or DBP ≥100 mmHg. Hypertension awareness was defined as knowing that participants had been diagnosed with hypertension before this study. Hypertension treatment was defined as patients with hypertension currently taking antihypertensive medications. Hypertension control was defined as effective control of blood pressure (SBP <140 mm Hg and DBP <90 mm Hg) in hypertensive

patients.

Body mass index (BMI) was obtained by dividing body weight by the square of height. According to the recommendations of the China Obesity Working Group [11], BMI was divided into the following categories: underweight: <18.5; normal: 18.5–23.9; overweight: 24.0–27.9; and obesity: ≥28.0.

4. Statistical analysis

The database was established by Epidata3.1, and SPSS 21.0 was used for statistical analysis. The description of measurement data was expressed by mean ± standard deviation; the comparison between measurement data was performed using t test; the description of count data was expressed by rate or composition ratio; and the comparison between count data was by chi-square test. Multivariate Logistic regression was used to analyze the risk factors related to hypertension and the relationship of population characteristics with hypertension awareness, treatment and control. $P<0.05$ indicated that the difference was statistically significant.

5. Patient and public involvement

Patients and public were not involved in this study.

Results

1. Multi-level analysis of the prevalence, awareness, treatment and control of

hypertension

A total of 6,846 participants (2,772 males, 4,074 females) were enrolled in this study, with a mean age of 70.28 years (SD 6.109). Among them, 6,672 (97.5%) are of Han nationality, 3,988 (58.3%) had retired, and 3,624 (52.9%) had hypertension (292 [4.3%] patients had stage 2 or stage 3 hypertension). There were differences in age, sex, BMI, marital status, occupation, educational level, annual income, physical exercise, smoking, family history of hypertension between hypertensive participants and non-hypertensive participants, and history of other diseases (coronary heart disease, stroke, diabetes, and hyperlipidemia). The proportion of female participants suffering from hypertension was higher than that of male ones; Compared with non-hypertensive participants, hypertensive participants exhibited high proportions in the following items (widowed, overweight or obesity, engaged in manual work, an annual income of less than ¥30,000, had a lower educational level, had history of coronary heart disease, stroke, diabetes, hyperlipidemia, or family history of hypertension). The age of patients with stage 2 or stage 3 hypertension was significantly higher than that of patients with stage 1 hypertension. The patients with stage 2 or stage 3 hypertension significantly differed from the ones with stage 1 hypertension in marital status, annual income, physical exercise, and history of other diseases (stroke, diabetes, and hyperlipidemia) (Table 1).

Among the hypertensive patients, 3,179 (87.7%) were aware of hypertension because they were diagnosed with hypertension before this survey, 2,518 (69.5%) were treated because they were currently taking antihypertensive medications, and

2,434(67.2%) were effective in controlling blood pressure. The treatment rate in female patients with hypertension was statistically higher than that in male ones (P<0.05). Compared with normal or underweight participants, overweight or obese ones had significantly high rates of awareness and treatment of hypertension (P<0.05). Participants with diabetes or hyperlipidemia had a significantly higher control rate of hypertension than those without diabetes or hyperlipidemia. Participants with stroke had a significantly higher awareness rate of hypertension than those without stroke. Participants with coronary heart disease or hypertension had significantly higher awareness, treatment, and control of hypertension than those without a history of coronary heart disease or a family history (Table 2).

2. Multivariate logistic analysis of prevalence, awareness, treatment, and control of hypertension

Multivariate logistic regression was used to analyze the association of population characteristics with the prevalence, awareness, treatment, and control of hypertension. We identified that BMI, marital status, occupation, annual income, history of disease (coronary heart disease, diabetes, and hyperlipidemia), and family history of hypertension were all associated with hypertension. In detail, overweight (OR=1.620, 95%CI: 1.457–1.802) or obesity (OR=2.524, 95%CI: 2.177–2.927), widowed (OR=1.296, 95%CI: 1.098–1.530), coronary heart disease (OR=1.415, 95%CI: 1.207–1.659), diabetes (OR=1.668, 95%CI: 1.502–1.853), hyperlipidemia (OR=1.128, 95%CI: 1.022–1.245), and family history of hypertension (OR=4.013, 95%CI: 3.283–

4.906) were revealed as risk factors of hypertension. However, underweight people (OR=0.571, 95%CI: 0.378–0.863), people who were engaged in mental work (OR=0.806, 95%CI: 0.685–0.948), or people with an annual income from ¥30,000 to ¥50,000 (OR=0.838, 95%CI: 0.753–0.932), had a lower risk of hypertension than normal people, people who were engaged in manual work, or people with an annual income of less than ¥30,000 (Table 3).

For awareness of hypertension, people with obesity (OR=1.426, 95%CI: 1.057–1.923), exercise regularly (OR=1.354, 95%CI: 1.061–1.728), personal history of heart coronary disease (OR=1.663, 95%CI: 1.170–2.364), or with a family history of hypertension (OR=2.174, 95%CI: 1.512–3.125) were more likely to recognize their risks of hypertension; whereas, people who were divorced/separated (OR=0.317, 95%CI: 0.159–0.633), engaged in mental work (OR=0.669, 95%CI: 0.484–0.923), or had a high annual income (¥30,000–50,000: OR=0.657, 95%CI: 0.523–0.823; > ¥50,000: OR=0.399, 95%CI:0.278–0.573), were more likely to ignore their risks of hypertension.

With respect to treatment of hypertension, women paid more attention to the treatment of hypertension than men (OR=1.305, 95%CI: 1.101–1.546). People with overweight (OR=1.396, 95%CI: 1.187–1.643) or obesity (OR=1.700, 95%CI: 1.378–2.097), exercise regularly (OR=1.499, 95%CI: 1.260–1.784), or with a family history of hypertension (OR=1.342, 95%CI: 1.083–1.663) were more active in the treatment of hypertension; however, people with more than ¥50,000 annual income (OR=0.661, 95%CI: 0.494–0.886) were more likely to ignore hypertension treatment.

In terms of control of hypertension, the effect of hypertension control for widowed people was poor (OR=0.668, 95%CI: 0.536–0.834). People who exercised regularly (OR=1.310, 95%CI: 1.101–1.558) had better blood pressure control, but people with an annual income of more than ¥50,000 (OR=0.470, 95%CI: 0.354–0.624), a history of diabetes (OR=0.826, 95%CI: 0.713–0.956), hyperlipidemia (OR=0.727, 95%CI: 0.629–0.840), or a family history of hypertension (OR=0.672, 95%CI: 0.554–0.815) were difficult in controlling blood pressure within the normal range (Table 4).

3. Analysis of use of antihypertensive medications in patients with hypertension

Among people taking antihypertensive medications, 2,332 (92.6%) used a single drug, and 186 (7.4%) used two or more combined drugs. Among the hypertensive population receiving medical treatment, 1,945 (77.2%) had their blood pressure under control. Among patients with grade 2 or grade 3 hypertension, 151(51.7%) took antihypertensive medications. Among the five commonly used antihypertensive medications, 73.8% people used calcium channel blockers (CCB) was the highest, 10.8% used angiotensin receptor blockers (ARB), 6.7% used traditional Chinese medicine (TCM), 6.1% used beta blockers (BB), 4.8% used angiotensin converting enzyme inhibitors (ACEI), and 3.3 % used diuretics (DIU). There was no statistically significant difference between male and female in the use of drugs, and there was no difference in the composition ratio of single medication and combination medication in terms of sex (Table 5).

Discussion

Our research is the latest report on the prevalence, awareness, treatment, and control of hypertension among elderly population in Changchun City, Jilin Province, China. The study found that the prevalence of hypertension among the elderly population in Changchun City was 52.9%, slightly higher than that of the elderly in the national large-scale survey in 2017 (50.1%) [7], but lower than that of the elderly population in Jilin Province in 2015 (56.6%) [12]. Compared with developed countries, such as the United States [13], the prevalence of hypertension in Changchun City was still at a relatively high level. Patients with stage 2 or stage 3 hypertension accounted for 4.3%, which was lower than a report from the United States in 2019 (7.3%) [14], and also lower than a domestic survey in the same period (5.7%) [15]. This discrepancy may result from the fact that the Jilin Provincial Government has addressed the primary management of hypertension and patient education and increased medical insurance funds in the past two years. Compared with those in other regions in China [16], the awareness rate, treatment rate, and control rate of patients with hypertension in this region were at a relatively high level, which may be benefit from the vigorous promotion and supervision of local health organizations, and importance patient's attention to hypertension.

Our research further found that, in agreement with other studies [17, 18], overweight or obesity, widowed, coronary heart disease, diabetes, and hyperlipidemia were all risk factors for hypertension, However, similar to the previous results in Jilin

Province [12], the proportion of women suffering from high blood pressure was higher than that of men. This result was different from that of the national research report [19]. Consistent with our study, clinical studies have shown that genetic factors are associated with the onset of hypertension; thus, people with a family history of hypertension are more susceptible to hypertension [20]. Although smoking and drinking are considered to be common risk factors for hypertension [21], our study did not find smoking and drinking as the risk factors, partially because of the small number of people smoking and drinking among the elderly in this region. We also found that, compared with men, women had better treatment and control of hypertension, which may contribute to women attaching more importance to physical health than men and having better treatment compliance. Although people with a personal history of hyperlipidemia or a family history of hypertension were more likely to recognize that they had high blood pressure, their hypertension control effect was not ideal, in concert with the results of a multi-center registration study based on hospital patients in China [22]. Therefore, more active and effective screening and management are necessary for people with hypertension.

Our research found that 92.6% of people taking antihypertensive medications were treated with a single drug, and 77.2% of them blood pressure was controlled. Previous study reported that the combined medication has better control effect on hypertension than single medication [23]. However, only 7.4% of people used combined medication treatment strategy, which may be related to the long-term medication habits of patients and the prescription habits of primary doctors. Among the commonly used

antihypertensive medications, CCB was the most commonly used, which was consistent with previous reports and may be related to the guideline recommendations and drug costs [24].

Our research provides some inspiration for the prevention and control strategies of hypertension in this region. Strengthening the monitoring of hypertensive people and integrating the management of hypertension into the routine primary health care system are need for primary health institutions in future interventions. Strengthening the education of hypertension prevention and control, promoting drug treatment and non-drug treatment strategies, and emphasizing the importance of combined medication and change public awareness are required for the government.

Our research has some limitations. Firstly, our research data were based on self-reported questionnaires; thus, the accuracy of the reported results cannot be determined. Secondly, because of the cross-sectional nature of the design of this study, the temporality of the association cannot be determined, and long-term follow-up of the population are needed to conduct. Thirdly, the potential impact of the 2017 American College of Cardiology/American Heart Association Guidelines on the prevention and treatment of hypertension in the Chinese population needs to be evaluated.

Conclusions

The prevalence of hypertension in the elderly population in Changchun City, Jilin

Province, China is lower than the national average, and the awareness, treatment, and control of hypertension are at a higher level, indicating that the prevention and control of hypertension in local health organizations in Changchun City have been achieved. However, in the use of antihypertensive medications, the combined use of drugs is relatively low, suggesting that the guidance and education of scientific medication are required for strengthening.

Contributors: Yawen Liu and Yi Cheng were involved in the study's conception and design; Yaxuan Ren, Jikang Shi, Yichun Qiao, Yulu Gu, Yong Li, Yunkai Liu collected the data; Yaxuan Ren, Jikang Shi, Yichun Qiao, Yulu Gu performed data analysis and interpretation; Yaxuan Ren wrote the paper; All authors read and approved the final manuscript.

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Patient consent: Not required.

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Table 1 General characteristics of study participants aged ≥60 years

Characteristics	Total (n=6846)	No hypertension (n=3222)	All hypertension (n=3624)	Stage 2 or stage 3 hypertension (n=292)	*P* value
Age(years)	70.28±6.109	69.58±5.879	70.89±6.243	72.07±6.503	<0.001[a]
Sex					0.002
Male	2772(40.5%)	1363(42.3%)	1409(38.9%)	111(38.0%)	
Female	4074(59.5%)	1859(57.7%)	2215(61.1%)	181(62.0%)	
Ethnicity					0.523
Han	6672(97.5%)	3140(97.5%)	3532(97.5%)	281(96.2%)	
Others	174(2.5%)	82(2.5%)	92(2.5%)	11(3.8%)	
BMI					<0.001
Underweight	109(1.6%)	74(2.3%)	35(1.0%)	6(2.1%)	
Normal	2595(37.9%)	1445(44.8%)	1150(31.7%)	98(33.6%)	
Overweight	3029(44.2%)	1334(41.4%)	1695(46.8%)	129(44.2%)	
Obesity	1113(16.3%)	369(11.5%)	744(20.5%)	59(20.2%)	
Marital status					0.005[a]
Unmarried	33(0.5%)	17(0.5%)	16(0.4%)	2(0.7%)	
Married/Cohabitation	6037(88.2%)	2886(89.6%)	3151(86.9%)	292(78.4%)	
Divorced/ Separated	83(1.2%)	36(1.1%)	47(1.3%)	2(0.7%)	
Widowed	693(10.1%)	283(8.8%)	410(11.3%)	59(20.2%)	
Occupation					0.005
Manual worker	1892(27.6%)	855(26.5%)	1037(28.6%)	97(33.2%)	
Mental worker	966(14.1%)	498(15.5%)	468(12.9%)	39(13.4%)	
Retirement	3988(58.3%)	1869(58.0%)	2119(58.5%)	156(53.4%)	
Educational level					0.017
Primary school or below	1084(15.80%)	469(14.60%)	615(17.00%)	53(18.2%)	
Junior middle school	2363(34.50%)	1094(34.00%)	1269(35.00%)	106(36.3%)	
Senior middle school	1881(27.50%)	908(28.20%)	973(26.80%)	71(24.3%)	
Undergraduate or above	1482(21.60%)	731(22.70%)	751(20.70%)	60(20.5%)	
Unknown	36(0.50%)	20(0.60%)	16(0.40%)	2(0.7%)	
Annual income (¥)					<0.001[a]
<30,000	3524(51.5%)	1575(48.9%)	1949(53.8%)	152(52.1%)	
30,000~50,000	2892(42.2%)	1456(45.2%)	1436(39.6%)	106(36.3%)	
>50,000	430(6.3%)	191(5.9%)	239(6.6%)	34(11.6%)	
Physical exercise					0.032[a]
Never	1376(20.1%)	628(19.5%)	748(20.6%)	82(28.1%)	
Sometimes	194(2.8%)	76(2.4%)	118(3.3%)	11(3.8%)	
Often	5276(77.1%)	2518(78.2%)	2758(76.1%)	199(68.2%)	
Current smoking	911(13.3%)	462 (14.3%)	449 (12.4%)	35(12.0%)	0.010
Current drinking	828(12.1%)	410(12.7%)	418 (11.5%)	35(12.0%)	0.071
Systolic blood pressure(mm Hg)	132.32±12.043	126.78±8.274	137.25±12.724	167.49±10.295	<0.001[a]
Diastolic blood	77.34±8.055	74.73±7.048	79.66±8.184	87.85±11.225	<0.001[a]

pressure(mm Hg)					
History of coronary heart disease	785(11.5%)	290(9.0%)	495(13.7%)	49(16.8%)	<0.001
History of stroke	203(3.0%)	82(2.5%)	121(3.3%)	17(5.8%)	0.031[a]
History of diabetes	2275(33.2%)	867(26.9%)	1408(38.9%)	138(47.3%)	<0.001[a]
History of hyperlipidemia	3080(45.0%)	1368(42.5%)	1712(47.2%)	159(54.5%)	<0.001[a]
Family history of hypertension	672(9.8%)	128(4.0%)	544(15.0%)	52(17.8%)	<0.001

a: the difference between stage 1 hypertension and stage 2 or stage 3 hypertension is statistically significant

Table 2 Investigation of awareness, treatment, control of hypertension

	Awareness (n=3179)	Treatment (n=2518)	Control (n=2434)
Age(years)	70.90±6.209	70.81±6.076	70.76±6.134
P value	0.741	0.221	0.081
Sex			
Male	1220(38.4%)	948(37.6%)	925(38.0%)
Female	1959(61.6%)	1570(62.4%)	1509(62.0%)
P value	0.054	0.012	0.065
Ethnicity			
Han	3097(97.4%)	2450(97.3%)	2380(97.8%)
Others	82(2.6%)	68(2.7%)	54(2.2%)
P value	0.413	0.207	0.052
BMI			
Underweight	27(0.8%)	18(0.7%)	19(0.8%)
Normal	987(31.0%)	737(29.3%)	772(31.7%)
Overweight	1496(47.1%)	1204(47.8%)	1146(47.1%)
Obesity	669(21.0%)	559(22.2%)	497(20.4%)
P value	0.010	<0.001	0.419
Marital status			
Unmarried	12(0.4%)	10(0.4%)	11(0.5%)
Married/Cohabitation	2771(87.2%)	2198(87.3%)	2144(88.1%)
Divorced/ Separated	35(1.1%)	29(1.2%)	31(1.3%)
Widowed	361(11.4%)	281(11.2%)	248(10.2%)
P value	0.017	0.574	0.024
Occupation			
Manual worker	917(28.8%)	728(28.9%)	684(28.1%)
Mental worker	387(12.2%)	312(12.4%)	295(12.1%)
Retirement	1875(59.0%)	1478(58.7%)	1455(59.8%)
P value	0.002	0.354	0.039
Educational level			
Primary school or below	542(17.0%)	422(16.8%)	430(17.7%)
Junior middle school	1109(34.9%)	882(35.0%)	853(35.0%)
Senior middle school	859(27.0%)	681(27.0%)	652(26.8%)
Undergraduate or above	653(20.5%)	524(20.8%)	488(20.0%)
Unknown	16(0.5%)	9(0.4%)	11(0.5%)
P value	0.531	0.793	0.438
Annual income (¥)			
<30,000	1751(55.1%)	1383(54.9%)	1339(55.0%)
30,000~50,000	1240(39.0%)	985(39.1%)	973(40.0%)
>50,000	188(5.9%)	150(6.0%)	122(5.0%)
P value	<0.001	0.022	<0.001
Physical exercise			
Never	642(20.2%)	472(18.7%)	473(19.4%)

Sometimes	96(3.0%)	78(3.1%)	64(2.6%)
Often	2441(76.8%)	1968(78.2%)	1897(77.9%)
P value	0.014	<0.001	<0.001
Current smoking	390(12.3%)	320(12.7%)	294(12.1%)
P value	0.299	0.205	0.224
Current drinking	368(11.6%)	283(11.2%)	281(11.5%)
P value	0.454	0.216	0.513
Systolic blood pressure(mm Hg)	135.69±12.078	135.56±11.586	130.94±6.328
P value	<0.001	<0.001	<0.001
Diastolic blood pressure(mm Hg)	79.21±7.917	79.13±7.821	77.70±6.830
P value	<0.001	<0.001	<0.001
History of coronary heart disease	456(14.3%)	362(14.4%)	308(12.7%)
P value	0.001	0.032	0.007
History of stroke	113(3.6%)	85(3.4%)	76(3.1%)
P value	0.030	0.471	0.174
History of diabetes	1243(39.1%)	982(39.0%)	905(37.2%)
P value	0.222	0.407	0.002
History of hyperlipidemia	1487(46.8%)	1172(46.5%)	1089(44.7%)
P value	0.074	0.109	<0.001
Family history of hypertension	508(16.0%)	408(16.2%)	317(13.0%)
P value	<0.001	0.001	<0.001

Table 3 Multivariate logistic regression analysis of factors associated with hypertension

	β	*SE*	χ^2	*P*	*OR*	*95%CI*
Sex (Female)	0.093	0.058	2.570	0.109	1.097	0.980–1.229
BMI						
Underweight	-0.560	0.211	7.071	0.008	0.571	0.378–0.863
Normal			189.417	<0.001	1	
Overweight	0.483	0.054	79.047	<0.001	1.620	1.457–1.802
Obesity	0.926	0.076	150.111	<0.001	2.524	2.177–2.927
Marital status						
Unmarried	-0.046	0.358	0.017	0.897	0.955	0.473–1.927
Married/Cohabitation			9.446	0.024	1	
Divorced/Separated	0.080	0.228	0.125	0.724	1.084	0.694–1.694
Widowed	0.259	0.085	9.348	0.002	1.296	1.098–1.530
Occupation						
Manual worker			10.616	0.005	1	
Mental worker	-0.216	0.083	6.800	0.009	0.806	0.685–0.948
Retirement	0.022	0.060	0.137	0.712	1.023	0.908–1.151
Educational level						
Primary school or below			2.865	0.581	1	
Junior middle school	-0.055	0.077	0.503	0.478	0.947	0.814–1.101
Senior middle school	-0.086	0.081	1.121	0.290	0.918	0.783–1.076
Undergraduate or above	-0.116	0.088	1.755	0.185	0.891	0.750–1.057
Unknown	-0.386	0.347	1.234	0.267	0.680	0.344–1.343
Annual income (¥)						
<30,000			15.312	<0.001	1	
30,000~50,000	-0.177	0.054	10.621	0.001	0.838	0.753–0.932
>50,000	0.133	0.107	1.540	0.215	1.142	0.926–1.409
Physical exercise						
Never			5.368	0.068	1	
Sometimes	0.208	0.161	1.674	0.196	1.231	0.899–1.686
Often	-0.090	0.062	2.071	0.150	0.914	0.809–1.033
Current smoking	-0.109	0.082	1.777	0.183	0.897	0.764–1.053
Current drinking	-0.011	0.087	0.017	0.897	0.989	0.834–1.173
History of coronary heart disease	0.347	0.081	18.334	<0.001	1.415	1.207–1.659
History of stroke	0.132	0.151	0.766	0.381	1.141	0.849–1.533
History of diabetes	0.512	0.054	90.991	<0.001	1.668	1.502–1.853
History of hyperlipidemia	0.120	0.050	5.708	0.017	1.128	1.022–1.245
Family history of hypertension	1.390	0.102	183.960	<0.001	4.013	3.283–4.906

1: the reference cell

Table 4 Individual characteristics associated with awareness, treatment, and control of hypertension

	Awareness		Treatment		Control	
	OR(95%CI)	*P*	*OR(95%CI)*	*P*	*OR(95%CI)*	*P*
Sex (Female)	1.258(0.994–1.594)	0.056	1.305(1.101–1.546)	0.002	1.254(1.060–1.484)	0.008
BMI						
Underweight	0.460(0.200–1.056)	0.067	0.565(0.285–1.122)	0.103	0.545(0.272–1.092)	0.087
Normal	1	0.011	1	<0.001	1	0.302
Overweight	1.239(0.986–1.556)	0.066	1.396(1.187–1.643)	<0.001	1.052(0.893–1.239)	0.546
Obesity	1.426(1.057–1.923)	0.020	1.700(1.378–2.097)	<0.001	1.032(0.843–1.263)	0.761
Marital status						
Unmarried	0.445(0.139–1.421)	0.172	0.850(0.304–2.377)	0.757	1.066(0.365–3.116)	0.907
Married/Cohabitation	1	0.006	1	0.342	1	0.005
Divorced/ Separated	0.317(0.159–0.633)	0.001	0.606(0.331–1.110)	0.105	0.938(0.504–1.747)	0.841
Widowed	0.937(0.673–1.303)	0.698	0.902(0.716–1.136)	0.382	0.668(0.536–0.834)	<0.001
Occupation						
Manual worker	1	0.005	1	0.371	1	0.072
Mental worker	0.669(0.484–0.923)	0.014	0.845(0.663–1.079)	0.177	0.937(0.738–1.189)	0.593
Retirement	1.064(0.828–1.367)	0.626	0.971(0.815–1.156)	0.741	1.158(0.976–1.374)	0.093
Educational level						
Primary school or below	1	0.926	1	0.578	1	0.804
Junior middle school	0.990(0.728–1.346)	0.948	1.086(0.875–1.348)	0.454	0.907(0.730–1.126)	0.375
Senior middle school	1.115(0.802–1.551)	0.516	1.145(0.909–1.440)	0.250	0.891(0.708–1.121)	0.325
Undergraduate or above	1.061(0.745–1.511)	0.744	1.178(0.916–1.514)	0.201	0.853(0.665–1.095)	0.213
Unknown	-	0.998	0.661(0.239–1.829)	0.426	0.878(0.296–2.599)	0.814
Annual income (¥)						
<30,000	1	<0.001	1	0.010	1	<0.001
30,000~50,000	0.657(0.523–0.823)	<0.001	0.855(0.728–1.002)	0.053	0.913(0.780–1.069)	0.259
>50,000	0.399(0.278–0.573)	<0.001	0.661(0.494–0.886)	0.005	0.470(0.354–0.624)	<0.001
Physical exercise						
Never	1	0.002	1	<0.001	1	<0.001
Sometimes	0.666(0.395–1.124)	0.128	1.074(0.708–1.629)	0.737	0.743(0.497–1.111)	0.148
Often	1.354(1.061–1.728)	0.015	1.499(1.260–1.784)	<0.001	1.310(1.101–1.558)	0.002
Current smoking	0.979(0.698–1.374)	0.902	1.343(1.046–1.725)	0.021	0.975(0.766–1.240)	0.834
Current drinking	1.243(0.861–1.795)	0.246	0.890(0.688–1.153)	0.378	1.109(0.857–1.435)	0.431
History of heart coronary disease	1.663(1.170–2.364)	0.005	1.198(0.962–1.492)	0.106	0.857(0.699–1.052)	0.140
History of stroke	1.824(0.876–3.799)	0.108	0.989(0.660–1.481)	0.956	0.888(0.604–1.306)	0.546
History of diabetes	1.052(0.850–1.302)	0.638	0.986(0.849–1.146)	0.854	0.826(0.713–0.956)	0.011
History of hyperlipidemia	0.796(0.647–0.979)	0.031	0.845(0.730–0.979)	0.025	0.727(0.629–0.840)	<0.001
Family history of hypertension	2.174(1.512–3.125)	<0.001	1.342(1.083–1.663)	0.007	0.672(0.554–0.815)	<0.001

1: the reference cell

Table 5 The use of antihypertensive medications among treated population with hypertension

		Total	Male	Female	*P* value
Monotherapy	DIU	84(3.3%)	33(3.5%)	51(3.2%)	0.417
	CCB	1859(73.8%)	697(73.5%)	1162(74.0%)	0.411
	ACEI	121(4.8%)	55(5.8%)	66(4.2%)	0.044
	BB	154(6.1%)	53(5.6%)	101(6.4%)	0.222
	ARB	271(10.8%)	112(11.8%)	159(10.1%)	0.105
	TCM	169(6.7%)	51(5.4%)	118(7.5%)	0.022
	Others	61(2.4%)	23(2.4%)	38(2.4%)	0.545
Total monotherapy		2332(92.6%)	877(92.5%)	1455(92.7%)	0.468
Combination therapy		186(7.4%)	71(7.5%)	115(7.3%)	

DIU: diuretics; CCB: calcium channel blockers; ACEI: angiotensin converting enzyme inhibitors; BB: beta blockers; ARB: angiotensin receptor blockers; TCM: traditional Chinese medicine

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	7

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	–
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	–
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	8
		Cross-sectional study—Report numbers of outcome events or summary measures	–
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Epidemiological status quo of hypertension in elderly population: an investigation conducted in Changchun, Jilin Province, China

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Abstract

Objectives: To investigate the epidemiological status quo of hypertension in the elderly population in Changchun, China, and provide a reference for the prevention and control strategies of hypertension in this region.

Design: A cross-sectional study in 10 districts in Changchun as a part of a comprehensive project in Northeast China.

Participants and setting: A total of 6,846 participants who were ≥60 years old were selected using a random sampling method.

Main outcome measures: The epidemiological status quo of hypertension.

Results: The prevalence of hypertension in Changchun was 52.6%, of which 87.6% had been diagnosed with hypertension before the study, 69.1% were currently taking antihypertensive medications, and 66.9% had effective blood pressure control. Obesity, widowed, history of diseases, and family history of hypertension were risk factors of hypertension (all $P<0.05$); people who were obesity, had a personal history of heart coronary disease, or a family history of hypertension were more likely to recognize their prevalence of hypertension(all $P<0.05$); but people with a history of diabetes, hyperlipidemia, or a family history of hypertension were not easy to control blood pressure within the normal range(all $P<0.05$). Among people taking antihypertensive medications, 92.6% used a single drug, and calcium channel blockers (CCB) was the most commonly used antihypertensive medications in monotherapy.

Conclusion: The prevalence of hypertension in the elderly population in Changchun,

China is lower than the national average, and the awareness, treatment, and control of hypertension are at a higher level, indicating that the prevention and control of hypertension in local health organizations in Changchun have been achieved. However, in the use of antihypertensive medications, the combined use of drugs is relatively low, suggesting that the guidance and education of scientific medication are required for strengthening.

Strengths and limitations of this study

1. This study investigated the epidemiological status quo of hypertension by assessing the prevalence, awareness, treatment, and control of hypertension in elderly population in China.

2. A large number of participants were included in the study.

3. The data in this study were based on self-reported questionnaires, so the accuracy of the reported results cannot be determined.

4. The temporality of the association cannot be determined because of the cross-sectional nature of the design of this study.

Introduction

Hypertension afflicts about 1.5 billion people globally, generating $370 billion of economic burden [1, 2]. A national survey performed from 2003 to 2012 has shown that the prevalence of hypertension continues to increase, and the risk factors of hypertension are also increasing in China [3]. In 2012, the prevalence of hypertension among the population over the age of 18 was 23.2% in China: 46.9% knew about their conditions, 40.7% received antihypertensive medications, and 15.3% controlled blood pressure among patients with hypertension [4]. Hypertension has been one of the leading risk factors of mortality in China.

The status quo is different in different regions in China, although the status quo of patients with hypertension, including awareness, treatment, and control, has increased in recent years [5, 6, 7]. Previous regional studies on hypertension mainly focused on the more developed southeast coast. Jilin Province is located in the northeast of China, and the winter in Jilin Province is cold and long. Changchun, the capital of Jilin Province, has been a heavy industry city since 1949, impacting a special environment and lifestyle for Changchun people [8]. Blood pressure increases steadily with age, leading to that hypertension is more common in people over the age of 60 years with the increasing of aging [9]. However, there are few studies focusing on the elderly in China. We, in this study, investigated the epidemiological status quo of hypertension by assessing the prevalence, awareness, treatment, and control of hypertension in elderly population in China.

Methods

1. Study design and enrollment of participants

The Comprehensive Project of Paradigm for Major Chronic Disease Prevention and Control Technology in Northeast China was conducted from July 1, 2019, to Oct 31, 2019, to investigate major chronic non-communicable disease prevention and control technology in Northeast China. This study was approved by the Ethics Committee of China Medical University. Data from 11,119 participants were inspected, indicating that the quality of the data was generally high because data from less than 0.3% of participants were missing. We, according to the principle of simple random sampling, chose 10 community health centers as the survey locations by randomly selecting one center from the 10 districts of Changchun, Jilin Province, China. Thereafter, we performed this survey, with the help of the staff of the community health centers. We enrolled 6,871 participants according to the following criteria: (1) over the age of 60 years, (2) with registered permanent residence (a record officially identifying area residents), and (3) living in Changchun for more than 6 months. Each participant filled out a questionnaire, provided a written informed consent, and was performed a physical examination. After participants with incomplete information were removed, 6,846 participants were remained in this study.

2. Data collection

The questionnaire was designed by the Comprehensive Demonstration Research Project Group of Major Chronic Noncommunicable Disease Prevention and Control Technology in Northeast China, and staff collecting information from eligible participants was trained by the Project Group. The questionnaire included the basic characteristics of the participants (age, sex, ethnicity, place of residence, marital status, education level, occupation, and annual income), health behaviors (smoking, drinking, and physical exercise), history of diseases (hypertension, diabetes, hyperlipidemia, coronary heart disease, and stroke), and medication history. The staff performed anthropometric measurements, including height, weight, and blood pressure. The blood pressure was measured twice on the right upper arm of the participants after sitting for 5 minutes using OMRON HEM-7200 Professional Portable Blood Pressure Monitor (OMRON, Japan). The sphygmomanometers and weight scales were calibrated by the Bureau of Quality and Technical Supervision before use.

3. Variable definition

According to 2018 Chinese Guidelines for the Management of Hypertension [10], hypertension was defined as a mean systolic blood pressure (SBP) ≥140 mm Hg and/or a mean diastolic blood pressure (DBP) ≥90 mm Hg, or self-reported use of antihypertensive medications in the past 2 weeks. Stage 2 or stage 3 hypertension was defined as SBP ≥160 mm Hg and/or DBP ≥100 mmHg. Hypertension awareness was defined as knowing that participants had been diagnosed with hypertension before this study. Hypertension treatment was defined as patients with hypertension currently

taking antihypertensive medications. Hypertension control was defined as effective control of blood pressure (SBP <140 mm Hg and DBP <90 mm Hg) in hypertensive patients.

Body mass index (BMI) was obtained by dividing body weight by the square of height. According to the recommendations of the China Obesity Working Group [11], BMI was divided into the following categories: underweight: <18.5; normal: 18.5–23.9; overweight: 24.0–27.9; and obesity: ≥28.0.

4. Statistical analysis

The database was established by Epidata3.1, and SPSS 21.0 was used for statistical analysis. All analyses were weighted based on the 2020 Jilin province population census data to represent the elderly population in Changchun. The description of measurement data was expressed by mean ± standard deviation; the comparison between measurement data was performed using t test; the description of count data was expressed by rate or composition ratio; and the comparison between count data was by chi-square test. Multivariate Logistic regression was used to analyze the risk factors related to hypertension and the relationship of population characteristics with hypertension awareness, treatment, and control. $P<0.05$ indicated that the difference was statistically significant.

5. Patient and public involvement

Patients and public were not involved in this study.

Results

1. Multi-level analysis of the prevalence, awareness, treatment and control of hypertension

A total of 6,846 participants (3,465 males, 3,381 females) were enrolled in this study, with a mean age of 70.31 years (SD 6.115). Among them, 6,669 (97.4%) are of Han nationality, 4,013 (58.6%) had retired, and 3,599 (52.6%) had hypertension (289 [4.2%] patients had stage 2 or stage 3 hypertension). There were differences in age, sex, BMI, marital status, occupation, educational level, annual income, physical exercise, smoking, family history of hypertension, and history of other diseases (coronary heart disease, stroke, diabetes, and hyperlipidemia) between hypertensive participants and non-hypertensive participants ($P<0.05$). The proportion of female participants suffering from hypertension was higher than that of male ones; Compared with non-hypertensive participants, hypertensive participants exhibited high proportions in the following items (widowed, overweight or obesity, engaged in manual work, an annual income of less than ¥30,000, had a lower educational level, had history of coronary heart disease, stroke, diabetes, hyperlipidemia, or family history of hypertension). The age of patients with stage 2 or stage 3 hypertension was significantly higher than that of patients with stage 1 hypertension. The patients with stage 2 or stage 3 hypertension significantly differed from the ones with stage 1 hypertension in marital status, annual income, physical exercise, and history of other

diseases (coronary heart disease, stroke, diabetes, and hyperlipidemia) (P<0.05) (Table 1).

Among the hypertensive patients, 3,151 (87.6%) were aware of hypertension because they were diagnosed with hypertension before this survey, 2,488 (69.1%) were treated because they were currently taking antihypertensive medications, and 2,408(66.9%) were effective in controlling blood pressure. The treatment rate in female patients with hypertension was statistically higher than that in male ones (P<0.05). Compared with normal or underweight participants, overweight or obese ones had significantly high rates of awareness and treatment of hypertension (P<0.05). Participants with diabetes or hyperlipidemia had a significantly higher control rate of hypertension than those without diabetes or hyperlipidemia. Participants with stroke had a significantly higher awareness rate of hypertension than those without stroke. Participants with coronary heart disease or hypertension had significantly higher awareness, treatment, and control of hypertension than those without a history of coronary heart disease or a family history (P<0.05) (Table 2).

2. Multivariate logistic analysis of prevalence, awareness, treatment, and control of hypertension

Multivariate logistic regression was used to analyze the association of population characteristics with the prevalence, awareness, treatment, and control of hypertension. We identified that BMI, marital status, occupation, annual income, history of disease (coronary heart disease, diabetes, and hyperlipidemia), and family history of

hypertension were all associated with hypertension. In detail, overweight (OR=1.640, 95%CI: 1.475–1.824) or obesity (OR=2.582, 95%CI: 2.225–2.996), widowed (OR=1.296, 95%CI: 1.088–1.545), coronary heart disease (OR=1.451, 95%CI: 1.237–1.702), diabetes (OR=1.636, 95%CI: 1.474–1.816), hyperlipidemia (OR=1.119, 95%CI: 1.014–1.235), and family history of hypertension (OR=4.013, 95%CI: 3.283–4.906) were revealed as risk factors of hypertension. However, underweight people (OR=0.549, 95%CI: 0.358–0.842), people who were engaged in mental work (OR=0.820, 95%CI: 0.696–0.964), or people with an annual income from ¥30,000 to ¥50,000 (OR=0.845, 95%CI: 0.759–0.940), had a lower risk of hypertension than normal people, people who were engaged in manual work, or people with an annual income of less than ¥30,000 (Table 3).

For awareness of hypertension, people with overweight (OR=1.282, 95%CI: 1.021–1.611) or obesity (OR=1.408, 95%CI: 1.046–1.896), exercise regularly (OR=1.355, 95%CI: 1.061–1.729), personal history of heart coronary disease (OR=1.610, 95%CI: 1.131–2.291), or with a family history of hypertension (OR=2.263, 95%CI: 1.561–3.279) were more likely to recognize their risks of hypertension; whereas, people who were divorced/separated (OR=0.310, 95%CI: 0.153–0.628), engaged in mental work (OR=0.654, 95%CI: 0.474–0.901), or had a high annual income (¥30,000–50,000: OR=0.639, 95%CI: 0.509–0.801; >¥50,000: OR=0.402, 95%CI:0.280–0.575), were more likely to ignore their risks of hypertension.

With respect to treatment of hypertension, women paid more attention to the

treatment of hypertension than men (OR=1.319, 95%CI: 1.118–1.556). People with overweight (OR=1.403, 95%CI: 1.191–1.651) or obesity (OR=1.678, 95%CI: 1.359–2.070), exercise regularly (OR=1.454, 95%CI: 1.220–1.732), or with a family history of hypertension (OR=1.323, 95%CI: 1.066–1.641) were more active in the treatment of hypertension; however, people with high annual income (¥30,000–50,000: OR=0.839, 95%CI: 0.715–0.984; >¥50,000: OR=0.665, 95%CI:0.499–0.888), or with personal history of hyperlipidemia (OR=0.850, 95%CI: 0.733–0.984) were more likely to ignore hypertension treatment.

In terms of control of hypertension, the effect of hypertension control for widowed people was poor (OR=0.685, 95%CI: 0.542–0.866). People who exercised regularly (OR=1.313, 95%CI: 1.103–1.564) had better blood pressure control, but people with an annual income of more than ¥50,000 (OR=0.472, 95%CI: 0.357–0.624), a history of diabetes (OR=0.839, 95%CI: 0.724–0.972), hyperlipidemia (OR=0.725, 95%CI: 0.627–0.838), or a family history of hypertension (OR=0.677, 95%CI: 0.557–0.822) were difficult in controlling blood pressure within the normal range (Table 4).

3. Analysis of use of antihypertensive medications in patients with hypertension

Among people taking antihypertensive medications, 2,304 (92.6%) used a single drug, and 184 (7.4%) used two or more combined drugs. Among the hypertensive population receiving medical treatment, 1,945 (78.2%) had their blood pressure under control. Among patients with grade 2 or grade 3 hypertension, 151(52.2%) took antihypertensive medications. Among the five commonly used antihypertensive

medications, 73.8% people used calcium channel blockers (CCB) was the highest, 10.9% used angiotensin receptor blockers (ARB), 6.5% used traditional Chinese medicine (TCM), 6.0% used beta blockers (BB), 5.0% used angiotensin converting enzyme inhibitors (ACEI), and 3.3 % used diuretics (DIU). The types of medication in males were not different from those in females. In parallel, the composition ratios of single medication and combination medication in males did not differ from those in females correspondingly (Table 5).

Discussion

Our research is the latest report on the prevalence, awareness, treatment, and control of hypertension among elderly population in Changchun City, Jilin Province, China. The study found that the prevalence of hypertension among the elderly population in Changchun City was 52.6%, slightly higher than that of the elderly in the national large-scale survey in 2017 (50.1%) [7], but lower than that of the elderly population in Jilin Province in 2015 (56.6%) [12]. Compared with developed countries, such as the United States [13], the prevalence of hypertension in Changchun City was still at a relatively high level. Patients with stage 2 or stage 3 hypertension accounted for 4.2%, which was lower than a report from the United States in 2019 (7.3%) [14], and also lower than a domestic survey in the same period (5.7%) [15]. This discrepancy may result from the fact that the Jilin Provincial Government has addressed the primary management of hypertension and patient education and increased medical

insurance funds in the past two years. Compared with those in other regions in China [16], the awareness rate, treatment rate, and control rate of patients with hypertension in this region were at a relatively high level, which may be benefit from the vigorous promotion and supervision of local health organizations, and importance patient's attention to hypertension.

Our research further found that, in agreement with other studies [17, 18], overweight or obesity, widowed, coronary heart disease, diabetes, and hyperlipidemia were all risk factors for hypertension. However, similar to the previous results in Jilin Province [12], the proportion of women suffering from high blood pressure was higher than that of men. This result was different from that of the national research report [19]. Consistent with our study, clinical studies have shown that genetic factors are associated with the onset of hypertension; thus, people with a family history of hypertension are more susceptible to hypertension [20]. Although smoking and drinking are considered to be common risk factors for hypertension [21], our study did not find smoking and drinking as the risk factors, partially because of the small number of people smoking and drinking among the elderly in this region. We also found that, compared with men, women had better treatment and control of hypertension, which may contribute to women attaching more importance to physical health than men and having better treatment compliance. Although people with a family history of hypertension were more likely to recognize that they had high blood pressure, their hypertension control effect was not ideal, in concert with the results of a multi-center registration study based on hospital patients in China [22]. Therefore,

more active and effective screening and management are necessary for people with hypertension.

Our research found that 92.6% of people taking antihypertensive medications were treated with a single drug, and 78.2% of them blood pressure was controlled. Previous study reported that the combined medication has better control effect on hypertension than single medication [23]. However, only 7.4% of people used combined medication treatment strategy, which may be related to the long-term medication habits of patients and the prescription habits of primary doctors. Among the commonly used antihypertensive medications, CCB was the most commonly used, which was consistent with previous reports and may be related to the guideline recommendations and drug costs [24].

Our results hold potential for refining the prevention and control strategies of hypertension, affording future interventions in strengthening the monitoring of patients with hypertension and integrating the management of hypertension into the routine primary health care system. Moreover, our results provide theoretical and practical suggestions for governments to guide the education of prevention and control and to enhance public awareness on hypertension. In addition, medication, especially combined medication, should become a focus for health institutions.

Our research has some limitations. Firstly, our research data were based on self-reported questionnaires; thus, the accuracy of the reported results cannot be determined. Hypertension diagnosed during one visit may overestimate the true prevalence of hypertension. Secondly, because of the cross-sectional nature of the

design of this study, the temporality of the association cannot be determined, and long-term follow-up of the population are needed to conduct. Thirdly, the potential impact of the 2017 American College of Cardiology/American Heart Association Guidelines on the prevention and treatment of hypertension in the Chinese population needs to be evaluated.

Conclusions

The prevalence of hypertension in the elderly population in Changchun City, Jilin Province, China is lower than the national average, and the awareness, treatment, and control of hypertension are at a higher level, indicating that the prevention and control of hypertension in local health organizations in Changchun City have been achieved. However, in the use of antihypertensive medications, the combined use of drugs is relatively low, suggesting that the guidance and education of scientific medication are required for strengthening.

Contributors: Yawen Liu and Yi Cheng were involved in the study's conception and design; Yaxuan Ren, Jikang Shi, Yichun Qiao, Yulu Gu, Yong Li, Yunkai Liu collected the data; Yaxuan Ren, Jikang Shi, Yichun Qiao, Yulu Gu performed data analysis and interpretation; Yaxuan Ren wrote the paper; All authors read and approved the final manuscript.

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Table 1 General characteristics of study participants aged ≥60 years

Characteristics	Total (n=6846)	No hypertension (n=3247)	All hypertension (n=3599)	Stage 2 or stage 3 hypertension (n=289)	*P* value
Age(years)	70.31±6.115	69.65±5.895	70.90±6.249	72.03±6.519	<0.001[a]
Sex					0.002
Male	3465(50.6%)	1704(52.5%)	1761(48.9%)	139(48.1%)	
Female	3381(49.4%)	1543(47.5%)	1838(51.1%)	150(51.9%)	
Ethnicity					0.466
Han	6669(97.4%)	3162(97.4%)	3507(97.4%)	277(95.8%)	
Others	177(2.6%)	85(2.6%)	92(2.6%)	12(4.2%)	
BMI					<0.001
Underweight	104(1.5%)	72(2.2%)	32(0.9%)	5(1.7%)	
Normal	2569(37.5%)	1445(44.5%)	1124(31.2%)	94(32.5%)	
Overweight	3071(44.9%)	1363(42.0%)	1708(47.4%)	131(45.3%)	
Obesity	1103(16.1%)	367(11.3%)	736(20.4%)	59(20.4%)	
Marital status					0.010[a]
Unmarried	32(0.5%)	16(0.5%)	16(0.4%)	2(0.7%)	
Married/Cohabitation	6117(89.4%)	2942(90.6%)	3175(88.2%)	232(80.6%)	
Divorced/ Separated	78(1.1%)	34(1.0%)	44(1.2%)	2(0.7%)	
Widowed	619(9.0%)	255(7.9%)	364(10.1%)	52(18.1%)	
Occupation					0.012
Manual worker	1876(27.4%)	861(26.5%)	1015(28.2%)	96(33.3%)	
Mental worker	958(14.0%)	495(15.2%)	463(12.9%)	41(14.2%)	
Retirement	4013(58.6%)	1891(58.2%)	2122(58.9%)	151(52.4%)	
Educational level					0.018
Primary school or below	1014(14.8%)	441(13.6%)	573(15.9%)	50(17.4%)	
Junior middle school	2346(34.3%)	1096(33.8%)	1250(34.7%)	106(36.8%)	
Senior middle school	1889(27.6%)	913(28.1%)	976(27.1%)	68(23.6%)	
Undergraduate or above	1564(22.8%)	777(23.9%)	787(21.9%)	62(21.5%)	
Unknown	35(0.5%)	20(0.6%)	15(0.4%)	2(0.7%)	
Annual income (¥)					<0.001[a]
<30,000	3481(50.9%)	1571(48.4%)	1910(53.1%)	148(51.2%)	
30,000~50,000	2914(42.6%)	1471(45.3%)	1443(40.1%)	106(36.7%)	
>50,000	450(6.6%)	204(6.3%)	246(6.8%)	35(12.1%)	
Physical exercise					0.030[a]
Never	1360(19.9%)	628(19.3%)	732(20.3%)	79(27.2%)	
Sometimes	185(2.7%)	72(2.2%)	113(3.1%)	11(3.8%)	
Often	5300(77.4%)	2546(78.4%)	2754(76.5%)	200(69.0%)	
Current smoking	1081(15.8%)	549 (16.9%)	532 (14.8%)	42(14.6%)	0.009
Current drinking	1014(14.8%)	500(15.4%)	514 (14.3%)	43(14.9%)	0.102
Systolic blood pressure	132.29±11.938	126.86±8.217	137.19±12.629	167.15±10.547	<0.001[a]

(mm Hg)					
Diastolic blood pressure (mm Hg)	77.43±8.014	74.84±6.997	79.77±8.153	88.29±11.233	<0.001[a]
History of coronary heart disease	759(11.1%)	284(8.7%)	475(13.2%)	49(17.0%)	<0.001 [a]
History of stroke	204(3.0%)	84(2.6%)	120(3.3%)	17(5.9%)	0.040 [a]
History of diabetes	2296(33.5%)	892(27.5%)	1404(39.0%)	138(47.8%)	<0.001[a]
History of hyperlipidemia	3015(44.0%)	1350(41.6%)	1665(46.3%)	157(54.3%)	<0.001[a]
Family history of hypertension	653(9.5%)	125(3.8%)	528(14.7%)	52(18.0%)	<0.001

a: the difference between stage 1 hypertension and stage 2 or stage 3 hypertension is statistically significant

Table 2 Investigation of awareness, treatment, control of hypertension

	Awareness (n=3151)	Treatment (n=2488)	Control (n=2408)
Age(years)	70.90±6.214	70.82±6.069	70.77±6.142
P value	0.894	0.276	0.086
Sex			
Male	1525(48.4%)	1185(47.6%)	1156(48.0%)
Female	1626(51.6%)	1303(52.4%)	1252(52.0%)
P value	0.050	0.011	0.062
Ethnicity			
Han	3069(97.4%)	2421(97.3%)	2355(97.8%)
Others	82(2.6%)	67(2.7%)	53(2.2%)
P value	0.503	0.255	0.037
BMI			
Underweight	25(0.8%)	16(0.6%)	18(0.7%)
Normal	961(30.5%)	716(28.8%)	752(31.2%)
Overweight	1507(47.8%)	1208(48.6%)	1153(47.9%)
Obesity	659(20.9%)	548(22.0%)	486(20.2%)
P value	0.015	<0.001	0.537
Marital status			
Unmarried	12(0.4%)	10(0.4%)	11(0.5%)
Married/Cohabitation	2785(88.4%)	2203(88.5%)	2148(89.2%)
Divorced/ Separated	33(1.0%)	27(1.1%)	29(1.2%)
Widowed	321(10.2%)	248(10.0%)	221(9.2%)
P value	0.012	0.606	0.067
Occupation			
Manual worker	894(28.4%)	705(28.3%)	663(27.5%)
Mental worker	381(12.1%)	308(12.4%)	289(12.0%)
Retirement	1876(59.5%)	1475(59.3%)	1456(60.5%)
P value	0.001	0.428	0.016
Educational level			
Primary school or below	500(15.9%)	388(15.6%)	397(16.5%)
Junior middle school	1088(34.5%)	858(34.5%)	833(34.6%)
Senior middle school	861(27.3%)	683(27.4%)	659(27.4%)
Undergraduate or above	687(21.8%)	552(22.2%)	510(21.2%)
Unknown	15(0.5%)	8(0.3%)	10(0.4%)
P value	0.582	0.520	0.535
Annual income (¥)			
<30,000	1713(54.4%)	1349(54.2%)	1308(54.3%)
30,000~50,000	1243(39.5%)	984(39.5%)	975(40.5%)
>50,000	194(6.2%)	155(6.2%)	126(5.2%)
P value	<0.001	0.026	<0.001

Physical exercise			
Never	627(19.9%)	462(18.6%)	461(19.1%)
Sometimes	91(2.9%)	74(3.0%)	61(2.5%)
Often	2433(77.2%)	1952(78.5%)	1887(78.3%)
P value	0.009	<0.001	<0.001
Current smoking	463(14.7%)	379(15.2%)	347(14.4%)
P value	0.376	0.135	0.198
Current drinking	452(14.3%)	348(14.0%)	345(14.3%)
P value	0.371	0.243	0.479
Systolic blood pressure (mm Hg)	135.63±11.967	135.50±11.469	130.94±6.282
P value	<0.001	<0.001	<0.001
Diastolic blood pressure (mm Hg)	79.32±7.865	79.23±7.779	77.77±6.722
P value	<0.001	<0.001	<0.001
History of coronary heart disease	436(13.8%)	345(13.9%)	294(12.2%)
P value	0.001	0.041	0.008
History of stroke	112(3.6%)	84(3.4%)	76(3.2%)
P value	0.028	0.516	0.225
History of diabetes	1240(39.4%)	976(39.2%)	901(37.4%)
P value	0.157	0.351	0.003
History of hyperlipidemia	1443(45.8%)	1135(45.6%)	1052(43.7%)
P value	0.081	0.125	<0.001
Family history of hypertension	494(15.7%)	394(15.8%)	307(12.7%)
P value	<0.001	0.002	<0.001

Table 3 Multivariate logistic regression analysis of factors associated with hypertension

	β	*SE*	χ^2	*P*	*OR*	*95%CI*
Sex (Female)	0.095	0.056	2.864	0.092	1.100	0.985–1.228
BMI						
Underweight	-0.599	0.218	7.556	0.006	0.549	0.358–0.842
Normal			196.969	<0.001	1	
Overweight	0.495	0.054	83.045	<0.001	1.640	1.475–1.824
Obesity	0.949	0.076	156.1371	<0.001	2.582	2.225–2.996
Marital status						
Unmarried	0.001	0.362	0.000	0.998	1.001	0.492–2.036
Married/Cohabitation			8.473	0.037	1	
Divorced/Separated	0.072	0.234	0.094	0.759	1.074	0.679–1.700
Widowed	0.260	0.089	8.431	0.004	1.296	1.088–1.545
Occupation						
Manual worker			9.860	0.007	1	
Mental worker	-0.199	0.083	5.739	0.017	0.820	0.696–0.964
Retirement	0.033	0.060	0.297	0.586	1.033	0.918–1.163
Educational level						
Primary school or below			3.694	0.449	1	
Junior middle school	-0.070	0.079	0.789	0.374	0.932	0.799–1.088
Senior middle school	-0.090	0.083	1.185	0.276	0.914	0.777–1.075
Undergraduate or above	-0.135	0.088	2.347	0.125	0.874	0.735–1.038
Unknown	-0.469	0.359	1.714	0.190	0.625	0.310–1.263
Annual income (¥)						
<30,000			13.465	0.001	1	
30,000~50,000	-0.169	0.054	9.637	0.002	0.845	0.759–0.940
>50,000	0.111	0.105	1.110	0.292	1.117	0.909–1.372
Physical exercise						
Never			5.672	0.059	1	
Sometimes	0.230	0.164	1.972	0.160	1.259	0.913–1.737
Often	-0.089	0.063	2.005	0.157	0.915	0.809–1.035
Current smoking	-0.109	0.076	2.070	0.150	0.896	0.772–1.040
Current drinking	0.001	0.079	0.000	0.986	1.001	0.857–1.170
History of coronary heart disease	0.372	0.081	20.933	<0.001	1.451	1.237–1.702
History of stroke	0.144	0.149	0.932	0.334	1.155	0.862–1.546
History of diabetes	0.492	0.053	85.768	<0.001	1.636	1.474–1.816
History of hyperlipidemia	0.112	0.050	5.016	0.025	1.119	1.014–1.235
Family history of hypertension	1.390	0.102	183.960	<0.001	4.013	3.283–4.906

1: the reference cell

Table 4 Individual characteristics associated with awareness, treatment, and control of hypertension

	Awareness		Treatment		Control	
	OR (95%CI)	*P*	OR (95%CI)	*P*	OR (95%CI)	*P*
Sex (Female)	1.281(1.018–1.613)	0.035	1.319(1.118–1.556)	0.001	1.255(1.066–1.478)	0.006
BMI						
Underweight	0.463(0.196–1.096)	0.080	0.563(0.275–1.152)	0.116	0.582(0.281–1.204)	0.145
Normal	1	0.010	1	<0.001	1	0.407
Overweight	1.282(1.021–1.611)	0.033	1.403(1.191–1.651)	<0.001	1.056(0.895–1.244)	0.520
Obesity	1.408(1.046–1.896)	0.024	1.678(1.359–2.070)	<0.001	1.002(0.818–1.228)	0981
Marital status						
Unmarried	0.436(0.139–1.367)	0.155	0.814(0.295–2. 247)	0.691	0.978(0.343–2.792)	0.967
Married/Cohabitation	1	0.006	1	0.380	1	0.018
Divorced/ Separated	0.310(0.153–0.628)	0.001	0.617(0.332–1.148)	0.127	0.938(0.496–1.772)	0.843
Widowed	0.994(0.699–1.414)	0.975	0.899(0.705–1.146)	0.389	0.685(0.542–0.866)	0.002
Occupation						
Manual worker	1	0.002	1	0.405	1	0.033
Mental worker	0.654(0.474–0.901)	0.010	0.862(0.675–1.101)	0.234	0.929(0.732–1.180)	0.547
Retirement	1.080(0.841–1.387)	0.546	0.996(0.836–1.186)	0.960	1.183(0.996–1.404)	0.055
Educational level						
Primary school or below	1	0.690	1	0.274	1	0.893
Junior middle school	1.033(0.758–1.408)	0.837	1.084(0.870–1.351)	0.471	0.918(0.736–1.146)	0.450
Senior middle school	1.203(0.863–1.677)	0.275	1.196(0.947–1.511)	0.133	0.948(0.750–1.198)	0.653
Undergraduate or above	1.199(0.841–1.709)	0.316	1.254(0.974–1.614)	0.079	0.881(0.686–1.133)	0.325
Unknown	--	0.999	0.635(0.220–1.835)	0.401	0.905(0.290–2.822)	0.864
Annual income (¥)						
<30,000	1	<0.001	1	0.008	1	<0.001
30,000~50,000	0.639(0.509–0.801)	<0.001	0.839(0.715–0.984)	0.031	0.900(0.768–1.053)	0.189
>50,000	0.402(0.280–0.575)	<0.001	0.665(0.499–0.888)	0.006	0.472(0.357–0.624)	<0.001
Physical exercise						
Never	1	0.002	1	<0.001	1	<0.001
Sometimes	0.651(0.385–1.102)	0.110	1.033(0.677–1.577)	0.881	0.745(0.495–1.123)	0.160
Often	1.355(1.061–1.729)	0.015	1.454(1.220–1.732)	<0.001	1.313(1.103–1.564)	0.002
Current smoking	1.015(0.740–1.393)	0.926	1.358(1.077–1.712)	0.010	0.967(0.774–1.209)	0768
Current drinking	1.235(0.883–1.725)	0.217	0.888(0.703–1.123)	0.323	1.107(0.876–1.399)	0.394
History of heart coronary disease	1.610(1.131–2.291)	0.008	1.189(0.952–1.484)	0.127	0.842(0.684–1.036)	0.104
History of stroke	1.885(0.901–3.943)	0.092	0.973(0.650–1.455)	0.892	0.919(0.623–1.355)	0.670
History of diabetes	1.088(0.879–1.346)	0.439	1.000(0.861–1.163)	0.996	0.839(0.724–0.972)	0.019
History of hyperlipidemia	0.796(0.647–0.979)	0.030	0.850(0.733–0.984)	0.030	0.725(0.627–0.838)	<0.001
Family history of	2.263(1.561–3.279)	<0.001	1.323(1.066–1.641)	0.011	0.677(0.557–0.822)	<0.001

hypertension

1: the reference cell

Table 5 The use of antihypertensive medications among treated population with hypertension

		Total	Male	Female	*P* value
Monotherapy	DIU	83(3.3%)	41(3.5%)	42(3.2%)	0.414
	CCB	1835(73.8%)	871(73.5%)	964(74.0%)	0.410
	ACEI	124(5.0%)	69(5.8%)	55(4.2%)	0.041
	BB	150(6.0%)	66(5.6%)	84(6.4%)	0.202
	ARB	272(10.9%)	140(11.8%)	132(10.1%)	0.100
	TCM	162(6.5%)	64(5.4%)	98(7.5%)	0.019
	Others	61(2.5%)	29(2.4%)	32(2.5%)	0.548
Total monotherapy		2304(92.6%)	1096(92.5%)	1208(92.7%)	0.447
Combination therapy		184(7.4%)	89(7.5%)	95(7.3%)	

DIU: diuretics; CCB: calcium channel blockers; ACEI: angiotensin converting enzyme inhibitors; BB: beta blockers; ARB: angiotensin receptor blockers; TCM: traditional Chinese medicine

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	7

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	–
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	–
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	8
		Cross-sectional study—Report numbers of outcome events or summary measures	–
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Epidemiological status quo of hypertension in elderly population: an investigation conducted in Changchun, China

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Abstract

Objectives: To investigate the epidemiological status quo of hypertension in elderly population in Changchun, China, and provide a reference for the prevention and control strategies of hypertension of elderly population in this region.

Design: A cross-sectional study, as a part of a comprehensive project in Northeast China, was designed to perform in ten districts in Changchun.

Participants and setting: A total of 6,846 participants who were ≥60 years old were selected using a random sampling method.

Main outcome measures: The epidemiological status quo of hypertension.

Results: The prevalence of hypertension in Changchun was 52.6%. Among participants with hypertension enrolled in this study, 87.6% of the participants had been diagnosed with hypertension before the study, 69.1% was taking antihypertensive medications, and 66.9% had effective blood pressure control. Obesity, widower/widow, history of diseases, and family history of hypertension were risk factors of hypertension (all $P<0.05$). Participants with obesity, a personal history of heart coronary disease, or a family history of hypertension were susceptible to realizing risks of hypertension (all $P<0.05$). However, participants with diabetes, hyperlipidemia, or a family history of hypertension were difficult to control blood pressure within the normal range (all $P<0.05$). In addition, 92.6% participants taking antihypertensive medications used a single medication, and calcium channel blockers (CCB) was the most commonly used antihypertensive medications in monotherapy.

Conclusion: The rates of awareness, treatment, and control of hypertension are

greater in Changchun than those in China, indicating that the prevention and control of hypertension in Changchun are effective. However, the prevalence of hypertension in the elderly population in China is lower than that in Changchun, also rendering Changchun a substantial challenge for the supervision of hypertension.

Strengths and limitations of this study

1. This study investigated the epidemiological status quo of hypertension by assessing the prevalence, awareness, treatment, and control of hypertension in elderly population in Changchun, China in 2019.

2. A large number of participants were included in the study.

3. The data in this study were based on self-reported questionnaires; thus, the accuracy of the reported results cannot be determined.

4. The temporality of the association cannot be determined because of the cross-sectional nature of this study.

Introduction

Hypertension afflicts about 1.5 billion people, generating $370 billion of economic burden globally [1, 2]. A national survey performed from 2003 to 2012 has shown that the prevalence of hypertension continues increasing in China [3]. In 2012, the prevalence of hypertension among the population over the age of 18 was 23.2% (≈244.5 million) in China. Overall, 46.9% knew whether they had hypertension, 40.7% received antihypertensive medications, and 15.3% controlled blood pressure [4]. Hypertension has been one of the leading risk factors of mortality in China [5].

The status quo in patients with hypertension, including awareness, treatment, and control, is different among different regions in China [6, 7, 8]. Previous regional studies on hypertension mainly focused on southeast region in China [9, 10]. Changchun is in the northeast of China, and winter in Changchun is cold and long. Changchun has been a heavy industry city since 1949, affecting a special environment and lifestyle for residents in this region [11]. Blood pressure increases steadily with age, leading to that hypertension is more common in people over the age of 60 years with the increasing of aging [12]. However, there are few studies focusing on the elderly in China. We, in this study, investigated the epidemiological status quo of hypertension by assessing the prevalence, awareness, treatment, and control of hypertension in elderly population in Changchun, China.

Methods

1. Study design and enrollment of participants

We conducted this survey of prevention and control of major chronic non-communicable diseases in Northeast China from July 1, 2019, to Oct 31, 2019. The survey was supported by the Comprehensive Project of Epitome for Major Chronic Disease Prevention and Control Technology in Northeast China, and approved by the Ethics Committee of China Medical University. After inspecting data from 11,119 participants, we found that blood pressure data of less than 0.3% of participants were missing. We, according to the principle of simple random sampling, chose 10 community health centers from 12 ones in Changchun, China. Thereafter, we performed this survey, with the help of staffs of the ten community health centers. Finally, we enrolled 6,846 participants according to following criteria: (1) over the age of 60 years, (2) with registered permanent residence (a record officially identifying area residents), and (3) living in Changchun for more than 6 months. Each participant filled out a questionnaire, provided a written informed consent, and was performed a physical examination.

2. Data collection

The questionnaire was designed by the committee of Comprehensive Project of Epitome for Major Chronic Disease Prevention and Control Technology in Northeast China. Staff collecting information from participants was trained by this committee. The questionnaire included the basic characteristics of the participants (age, sex,

ethnicity, place of residence, marital status, education level, occupation, and annual income), health behaviors (smoking, drinking, and physical exercise), history of diseases (hypertension, diabetes, hyperlipidemia, coronary heart disease, and stroke), and medication history. The staff performed anthropometric measurements, including height, weight, and blood pressure. The blood pressure was measured twice on the right upper arm of the participants after sitting for 5 minutes using OMRON HEM-7200 Professional Portable Blood Pressure Monitor (OMRON, Japan), and the average of these two readings represented datum of blood pressure of one participant. The sphygmomanometers and weight scales were calibrated by the Bureau of Quality and Technical Supervision before use.

3. Definition of variables

According to 2018 Chinese Guidelines for the Management of Hypertension [13], hypertension was defined as an average systolic blood pressure (SBP) ≥140 mm Hg and/or an average diastolic blood pressure (DBP) ≥90 mm Hg, or self-reported use of antihypertensive medications in past two weeks. Stage 2 or stage 3 hypertension was defined as an average SBP ≥160 mm Hg and/or an average DBP ≥100 mmHg. Awareness of hypertension was defined as a participant knowing diagnosed hypertension before this study. Treatment of hypertension was defined as currently taking antihypertensive medications in patients with hypertension. Control of hypertension was defined as effectively maintaining an average SBP <140 mm Hg and an average DBP <90 mm Hg in patients with hypertension.

Body mass index (BMI) was obtained by dividing body weight by the square of height. According to the recommendations of the Chinese Obesity Working Group [14], BMI was divided into following categories: underweight: <18.5, normal: 18.5–23.9, overweight: 24.0–27.9, and obesity: ≥28.0.

4. Statistical analysis

We established the database of this survey using Epidata3.1, and IBM SPSS 24.0 was used for statistical analyses. The 2020 China population census data were used to confer weight on variables, evaluating the status quo of elderly population in Changchun. The description of measurement data was expressed by mean ± standard deviation; the comparison between measurement data was performed using t test; the description of count data was expressed by rate or composition ratio; and the comparison between count data was by chi-square test. Multivariate Logistic regression was used to analyze the risk factors relating to hypertension. A *P* value less than 0.05 was considered statistically significant.

5. Patient and public involvement

Patients and public were not involved in the design, recruitment, and conduct of the study.

Results

1. Multi-level analysis of the prevalence, awareness, treatment and control of hypertension

A total of 6,846 participants (3,465 males, 3,381 females) were enrolled in this study, with a mean age of 70.31 years (SD 6.115). Among them, 6,669 (97.4%) are Han nationality, 4,013 (58.6%) had retired, and 3,599 (52.6%) were patients with hypertension (289 [4.2%] patients with stage 2 or stage 3 hypertension). There were significant differences in age, sex, BMI, marital status, occupation, educational level, annual income, physical exercise, smoking, family history of hypertension, and history of other diseases (coronary heart disease, stroke, diabetes, or hyperlipidemia) between hypertensive and non-hypertensive participants (P<0.05). The proportion of female participants suffering from hypertension was higher than that of male ones. Compared with non-hypertensive participants, hypertensive participants exhibited high proportions in following items (widowered/widowed; overweight or obesity; engaged in manual work; an annual income of less than ¥30,000; with a lower educational level; with history of coronary heart disease, stroke, diabetes, hyperlipidemia, or family history of hypertension). The age of patients with stage 2 or stage 3 hypertension was significantly higher than that of patients with stage 1 hypertension (P<0.05). The patients with stage 2 or stage 3 hypertension significantly differed from the ones with stage 1 hypertension in marital status, annual income, physical exercise, and history of other diseases (coronary heart disease, stroke, diabetes, or hyperlipidemia) (P<0.05) (Table 1).

Among the patients with hypertension, 3,151 (87.6%) who were diagnosed with hypertension before this survey were aware of hypertension, 2,488 (69.1%) were currently taking antihypertensive medications, and 2,408 (66.9%) were effective in controlling blood pressure. The treatment rate in female patients with hypertension was statistically higher than that in male ones (P<0.05). Compared with normal or underweight participants, overweight or obese ones had significantly high rates of awareness and treatment of hypertension (P<0.05). Participants with diabetes or hyperlipidemia had a significantly higher control rate of hypertension than those without diabetes or hyperlipidemia (P<0.05). Participants with stroke had a significantly higher awareness rate of hypertension than those without stroke (P<0.05). Participants with coronary heart disease or family history of hypertension had significantly higher awareness, treatment, and control of hypertension than those without corresponding diseases or family history (P<0.05) (Table 2).

2. Multivariate logistic analysis of prevalence, awareness, treatment, and control of hypertension

Multivariate logistic regression was used to analyze the association of population characteristics with the prevalence, awareness, treatment, and control of hypertension. We identified that BMI, marital status, occupation, annual income, history of disease (coronary heart disease, diabetes, or hyperlipidemia), and family history of hypertension were all significantly associated with risks of hypertension (P<0.05). In detail, overweight (OR=1.640, 95%CI: 1.475–1.824) or obesity (OR=2.582, 95%CI:

2.225–2.996), widowered/widowed (OR=1.296, 95%CI: 1.088–1.545), coronary heart disease (OR=1.451, 95%CI: 1.237–1.702), diabetes (OR=1.636, 95%CI: 1.474–1.816), hyperlipidemia (OR=1.119, 95%CI: 1.014–1.235), and family history of hypertension (OR=4.013, 95%CI: 3.283–4.906) were revealed as higher risk factors of hypertension. However, underweight participants (OR=0.549, 95%CI: 0.358–0.842), participants who were engaged in mental work (OR=0.820, 95%CI: 0.696–0.964), or participants with an annual income from ¥30,000 to ¥50,000 (OR=0.845, 95%CI: 0.759–0.940), had lower risks of hypertension than normal participants, participants who were engaged in manual work, or participants with an annual income of less than ¥30,000 (Table 3).

For awareness of hypertension, participants with overweight (OR=1.282, 95%CI: 1.021–1.611) or obesity (OR=1.408, 95%CI: 1.046–1.896), exercise regularly (OR=1.355, 95%CI: 1.061–1.729), personal history of coronary heart disease (OR=1.610, 95%CI: 1.131–2.291), or with a family history of hypertension (OR=2.263, 95%CI: 1.561–3.279) were more likely to realize their risks of hypertension. Whereas participants who were divorced/separated (OR=0.310, 95%CI: 0.153–0.628), engaged in mental work (OR=0.654, 95%CI: 0.474–0.901), or had a high annual income (¥30,000–50,000: OR=0.639, 95%CI: 0.509–0.801; >¥50,000: OR=0.402, 95%CI:0.280–0.575), were more likely to ignore their risks of hypertension.

With respect to treatment of hypertension, female participants paid more attention to the treatment of hypertension than male ones (OR=1.319, 95%CI: 1.118–1.556).

Participants with overweight (OR=1.403, 95%CI: 1.191–1.651) or obesity (OR=1.678, 95%CI: 1.359–2.070), exercise regularly (OR=1.454, 95%CI: 1.220–1.732), or with family history of hypertension (OR=1.323, 95%CI: 1.066–1.641) were more active in the treatment of hypertension. However, participants with high annual income (¥30,000–50,000: OR=0.839, 95%CI: 0.715–0.984; >¥50,000: OR=0.665, 95%CI: 0.499–0.888), or with personal history of hyperlipidemia (OR=0.850, 95%CI: 0.733–0.984) were more likely to ignore hypertension treatment.

In terms of control of hypertension, the hypertension control for widowered/widowed participants was poor (OR=0.685, 95%CI: 0.542–0.866). Participants who exercised regularly (OR=1.313, 95%CI: 1.103–1.564) had better blood pressure control. However, participants with annual income of more than ¥50,000 (OR=0.472, 95%CI: 0.357–0.624), history of diabetes (OR=0.839, 95%CI: 0.724–0.972), hyperlipidemia (OR=0.725, 95%CI: 0.627–0.838), or family history of hypertension (OR=0.677, 95%CI: 0.557–0.822) were difficult in controlling blood pressure within the normal range (Table 4).

3. Analysis of use of antihypertensive medications in patients with hypertension

Among participants taking antihypertensive medications, 2,304 (92.6%) used a single medication, and 184 (7.4%) used two or more combined medications. Among the hypertensive patients receiving medical treatment, 1,945 (78.2%) maintained their blood pressure under control. Among patients with grade 2 or grade 3 hypertension, 151(52.2%) took antihypertensive medications. Among commonly used

antihypertensive medications, calcium channel blockers (CCB) were used in 73.8% participants, angiotensin receptor blockers (ARB) were used in 10.9% participants, traditional Chinese medicine (TCM) were used in 6.5% participants, beta blockers (BB) were used in 6.0% participants, angiotensin converting enzyme inhibitors (ACEI) were used in 5.0% participants, and diuretics (DIU) were used in 3.3% participants. The types of medication in males were not different from those in females. In parallel, the composition ratios of single medication and combined medications in males did not differ from those in females correspondingly (Table 5).

Discussion

In this paper, we corroborated that the prevalence of hypertension in the elderly population in Changchun was still greater than that in China; moreover, the rates of awareness, treatment, and control of hypertension were at a higher level in Changchun than those in China.

Compared with the prevalence (about 60.0%) of hypertension in Changchun in 2012 [15], the prevalence of hypertension in the elderly population in Changchun decreased to 52.6% in 2019. Compared with those in other regions in China [16], the rates of awareness, treatment, and control of patients with hypertension in Changchun were high. These discrepancies documented that the effectiveness of efforts of Changchun Government, including enhanced primary management, strengthen education, and increased medical funds for patients with hypertension in Changchun.

Notably, the prevalence of hypertension in elderly population decreased 58.9% [17] in 2012 to 50.1% [8] in 2017 in China, suggesting that Changchun Government needs further efforts for controlling hypertension.

Stage 2 or stage 3 hypertension causes much more serious problems for heart. Patients with stage 2 or stage 3 hypertension accounted for 7.3% in whole patients with hypertension in USA [18], 5.7% in those in China [19], and 4.2% in those in Changchun. Of note, low temperatures lead to narrowing blood vessels, increasing blood pressure by forcing blood through narrowed veins and arteries. Thus, blood pressure is generally higher in population in northeast of China [20]. Unexpectedly, our results showed the prevalence of patients with stage 2 or stage 3 hypertension in Changchun was less than that in China. This discrepancy may arise from low participation rate of patients with stage 2 or stage 3 hypertension in Changchun.

Our results of risk factors for hypertension matched closely with the ones observed in other studies in China, including overweight or obesity, widower/widow, coronary heart disease, diabetes, and hyperlipidemia [21, 22]. As opposed to discoveries from Southern China [23], the proportion of women with hypertension was higher than that of men in Changchun. Women have a higher ratio of surface area to volume, leading to a rapid loss of heat; moreover, metabolic rate is lower in women than that in men [24]. In contrast, men have a greater muscle mass than women; thus, men generate more heat than women. Cumulatively, these confirmed more women afflicted by hypertension than men in Changchun. Additionally, both our study and clinical investigations have shown that genetic factors are associated with the onset of

hypertension; thus, people with a family history of hypertension are more susceptible to hypertension [25]. Although smoking and drinking are considered as common risk factors for hypertension [26], our study did not find that smoking and drinking were risk factors of hypertension, partially because of the small number of people smoking and drinking among the elderly in Changchun.

We also found that, for the patients with hypertension, women better controlled blood pressure than men, because women much more valued their health and had higher treatment compliance. In concert with the results of a multi-center registration study based on hospital patients in China [27], our results also showed blood pressure was not controlled well in the participants with family history of hypertension, although these participants were more likely to realize that they had high blood pressure. As combined medication has better effect controlling hypertension than single medication [28], we found that combined medication was used in only 7.4% in the patients of hypertension, reflecting long-term prescription habits of cardiovascular physicians in Changchun.

Our results can be utilized to refine the prevention and control strategies of hypertension of elderly population for the Changchun government. In addition, epidemiological investigation of hypertension should be further strengthened for elderly residents; moreover, the cardiovascular physicians should focus on combined medication in Changchun.

Our research has some limitations. Firstly, our research data were based on self-reported questionnaires; thus, the accuracy of the reported results cannot be

determined. Hypertension diagnosed during one visit may overestimate the true prevalence of hypertension. Secondly, because of the cross-sectional nature of the design of this study, the temporality of the association cannot be determined, and long-term follow-up of these participants is needed to conduct. Thirdly, the feasibility of the 2017 American College of Cardiology/American Heart Association Guidelines about the prevention and treatment of hypertension needs to be re-evaluated.

Conclusions

The rates of awareness, treatment, and control of hypertension are greater in Changchun than those in China, indicating that the prevention and control of hypertension in Changchun are effective. However, the prevalence of hypertension in the elderly population in China is lower than that in Changchun, also rendering Changchun a substantial challenge for the supervision of hypertension.

Contributors: Yawen Liu and Yi Cheng were involved in the study's conception and design; Yaxuan Ren, Jikang Shi, Yichun Qiao, Yulu Gu, Yong Li, Yunkai Liu collected the data; Yaxuan Ren, Jikang Shi, Yichun Qiao, Yulu Gu performed data analysis and interpretation; Yaxuan Ren wrote the paper; All authors read and approved the final manuscript.

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Table 1 General characteristics of study participants aged ≥60 years

Characteristics	Total (n=6846)	No hypertension (n=3247)	All hypertension (n=3599)	Stage 2 or stage 3 hypertension (n=289)	*P* value
Age(years)	70.31±6.115	69.65±5.895	70.90±6.249	72.03±6.519	<0.001[a]
Sex					0.002
Male	3465(50.6%)	1704(52.5%)	1761(48.9%)	139(48.1%)	
Female	3381(49.4%)	1543(47.5%)	1838(51.1%)	150(51.9%)	
Ethnicity					0.466
Han	6669(97.4%)	3162(97.4%)	3507(97.4%)	277(95.8%)	
Others	177(2.6%)	85(2.6%)	92(2.6%)	12(4.2%)	
BMI					<0.001
Underweight	104(1.5%)	72(2.2%)	32(0.9%)	5(1.7%)	
Normal	2569(37.5%)	1445(44.5%)	1124(31.2%)	94(32.5%)	
Overweight	3071(44.9%)	1363(42.0%)	1708(47.4%)	131(45.3%)	
Obesity	1103(16.1%)	367(11.3%)	736(20.4%)	59(20.4%)	
Marital status					0.010[a]
Unmarried	32(0.5%)	16(0.5%)	16(0.4%)	2(0.7%)	
Married/Cohabitation	6117(89.4%)	2942(90.6%)	3175(88.2%)	232(80.6%)	
Divorced/ Separated	78(1.1%)	34(1.0%)	44(1.2%)	2(0.7%)	
Widowered/widowed	619(9.0%)	255(7.9%)	364(10.1%)	52(18.1%)	
Occupation					0.012
Manual worker	1876(27.4%)	861(26.5%)	1015(28.2%)	96(33.3%)	
Mental worker	958(14.0%)	495(15.2%)	463(12.9%)	41(14.2%)	
Retirement	4013(58.6%)	1891(58.2%)	2122(58.9%)	151(52.4%)	
Educational level					0.018
Primary school or below	1014(14.8%)	441(13.6%)	573(15.9%)	50(17.4%)	
Junior middle school	2346(34.3%)	1096(33.8%)	1250(34.7%)	106(36.8%)	
Senior middle school	1889(27.6%)	913(28.1%)	976(27.1%)	68(23.6%)	
Undergraduate or above	1564(22.8%)	777(23.9%)	787(21.9%)	62(21.5%)	
Unknown	35(0.5%)	20(0.6%)	15(0.4%)	2(0.7%)	
Annual income (¥)					<0.001[a]
<30,000	3481(50.9%)	1571(48.4%)	1910(53.1%)	148(51.2%)	
30,000~50,000	2914(42.6%)	1471(45.3%)	1443(40.1%)	106(36.7%)	
>50,000	450(6.6%)	204(6.3%)	246(6.8%)	35(12.1%)	
Physical exercise					0.030[a]
Never	1360(19.9%)	628(19.3%)	732(20.3%)	79(27.2%)	
Sometimes	185(2.7%)	72(2.2%)	113(3.1%)	11(3.8%)	
Often	5300(77.4%)	2546(78.4%)	2754(76.5%)	200(69.0%)	
Current smoking	1081(15.8%)	549 (16.9%)	532 (14.8%)	42(14.6%)	0.009
Current drinking	1014(14.8%)	500(15.4%)	514 (14.3%)	43(14.9%)	0.102
Systolic blood pressure	132.29±11.938	126.86±8.217	137.19±12.629	167.15±10.547	<0.001[a]

(mm Hg)					
Diastolic blood pressure (mm Hg)	77.43±8.014	74.84±6.997	79.77±8.153	88.29±11.233	<0.001[a]
History of coronary heart disease	759(11.1%)	284(8.7%)	475(13.2%)	49(17.0%)	<0.001 [a]
History of stroke	204(3.0%)	84(2.6%)	120(3.3%)	17(5.9%)	0.040 [a]
History of diabetes	2296(33.5%)	892(27.5%)	1404(39.0%)	138(47.8%)	<0.001[a]
History of hyperlipidemia	3015(44.0%)	1350(41.6%)	1665(46.3%)	157(54.3%)	<0.001[a]
Family history of hypertension	653(9.5%)	125(3.8%)	528(14.7%)	52(18.0%)	<0.001

a: the difference between stage 1 hypertension and stage 2 or stage 3 hypertension is statistically significant

Table 2 Investigation of awareness, treatment, control of hypertension

	Awareness (n=3151)	Treatment (n=2488)	Control (n=2408)
Age(years)	70.90±6.214	70.82±6.069	70.77±6.142
P value	0.894	0.276	0.086
Sex			
Male	1525(48.4%)	1185(47.6%)	1156(48.0%)
Female	1626(51.6%)	1303(52.4%)	1252(52.0%)
P value	0.050	0.011	0.062
Ethnicity			
Han	3069(97.4%)	2421(97.3%)	2355(97.8%)
Others	82(2.6%)	67(2.7%)	53(2.2%)
P value	0.503	0.255	0.037
BMI			
Underweight	25(0.8%)	16(0.6%)	18(0.7%)
Normal	961(30.5%)	716(28.8%)	752(31.2%)
Overweight	1507(47.8%)	1208(48.6%)	1153(47.9%)
Obesity	659(20.9%)	548(22.0%)	486(20.2%)
P value	0.015	<0.001	0.537
Marital status			
Unmarried	12(0.4%)	10(0.4%)	11(0.5%)
Married/Cohabitation	2785(88.4%)	2203(88.5%)	2148(89.2%)
Divorced/ Separated	33(1.0%)	27(1.1%)	29(1.2%)
Widowered/widowed	321(10.2%)	248(10.0%)	221(9.2%)
P value	0.012	0.606	0.067
Occupation			
Manual worker	894(28.4%)	705(28.3%)	663(27.5%)
Mental worker	381(12.1%)	308(12.4%)	289(12.0%)
Retirement	1876(59.5%)	1475(59.3%)	1456(60.5%)
P value	0.001	0.428	0.016
Educational level			
Primary school or below	500(15.9%)	388(15.6%)	397(16.5%)
Junior middle school	1088(34.5%)	858(34.5%)	833(34.6%)
Senior middle school	861(27.3%)	683(27.4%)	659(27.4%)
Undergraduate or above	687(21.8%)	552(22.2%)	510(21.2%)
Unknown	15(0.5%)	8(0.3%)	10(0.4%)
P value	0.582	0.520	0.535
Annual income (¥)			
<30,000	1713(54.4%)	1349(54.2%)	1308(54.3%)
30,000~50,000	1243(39.5%)	984(39.5%)	975(40.5%)
>50,000	194(6.2%)	155(6.2%)	126(5.2%)
P value	<0.001	0.026	<0.001

Physical exercise			
Never	627(19.9%)	462(18.6%)	461(19.1%)
Sometimes	91(2.9%)	74(3.0%)	61(2.5%)
Often	2433(77.2%)	1952(78.5%)	1887(78.3%)
P value	0.009	<0.001	<0.001
Current smoking	463(14.7%)	379(15.2%)	347(14.4%)
P value	0.376	0.135	0.198
Current drinking	452(14.3%)	348(14.0%)	345(14.3%)
P value	0.371	0.243	0.479
Systolic blood pressure (mm Hg)	135.63±11.967	135.50±11.469	130.94±6.282
P value	<0.001	<0.001	<0.001
Diastolic blood pressure (mm Hg)	79.32±7.865	79.23±7.779	77.77±6.722
P value	<0.001	<0.001	<0.001
History of coronary heart disease	436(13.8%)	345(13.9%)	294(12.2%)
P value	0.001	0.041	0.008
History of stroke	112(3.6%)	84(3.4%)	76(3.2%)
P value	0.028	0.516	0.225
History of diabetes	1240(39.4%)	976(39.2%)	901(37.4%)
P value	0.157	0.351	0.003
History of hyperlipidemia	1443(45.8%)	1135(45.6%)	1052(43.7%)
P value	0.081	0.125	<0.001
Family history of hypertension	494(15.7%)	394(15.8%)	307(12.7%)
P value	<0.001	0.002	<0.001

Table 3 Multivariate logistic regression analysis of factors associated with hypertension

	β	*SE*	χ^2	*P*	*OR*	*95%CI*
Sex (Female)	0.095	0.056	2.864	0.092	1.100	0.985–1.228
BMI						
Underweight	-0.599	0.218	7.556	0.006	0.549	0.358–0.842
Normal			196.969	<0.001	1	
Overweight	0.495	0.054	83.045	<0.001	1.640	1.475–1.824
Obesity	0.949	0.076	156.1371	<0.001	2.582	2.225–2.996
Marital status						
Unmarried	0.001	0.362	0.000	0.998	1.001	0.492–2.036
Married/Cohabitation			8.473	0.037	1	
Divorced/Separated	0.072	0.234	0.094	0.759	1.074	0.679–1.700
Widowered/widowed	0.260	0.089	8.431	0.004	1.296	1.088–1.545
Occupation						
Manual worker			9.860	0.007	1	
Mental worker	-0.199	0.083	5.739	0.017	0.820	0.696–0.964
Retirement	0.033	0.060	0.297	0.586	1.033	0.918–1.163
Educational level						
Primary school or below			3.694	0.449	1	
Junior middle school	-0.070	0.079	0.789	0.374	0.932	0.799–1.088
Senior middle school	-0.090	0.083	1.185	0.276	0.914	0.777–1.075
Undergraduate or above	-0.135	0.088	2.347	0.125	0.874	0.735–1.038
Unknown	-0.469	0.359	1.714	0.190	0.625	0.310–1.263
Annual income (¥)						
<30,000			13.465	0.001	1	
30,000~50,000	-0.169	0.054	9.637	0.002	0.845	0.759–0.940
>50,000	0.111	0.105	1.110	0.292	1.117	0.909–1.372
Physical exercise						
Never			5.672	0.059	1	
Sometimes	0.230	0.164	1.972	0.160	1.259	0.913–1.737
Often	-0.089	0.063	2.005	0.157	0.915	0.809–1.035
Current smoking	-0.109	0.076	2.070	0.150	0.896	0.772–1.040
Current drinking	0.001	0.079	0.000	0.986	1.001	0.857–1.170
History of coronary heart disease	0.372	0.081	20.933	<0.001	1.451	1.237–1.702
History of stroke	0.144	0.149	0.932	0.334	1.155	0.862–1.546
History of diabetes	0.492	0.053	85.768	<0.001	1.636	1.474–1.816
History of hyperlipidemia	0.112	0.050	5.016	0.025	1.119	1.014–1.235
Family history of hypertension	1.390	0.102	183.960	<0.001	4.013	3.283–4.906

1: the reference cell

Table 4 Individual characteristics associated with awareness, treatment, and control of hypertension

	Awareness		Treatment		Control	
	OR (95%CI)	*P*	OR (95%CI)	*P*	OR (95%CI)	*P*
Sex (Female)	1.281(1.018–1.613)	0.035	1.319(1.118–1.556)	0.001	1.255(1.066–1.478)	0.006
BMI						
Underweight	0.463(0.196–1.096)	0.080	0.563(0.275–1.152)	0.116	0.582(0.281–1.204)	0.145
Normal	1	0.010	1	<0.001	1	0.407
Overweight	1.282(1.021–1.611)	0.033	1.403(1.191–1.651)	<0.001	1.056(0.895–1.244)	0.520
Obesity	1.408(1.046–1.896)	0.024	1.678(1.359–2.070)	<0.001	1.002(0.818–1.228)	0981
Marital status						
Unmarried	0.436(0.139–1.367)	0.155	0.814(0.295–2. 247)	0.691	0.978(0.343–2.792)	0.967
Married/Cohabitation	1	0.006	1	0.380	1	0.018
Divorced/ Separated	0.310(0.153–0.628)	0.001	0.617(0.332–1.148)	0.127	0.938(0.496–1.772)	0.843
Widowered/widowed	0.994(0.699–1.414)	0.975	0.899(0.705–1.146)	0.389	0.685(0.542–0.866)	0.002
Occupation						
Manual worker	1	0.002	1	0.405	1	0.033
Mental worker	0.654(0.474–0.901)	0.010	0.862(0.675–1.101)	0.234	0.929(0.732–1.180)	0.547
Retirement	1.080(0.841–1.387)	0.546	0.996(0.836–1.186)	0.960	1.183(0.996–1.404)	0.055
Educational level						
Primary school or below	1	0.690	1	0.274	1	0.893
Junior middle school	1.033(0.758–1.408)	0.837	1.084(0.870–1.351)	0.471	0.918(0.736–1.146)	0.450
Senior middle school	1.203(0.863–1.677)	0.275	1.196(0.947–1.511)	0.133	0.948(0.750–1.198)	0.653
Undergraduate or above	1.199(0.841–1.709)	0.316	1.254(0.974–1.614)	0.079	0.881(0.686–1.133)	0.325
Unknown	--	0.999	0.635(0.220–1.835)	0.401	0.905(0.290–2.822)	0.864
Annual income (¥)						
<30,000	1	<0.001	1	0.008	1	<0.001
30,000~50,000	0.639(0.509–0.801)	<0.001	0.839(0.715–0.984)	0.031	0.900(0.768–1.053)	0.189
>50,000	0.402(0.280–0.575)	<0.001	0.665(0.499–0.888)	0.006	0.472(0.357–0.624)	<0.001
Physical exercise						
Never	1	0.002	1	<0.001	1	<0.001
Sometimes	0.651(0.385–1.102)	0.110	1.033(0.677–1.577)	0.881	0.745(0.495–1.123)	0.160
Often	1.355(1.061–1.729)	0.015	1.454(1.220–1.732)	<0.001	1.313(1.103–1.564)	0.002
Current smoking	1.015(0.740–1.393)	0.926	1.358(1.077–1.712)	0.010	0.967(0.774–1.209)	0768
Current drinking	1.235(0.883–1.725)	0.217	0.888(0.703–1.123)	0.323	1.107(0.876–1.399)	0.394
History of heart coronary disease	1.610(1.131–2.291)	0.008	1.189(0.952–1.484)	0.127	0.842(0.684–1.036)	0.104
History of stroke	1.885(0.901–3.943)	0.092	0.973(0.650–1.455)	0.892	0.919(0.623–1.355)	0.670
History of diabetes	1.088(0.879–1.346)	0.439	1.000(0.861–1.163)	0.996	0.839(0.724–0.972)	0.019
History of hyperlipidemia	0.796(0.647–0.979)	0.030	0.850(0.733–0.984)	0.030	0.725(0.627–0.838)	<0.001
Family history of	2.263(1.561–3.279)	<0.001	1.323(1.066–1.641)	0.011	0.677(0.557–0.822)	<0.001

hypertension

1: the reference cell

Table 5 The use of antihypertensive medications among treated population with hypertension

		Total	Male	Female	*P* value
Monotherapy	DIU	83(3.3%)	41(3.5%)	42(3.2%)	0.414
	CCB	1835(73.8%)	871(73.5%)	964(74.0%)	0.410
	ACEI	124(5.0%)	69(5.8%)	55(4.2%)	0.041
	BB	150(6.0%)	66(5.6%)	84(6.4%)	0.202
	ARB	272(10.9%)	140(11.8%)	132(10.1%)	0.100
	TCM	162(6.5%)	64(5.4%)	98(7.5%)	0.019
	Others	61(2.5%)	29(2.4%)	32(2.5%)	0.548
Total monotherapy		2304(92.6%)	1096(92.5%)	1208(92.7%)	0.447
Combination therapy		184(7.4%)	89(7.5%)	95(7.3%)	

DIU: diuretics; CCB: calcium channel blockers; ACEI: angiotensin converting enzyme inhibitors; BB: beta blockers; ARB: angiotensin receptor blockers; TCM: traditional Chinese medicine

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	7

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	–
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	–
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	8
		Cross-sectional study—Report numbers of outcome events or summary measures	–
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Epidemiological status quo of hypertension in elderly population: an investigation conducted in Changchun, China

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Abstract

Objectives: To investigate the epidemiological status quo of hypertension in elderly population in Changchun, China, and provide a reference for the prevention and control strategies of hypertension of elderly population in this region.

Design: A cross-sectional study, as a part of a comprehensive project in Northeast China, was designed to perform in ten districts in Changchun.

Participants and setting: A total of 6,846 participants who were ≥60 years old were selected using a random sampling method.

Main outcome measures: The epidemiological status quo of hypertension.

Results: The prevalence of hypertension in Changchun was 52.6%. Among participants with hypertension enrolled in this study, 87.6% of the participants had been diagnosed with hypertension before the study, 69.1% was taking antihypertensive medications, and 66.9% had effective blood pressure control. Obesity, widower/widow, history of diseases, and family history of hypertension were risk factors of hypertension (all $P<0.05$). Participants with obesity, a personal history of heart coronary disease, or a family history of hypertension were susceptible to realizing risks of hypertension (all $P<0.05$). However, participants with diabetes, hyperlipidemia, or a family history of hypertension were difficult to control blood pressure within the normal range (all $P<0.05$). In addition, 92.6% participants taking antihypertensive medications used a single medication, and calcium channel blockers (CCB) was the most commonly used antihypertensive medications in monotherapy.

Conclusion: The rates of awareness, treatment, and control of hypertension are

greater in Changchun than those in China, indicating that the prevention and control of hypertension in Changchun are effective. However, the prevalence of hypertension in the elderly population in China is lower than that in Changchun, also rendering Changchun a substantial challenge for the supervision of hypertension.

Strengths and limitations of this study

1. This study investigated the epidemiological status quo of hypertension by assessing the prevalence, awareness, treatment, and control of hypertension in elderly population in Changchun, China in 2019.

2. A large number of participants were included in the study.

3. The data other than anthropometric data in this study were based on self-reported questionnaires.

4. The temporality of the association cannot be determined because of the cross-sectional nature of this study.

Introduction

Hypertension afflicts about 1.5 billion people, generating $370 billion of economic burden globally [1, 2]. A national survey performed from 2003 to 2012 has shown that the prevalence of hypertension continues increasing in China [3]. In 2012, the prevalence of hypertension among the population over the age of 18 was 23.2% (≈244.5 million) in China. Overall, 46.9% knew whether they had hypertension, 40.7% received antihypertensive medications, and 15.3% controlled blood pressure [4]. Hypertension has been one of the leading risk factors of mortality in China [5].

The status quo in patients with hypertension, including awareness, treatment, and control, is different among different regions in China [6, 7, 8]. Previous regional studies on hypertension mainly focused on southeast region in China [9, 10]. Changchun is in the northeast of China, and winter in Changchun is cold and long. Changchun has been a heavy industry city since 1949, affecting a special environment and lifestyle for residents in this region [11]. Blood pressure increases steadily with age, leading to that hypertension is more common in people over the age of 60 years with the increasing of aging [12]. However, there are few studies focusing on the elderly in China. We, in this study, investigated the epidemiological status quo of hypertension by assessing the prevalence, awareness, treatment, and control of hypertension in elderly population in Changchun, China.

Methods

1. Study design and enrollment of participants

We conducted this survey of prevention and control of major chronic non-communicable diseases in Northeast China from July 1, 2019, to Oct 31, 2019. The survey was supported by the Comprehensive Project of Epitome for Major Chronic Disease Prevention and Control Technology in Northeast China, and approved by the Ethics Committee of China Medical University. After inspecting data from 11,119 participants, we found that blood pressure data of less than 0.3% of participants were missing. We, according to the principle of simple random sampling, chose 10 community health centers from 12 ones in Changchun, China. Thereafter, we performed this survey, with the help of staffs of the ten community health centers. Finally, we enrolled 6,846 participants according to following criteria: (1) over the age of 60 years, (2) with registered permanent residence (a record officially identifying area residents), and (3) living in Changchun for more than 6 months. Each participant filled out a questionnaire, provided a written informed consent, and was performed a physical examination.

2. Data collection

The questionnaire was designed by the committee of Comprehensive Project of Epitome for Major Chronic Disease Prevention and Control Technology in Northeast China. Staff collecting information from participants was trained by this committee. The questionnaire included the basic characteristics of the participants (age, sex,

ethnicity, place of residence, marital status, education level, occupation, and annual income), health behaviors (smoking, drinking, and physical exercise), history of diseases (hypertension, diabetes, hyperlipidemia, coronary heart disease, and stroke), and medication history. The staff performed anthropometric measurements, including height, weight, and blood pressure. The blood pressure was measured twice on the right upper arm of the participants after sitting for 5 minutes using OMRON HEM-7200 Professional Portable Blood Pressure Monitor (OMRON, Japan), and the average of these two readings represented datum of blood pressure of one participant. The sphygmomanometers and weight scales were calibrated by the Bureau of Quality and Technical Supervision before use.

3. Definition of variables

According to 2018 Chinese Guidelines for the Management of Hypertension [13], hypertension was defined as an average systolic blood pressure (SBP) ≥140 mm Hg and/or an average diastolic blood pressure (DBP) ≥90 mm Hg, or self-reported use of antihypertensive medications in past two weeks. Stage 2 or stage 3 hypertension was defined as an average SBP ≥160 mm Hg and/or an average DBP ≥100 mmHg. Awareness of hypertension was defined as a participant knowing diagnosed hypertension before this study. Treatment of hypertension was defined as currently taking antihypertensive medications in patients with hypertension. Control of hypertension was defined as effectively maintaining an average SBP <140 mm Hg and an average DBP <90 mm Hg in patients with hypertension.

Body mass index (BMI) was obtained by dividing body weight by the square of height. According to the recommendations of the Chinese Obesity Working Group [14], BMI was divided into following categories: underweight: <18.5, normal: 18.5–23.9, overweight: 24.0–27.9, and obesity: ≥28.0.

4. Statistical analysis

We established the database of this survey using Epidata3.1, and IBM SPSS 24.0 was used for statistical analyses. The 2020 China population census data were used to confer weight on variables, evaluating the status quo of elderly population in Changchun. The description of measurement data was expressed by mean ± standard deviation; the comparison between measurement data was performed using t test; the description of count data was expressed by rate or composition ratio; and the comparison between count data was by chi-square test. Multivariate Logistic regression was used to analyze the risk factors relating to hypertension. A *P* value less than 0.05 was considered statistically significant.

5. Patient and public involvement

Patients and public were not involved in the design, recruitment, and conduct of the study.

Results

1. Multi-level analysis of the prevalence, awareness, treatment and control of hypertension

A total of 6,846 participants (3,465 males, 3,381 females) were enrolled in this study, with a mean age of 70.31 years (SD 6.115). Among them, 6,669 (97.4%) are Han nationality, 4,013 (58.6%) had retired, and 3,599 (52.6%) were patients with hypertension (289 [4.2%] patients with stage 2 or stage 3 hypertension). There were significant differences in age, sex, BMI, marital status, occupation, educational level, annual income, physical exercise, smoking, family history of hypertension, and history of other diseases (coronary heart disease, stroke, diabetes, or hyperlipidemia) between hypertensive and non-hypertensive participants (P<0.05). The proportion of female participants suffering from hypertension was higher than that of male ones. Compared with non-hypertensive participants, hypertensive participants exhibited high proportions in following items (widowered/widowed; overweight or obesity; engaged in manual work; an annual income of less than ¥30,000; with a lower educational level; with history of coronary heart disease, stroke, diabetes, hyperlipidemia, or family history of hypertension). The age of patients with stage 2 or stage 3 hypertension was significantly higher than that of patients with stage 1 hypertension (P<0.05). The patients with stage 2 or stage 3 hypertension significantly differed from the ones with stage 1 hypertension in marital status, annual income, physical exercise, and history of other diseases (coronary heart disease, stroke, diabetes, or hyperlipidemia) (P<0.05) (Table 1).

Among the patients with hypertension, 3,151 (87.6%) who were diagnosed with hypertension before this survey were aware of hypertension, 2,488 (69.1%) were currently taking antihypertensive medications, and 2,408 (66.9%) were effective in controlling blood pressure. The treatment rate in female patients with hypertension was statistically higher than that in male ones (P<0.05). Compared with normal or underweight participants, overweight or obese ones had significantly high rates of awareness and treatment of hypertension (P<0.05). Participants with diabetes or hyperlipidemia had a significantly higher control rate of hypertension than those without diabetes or hyperlipidemia (P<0.05). Participants with stroke had a significantly higher awareness rate of hypertension than those without stroke (P<0.05). Participants with coronary heart disease or family history of hypertension had significantly higher awareness, treatment, and control of hypertension than those without corresponding diseases or family history (P<0.05) (Table 2).

2. Multivariate logistic analysis of prevalence, awareness, treatment, and control of hypertension

Multivariate logistic regression was used to analyze the association of population characteristics with the prevalence, awareness, treatment, and control of hypertension. We identified that BMI, marital status, occupation, annual income, history of disease (coronary heart disease, diabetes, or hyperlipidemia), and family history of hypertension were all significantly associated with risks of hypertension (P<0.05). In detail, overweight (OR=1.640, 95%CI: 1.475–1.824) or obesity (OR=2.582, 95%CI:

2.225–2.996), widowered/widowed (OR=1.296, 95%CI: 1.088–1.545), coronary heart disease (OR=1.451, 95%CI: 1.237–1.702), diabetes (OR=1.636, 95%CI: 1.474–1.816), hyperlipidemia (OR=1.119, 95%CI: 1.014–1.235), and family history of hypertension (OR=4.013, 95%CI: 3.283–4.906) were revealed as higher risk factors of hypertension. However, underweight participants (OR=0.549, 95%CI: 0.358–0.842), participants who were engaged in mental work (OR=0.820, 95%CI: 0.696–0.964), or participants with an annual income from ¥30,000 to ¥50,000 (OR=0.845, 95%CI: 0.759–0.940), had lower risks of hypertension than normal participants, participants who were engaged in manual work, or participants with an annual income of less than ¥30,000 (Table 3).

For awareness of hypertension, participants with overweight (OR=1.282, 95%CI: 1.021–1.611) or obesity (OR=1.408, 95%CI: 1.046–1.896), exercise regularly (OR=1.355, 95%CI: 1.061–1.729), personal history of coronary heart disease (OR=1.610, 95%CI: 1.131–2.291), or with a family history of hypertension (OR=2.263, 95%CI: 1.561–3.279) were more likely to realize their risks of hypertension. Whereas participants who were divorced/separated (OR=0.310, 95%CI: 0.153–0.628), engaged in mental work (OR=0.654, 95%CI: 0.474–0.901), or had a high annual income (¥30,000–50,000: OR=0.639, 95%CI: 0.509–0.801; >¥50,000: OR=0.402, 95%CI:0.280–0.575), were more likely to ignore their risks of hypertension.

With respect to treatment of hypertension, female participants paid more attention to the treatment of hypertension than male ones (OR=1.319, 95%CI: 1.118–1.556).

Participants with overweight (OR=1.403, 95%CI: 1.191–1.651) or obesity (OR=1.678, 95%CI: 1.359–2.070), exercise regularly (OR=1.454, 95%CI: 1.220–1.732), or with family history of hypertension (OR=1.323, 95%CI: 1.066–1.641) were more active in the treatment of hypertension. However, participants with high annual income (¥30,000–50,000: OR=0.839, 95%CI: 0.715–0.984; >¥50,000: OR=0.665, 95%CI: 0.499–0.888), or with personal history of hyperlipidemia (OR=0.850, 95%CI: 0.733–0.984) were more likely to ignore hypertension treatment.

In terms of control of hypertension, the hypertension control for widowered/widowed participants was poor (OR=0.685, 95%CI: 0.542–0.866). Participants who exercised regularly (OR=1.313, 95%CI: 1.103–1.564) had better blood pressure control. However, participants with annual income of more than ¥50,000 (OR=0.472, 95%CI: 0.357–0.624), history of diabetes (OR=0.839, 95%CI: 0.724–0.972), hyperlipidemia (OR=0.725, 95%CI: 0.627–0.838), or family history of hypertension (OR=0.677, 95%CI: 0.557–0.822) were difficult in controlling blood pressure within the normal range (Table 4).

3. Analysis of use of antihypertensive medications in patients with hypertension

Among participants taking antihypertensive medications, 2,304 (92.6%) used a single medication, and 184 (7.4%) used two or more combined medications. Among the hypertensive patients receiving medical treatment, 1,945 (78.2%) maintained their blood pressure under control. Among patients with grade 2 or grade 3 hypertension, 151(52.2%) took antihypertensive medications. Among commonly used

antihypertensive medications, calcium channel blockers (CCB) were used in 73.8% participants, angiotensin receptor blockers (ARB) were used in 10.9% participants, traditional Chinese medicine (TCM) were used in 6.5% participants, beta blockers (BB) were used in 6.0% participants, angiotensin converting enzyme inhibitors (ACEI) were used in 5.0% participants, and diuretics (DIU) were used in 3.3% participants. The types of medication in males were not different from those in females. In parallel, the composition ratios of single medication and combined medications in males did not differ from those in females correspondingly (Table 5).

Discussion

In this paper, we corroborated that the prevalence of hypertension in the elderly population in Changchun was still greater than that in China; moreover, the rates of awareness, treatment, and control of hypertension were at a higher level in Changchun than those in China.

Compared with the prevalence (about 60.0%) of hypertension in Changchun in 2012 [15], the prevalence of hypertension in the elderly population in Changchun decreased to 52.6% in 2019. Compared with those in other regions in China [16], the rates of awareness, treatment, and control of patients with hypertension in Changchun were high. These discrepancies documented that the effectiveness of efforts of Changchun Government, including enhanced primary management, strengthen education, and increased medical funds for patients with hypertension in Changchun.

Notably, the prevalence of hypertension in elderly population decreased 58.9% [17] in 2012 to 50.1% [8] in 2017 in China, suggesting that Changchun Government needs further efforts for controlling hypertension.

Stage 2 or stage 3 hypertension causes much more serious problems for heart. Patients with stage 2 or stage 3 hypertension accounted for 7.3% in whole patients with hypertension in USA [18], 5.7% in those in China [19], and 4.2% in those in Changchun. Of note, low temperatures lead to narrowing blood vessels, increasing blood pressure by forcing blood through narrowed veins and arteries. Thus, blood pressure is generally higher in population in northeast of China [20]. Unexpectedly, our results showed the prevalence of patients with stage 2 or stage 3 hypertension in Changchun was less than that in China. This discrepancy may arise from low participation rate of patients with stage 2 or stage 3 hypertension in Changchun.

Our results of risk factors for hypertension matched closely with the ones observed in other studies in China, including overweight or obesity, widower/widow, coronary heart disease, diabetes, and hyperlipidemia [21, 22]. As opposed to discoveries from Southern China [23], the proportion of women with hypertension was higher than that of men in Changchun. Women have a higher ratio of surface area to volume, leading to a rapid loss of heat; moreover, metabolic rate is lower in women than that in men [24]. In contrast, men have a greater muscle mass than women; thus, men generate more heat than women. Cumulatively, these confirmed more women afflicted by hypertension than men in Changchun. Additionally, both our study and clinical investigations have shown that genetic factors are associated with the onset of

hypertension; thus, people with a family history of hypertension are more susceptible to hypertension [25]. Although smoking and drinking are considered as common risk factors for hypertension [26], our study did not find that smoking and drinking were risk factors of hypertension, partially because of the small number of people smoking and drinking among the elderly in Changchun.

We also found that, for the patients with hypertension, women better controlled blood pressure than men, because women much more valued their health and had higher treatment compliance. In concert with the results of a multi-center registration study based on hospital patients in China [27], our results also showed blood pressure was not controlled well in the participants with family history of hypertension, although these participants were more likely to realize that they had high blood pressure. As combined medication has better effect controlling hypertension than single medication [28], we found that combined medication was used in only 7.4% in the patients of hypertension, reflecting long-term prescription habits of cardiovascular physicians in Changchun.

Our results can be utilized to refine the prevention and control strategies of hypertension of elderly population for the Changchun government. In addition, epidemiological investigation of hypertension should be further strengthened for elderly residents; moreover, the cardiovascular physicians should focus on combined medication in Changchun.

Our research has some limitations. Firstly, our research data were based on self-reported questionnaires; thus, the accuracy of the reported results cannot be

determined. Hypertension diagnosed during one visit may overestimate the true prevalence of hypertension. Secondly, because of the cross-sectional nature of the design of this study, the temporality of the association cannot be determined, and long-term follow-up of these participants is needed to conduct. Thirdly, the feasibility of the 2017 American College of Cardiology/American Heart Association Guidelines about the prevention and treatment of hypertension needs to be re-evaluated.

Conclusions

The rates of awareness, treatment, and control of hypertension are greater in Changchun than those in China, indicating that the prevention and control of hypertension in Changchun are effective. However, the prevalence of hypertension in the elderly population in China is lower than that in Changchun, also rendering Changchun a substantial challenge for the supervision of hypertension.

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Patient consent: Not required.

Ethics approval: This study was approved by the Ethics Committee of China Medical University.

Data sharing statement: Data are available upon reasonable request.

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Table 1 General characteristics of study participants aged ≥60 years

Characteristics	Total (n=6846)	No hypertension (n=3247)	All hypertension (n=3599)	Stage 2 or stage 3 hypertension (n=289)	*P* value
Age(years)	70.31±6.115	69.65±5.895	70.90±6.249	72.03±6.519	<0.001[a]
Sex					0.002
Male	3465(50.6%)	1704(52.5%)	1761(48.9%)	139(48.1%)	
Female	3381(49.4%)	1543(47.5%)	1838(51.1%)	150(51.9%)	
Ethnicity					0.466
Han	6669(97.4%)	3162(97.4%)	3507(97.4%)	277(95.8%)	
Others	177(2.6%)	85(2.6%)	92(2.6%)	12(4.2%)	
BMI					<0.001
Underweight	104(1.5%)	72(2.2%)	32(0.9%)	5(1.7%)	
Normal	2569(37.5%)	1445(44.5%)	1124(31.2%)	94(32.5%)	
Overweight	3071(44.9%)	1363(42.0%)	1708(47.4%)	131(45.3%)	
Obesity	1103(16.1%)	367(11.3%)	736(20.4%)	59(20.4%)	
Marital status					0.010[a]
Unmarried	32(0.5%)	16(0.5%)	16(0.4%)	2(0.7%)	
Married/Cohabitation	6117(89.4%)	2942(90.6%)	3175(88.2%)	232(80.6%)	
Divorced/ Separated	78(1.1%)	34(1.0%)	44(1.2%)	2(0.7%)	
Widowered/widowed	619(9.0%)	255(7.9%)	364(10.1%)	52(18.1%)	
Occupation					0.012
Manual worker	1876(27.4%)	861(26.5%)	1015(28.2%)	96(33.3%)	
Mental worker	958(14.0%)	495(15.2%)	463(12.9%)	41(14.2%)	
Retirement	4013(58.6%)	1891(58.2%)	2122(58.9%)	151(52.4%)	
Educational level					0.018
Primary school or below	1014(14.8%)	441(13.6%)	573(15.9%)	50(17.4%)	
Junior middle school	2346(34.3%)	1096(33.8%)	1250(34.7%)	106(36.8%)	
Senior middle school	1889(27.6%)	913(28.1%)	976(27.1%)	68(23.6%)	
Undergraduate or above	1564(22.8%)	777(23.9%)	787(21.9%)	62(21.5%)	
Unknown	35(0.5%)	20(0.6%)	15(0.4%)	2(0.7%)	
Annual income (¥)					<0.001[a]
<30,000	3481(50.9%)	1571(48.4%)	1910(53.1%)	148(51.2%)	
30,000~50,000	2914(42.6%)	1471(45.3%)	1443(40.1%)	106(36.7%)	
>50,000	450(6.6%)	204(6.3%)	246(6.8%)	35(12.1%)	
Physical exercise					0.030[a]
Never	1360(19.9%)	628(19.3%)	732(20.3%)	79(27.2%)	
Sometimes	185(2.7%)	72(2.2%)	113(3.1%)	11(3.8%)	
Often	5300(77.4%)	2546(78.4%)	2754(76.5%)	200(69.0%)	
Current smoking	1081(15.8%)	549 (16.9%)	532 (14.8%)	42(14.6%)	0.009
Current drinking	1014(14.8%)	500(15.4%)	514 (14.3%)	43(14.9%)	0.102
Systolic blood pressure	132.29±11.938	126.86±8.217	137.19±12.629	167.15±10.547	<0.001[a]

(mm Hg)					
Diastolic blood pressure (mm Hg)	77.43±8.014	74.84±6.997	79.77±8.153	88.29±11.233	<0.001[a]
History of coronary heart disease	759(11.1%)	284(8.7%)	475(13.2%)	49(17.0%)	<0.001 [a]
History of stroke	204(3.0%)	84(2.6%)	120(3.3%)	17(5.9%)	0.040 [a]
History of diabetes	2296(33.5%)	892(27.5%)	1404(39.0%)	138(47.8%)	<0.001[a]
History of hyperlipidemia	3015(44.0%)	1350(41.6%)	1665(46.3%)	157(54.3%)	<0.001[a]
Family history of hypertension	653(9.5%)	125(3.8%)	528(14.7%)	52(18.0%)	<0.001

a: the difference between stage 1 hypertension and stage 2 or stage 3 hypertension is statistically significant

Table 2 Investigation of awareness, treatment, control of hypertension

	Awareness (n=3151)	Treatment (n=2488)	Control (n=2408)
Age(years)	70.90±6.214	70.82±6.069	70.77±6.142
P value	0.894	0.276	0.086
Sex			
Male	1525(48.4%)	1185(47.6%)	1156(48.0%)
Female	1626(51.6%)	1303(52.4%)	1252(52.0%)
P value	0.050	0.011	0.062
Ethnicity			
Han	3069(97.4%)	2421(97.3%)	2355(97.8%)
Others	82(2.6%)	67(2.7%)	53(2.2%)
P value	0.503	0.255	0.037
BMI			
Underweight	25(0.8%)	16(0.6%)	18(0.7%)
Normal	961(30.5%)	716(28.8%)	752(31.2%)
Overweight	1507(47.8%)	1208(48.6%)	1153(47.9%)
Obesity	659(20.9%)	548(22.0%)	486(20.2%)
P value	0.015	<0.001	0.537
Marital status			
Unmarried	12(0.4%)	10(0.4%)	11(0.5%)
Married/Cohabitation	2785(88.4%)	2203(88.5%)	2148(89.2%)
Divorced/ Separated	33(1.0%)	27(1.1%)	29(1.2%)
Widowered/widowed	321(10.2%)	248(10.0%)	221(9.2%)
P value	0.012	0.606	0.067
Occupation			
Manual worker	894(28.4%)	705(28.3%)	663(27.5%)
Mental worker	381(12.1%)	308(12.4%)	289(12.0%)
Retirement	1876(59.5%)	1475(59.3%)	1456(60.5%)
P value	0.001	0.428	0.016
Educational level			
Primary school or below	500(15.9%)	388(15.6%)	397(16.5%)
Junior middle school	1088(34.5%)	858(34.5%)	833(34.6%)
Senior middle school	861(27.3%)	683(27.4%)	659(27.4%)
Undergraduate or above	687(21.8%)	552(22.2%)	510(21.2%)
Unknown	15(0.5%)	8(0.3%)	10(0.4%)
P value	0.582	0.520	0.535
Annual income (¥)			
<30,000	1713(54.4%)	1349(54.2%)	1308(54.3%)
30,000~50,000	1243(39.5%)	984(39.5%)	975(40.5%)
>50,000	194(6.2%)	155(6.2%)	126(5.2%)
P value	<0.001	0.026	<0.001

Physical exercise			
Never	627(19.9%)	462(18.6%)	461(19.1%)
Sometimes	91(2.9%)	74(3.0%)	61(2.5%)
Often	2433(77.2%)	1952(78.5%)	1887(78.3%)
P value	0.009	<0.001	<0.001
Current smoking	463(14.7%)	379(15.2%)	347(14.4%)
P value	0.376	0.135	0.198
Current drinking	452(14.3%)	348(14.0%)	345(14.3%)
P value	0.371	0.243	0.479
Systolic blood pressure (mm Hg)	135.63±11.967	135.50±11.469	130.94±6.282
P value	<0.001	<0.001	<0.001
Diastolic blood pressure (mm Hg)	79.32±7.865	79.23±7.779	77.77±6.722
P value	<0.001	<0.001	<0.001
History of coronary heart disease	436(13.8%)	345(13.9%)	294(12.2%)
P value	0.001	0.041	0.008
History of stroke	112(3.6%)	84(3.4%)	76(3.2%)
P value	0.028	0.516	0.225
History of diabetes	1240(39.4%)	976(39.2%)	901(37.4%)
P value	0.157	0.351	0.003
History of hyperlipidemia	1443(45.8%)	1135(45.6%)	1052(43.7%)
P value	0.081	0.125	<0.001
Family history of hypertension	494(15.7%)	394(15.8%)	307(12.7%)
P value	<0.001	0.002	<0.001

Table 3 Multivariate logistic regression analysis of factors associated with hypertension

	β	*SE*	χ^2	*P*	*OR*	*95%CI*
Sex (Female)	0.095	0.056	2.864	0.092	1.100	0.985–1.228
BMI						
Underweight	-0.599	0.218	7.556	0.006	0.549	0.358–0.842
Normal			196.969	<0.001	1	
Overweight	0.495	0.054	83.045	<0.001	1.640	1.475–1.824
Obesity	0.949	0.076	156.1371	<0.001	2.582	2.225–2.996
Marital status						
Unmarried	0.001	0.362	0.000	0.998	1.001	0.492–2.036
Married/Cohabitation			8.473	0.037	1	
Divorced/Separated	0.072	0.234	0.094	0.759	1.074	0.679–1.700
Widowered/widowed	0.260	0.089	8.431	0.004	1.296	1.088–1.545
Occupation						
Manual worker			9.860	0.007	1	
Mental worker	-0.199	0.083	5.739	0.017	0.820	0.696–0.964
Retirement	0.033	0.060	0.297	0.586	1.033	0.918–1.163
Educational level						
Primary school or below			3.694	0.449	1	
Junior middle school	-0.070	0.079	0.789	0.374	0.932	0.799–1.088
Senior middle school	-0.090	0.083	1.185	0.276	0.914	0.777–1.075
Undergraduate or above	-0.135	0.088	2.347	0.125	0.874	0.735–1.038
Unknown	-0.469	0.359	1.714	0.190	0.625	0.310–1.263
Annual income (¥)						
<30,000			13.465	0.001	1	
30,000~50,000	-0.169	0.054	9.637	0.002	0.845	0.759–0.940
>50,000	0.111	0.105	1.110	0.292	1.117	0.909–1.372
Physical exercise						
Never			5.672	0.059	1	
Sometimes	0.230	0.164	1.972	0.160	1.259	0.913–1.737
Often	-0.089	0.063	2.005	0.157	0.915	0.809–1.035
Current smoking	-0.109	0.076	2.070	0.150	0.896	0.772–1.040
Current drinking	0.001	0.079	0.000	0.986	1.001	0.857–1.170
History of coronary heart disease	0.372	0.081	20.933	<0.001	1.451	1.237–1.702
History of stroke	0.144	0.149	0.932	0.334	1.155	0.862–1.546
History of diabetes	0.492	0.053	85.768	<0.001	1.636	1.474–1.816
History of hyperlipidemia	0.112	0.050	5.016	0.025	1.119	1.014–1.235
Family history of hypertension	1.390	0.102	183.960	<0.001	4.013	3.283–4.906

1: the reference cell

Table 4 Individual characteristics associated with awareness, treatment, and control of hypertension

	Awareness		Treatment		Control	
	OR (95%CI)	*P*	OR (95%CI)	*P*	OR (95%CI)	*P*
Sex (Female)	1.281(1.018–1.613)	0.035	1.319(1.118–1.556)	0.001	1.255(1.066–1.478)	0.006
BMI						
Underweight	0.463(0.196–1.096)	0.080	0.563(0.275–1.152)	0.116	0.582(0.281–1.204)	0.145
Normal	1	0.010	1	<0.001	1	0.407
Overweight	1.282(1.021–1.611)	0.033	1.403(1.191–1.651)	<0.001	1.056(0.895–1.244)	0.520
Obesity	1.408(1.046–1.896)	0.024	1.678(1.359–2.070)	<0.001	1.002(0.818–1.228)	0981
Marital status						
Unmarried	0.436(0.139–1.367)	0.155	0.814(0.295–2. 247)	0.691	0.978(0.343–2.792)	0.967
Married/Cohabitation	1	0.006	1	0.380	1	0.018
Divorced/ Separated	0.310(0.153–0.628)	0.001	0.617(0.332–1.148)	0.127	0.938(0.496–1.772)	0.843
Widowered/widowed	0.994(0.699–1.414)	0.975	0.899(0.705–1.146)	0.389	0.685(0.542–0.866)	0.002
Occupation						
Manual worker	1	0.002	1	0.405	1	0.033
Mental worker	0.654(0.474–0.901)	0.010	0.862(0.675–1.101)	0.234	0.929(0.732–1.180)	0.547
Retirement	1.080(0.841–1.387)	0.546	0.996(0.836–1.186)	0.960	1.183(0.996–1.404)	0.055
Educational level						
Primary school or below	1	0.690	1	0.274	1	0.893
Junior middle school	1.033(0.758–1.408)	0.837	1.084(0.870–1.351)	0.471	0.918(0.736–1.146)	0.450
Senior middle school	1.203(0.863–1.677)	0.275	1.196(0.947–1.511)	0.133	0.948(0.750–1.198)	0.653
Undergraduate or above	1.199(0.841–1.709)	0.316	1.254(0.974–1.614)	0.079	0.881(0.686–1.133)	0.325
Unknown	--	0.999	0.635(0.220–1.835)	0.401	0.905(0.290–2.822)	0.864
Annual income (¥)						
<30,000	1	<0.001	1	0.008	1	<0.001
30,000~50,000	0.639(0.509–0.801)	<0.001	0.839(0.715–0.984)	0.031	0.900(0.768–1.053)	0.189
>50,000	0.402(0.280–0.575)	<0.001	0.665(0.499–0.888)	0.006	0.472(0.357–0.624)	<0.001
Physical exercise						
Never	1	0.002	1	<0.001	1	<0.001
Sometimes	0.651(0.385–1.102)	0.110	1.033(0.677–1.577)	0.881	0.745(0.495–1.123)	0.160
Often	1.355(1.061–1.729)	0.015	1.454(1.220–1.732)	<0.001	1.313(1.103–1.564)	0.002
Current smoking	1.015(0.740–1.393)	0.926	1.358(1.077–1.712)	0.010	0.967(0.774–1.209)	0768
Current drinking	1.235(0.883–1.725)	0.217	0.888(0.703–1.123)	0.323	1.107(0.876–1.399)	0.394
History of heart coronary disease	1.610(1.131–2.291)	0.008	1.189(0.952–1.484)	0.127	0.842(0.684–1.036)	0.104
History of stroke	1.885(0.901–3.943)	0.092	0.973(0.650–1.455)	0.892	0.919(0.623–1.355)	0.670
History of diabetes	1.088(0.879–1.346)	0.439	1.000(0.861–1.163)	0.996	0.839(0.724–0.972)	0.019
History of hyperlipidemia	0.796(0.647–0.979)	0.030	0.850(0.733–0.984)	0.030	0.725(0.627–0.838)	<0.001
Family history of	2.263(1.561–3.279)	<0.001	1.323(1.066–1.641)	0.011	0.677(0.557–0.822)	<0.001

hypertension

1: the reference cell

Table 5 The use of antihypertensive medications among treated population with hypertension

		Total	Male	Female	*P* value
Monotherapy	DIU	83(3.3%)	41(3.5%)	42(3.2%)	0.414
	CCB	1835(73.8%)	871(73.5%)	964(74.0%)	0.410
	ACEI	124(5.0%)	69(5.8%)	55(4.2%)	0.041
	BB	150(6.0%)	66(5.6%)	84(6.4%)	0.202
	ARB	272(10.9%)	140(11.8%)	132(10.1%)	0.100
	TCM	162(6.5%)	64(5.4%)	98(7.5%)	0.019
	Others	61(2.5%)	29(2.4%)	32(2.5%)	0.548
Total monotherapy		2304(92.6%)	1096(92.5%)	1208(92.7%)	0.447
Combination therapy		184(7.4%)	89(7.5%)	95(7.3%)	

DIU: diuretics; CCB: calcium channel blockers; ACEI: angiotensin converting enzyme inhibitors; BB: beta blockers; ARB: angiotensin receptor blockers; TCM: traditional Chinese medicine

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	7

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	–
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	–
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	8
		Cross-sectional study—Report numbers of outcome events or summary measures	–
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
		(*b*) Report category boundaries when continuous variables were categorized	9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.