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Original Article

Epidemiological investigation and analysis of hypertension in the central urban areas of Shanghai

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Abstract: Objective: To understand the prevalence, awareness, control, major risk factors, and concomitant diseases of hypertension among residents in the communities of central urban Shanghai. Methods: A cross-sectional survey was performed on residents 25 years of age and older who live in the four large communities in the Changning District of Shanghai, by using a multistage random sampling method, the total sample of which is 21,930. Trained investigators measured blood pressure and collected data. The prevalence, awareness, and control of hypertension, as well as risk factors and concomitant diseases, were analyzed using descriptive methods and a logistic regression method. Results: The prevalence of hypertension was 39.23%; and there was significant difference between the men and women ($P<0.05$). Hypertension showed a rising tendency with increasing age ($P=0.000$). The awareness and control rate of patients with hypertension was 84.66% and 56.08%, respectively. Multivariate logistic regression analysis showed that hypertension was associated with a family history of hypertension, a family history of cardio-cerebral-vascular disease, employment status, salt intake, BMI, age, gender, diabetes, hyperlipidemia, previous stroke (s), organic heart disease, and tumors ($P<0.05$). Conclusion: The prevalence, awareness, and control rates of hypertension for residents in the communities of central urban Shanghai are relatively high. The risk factors of hypertension in these areas are age, female gender, a family history of hypertension or cardiovascular disease, unemployment, a high-salt diet, and obesity. Diabetes, hyperlipidemia, stroke, organic heart disease and tumors are concomitant diseases of hypertension.

Keywords: Community, hypertension, prevalence, awareness, control, risk factor, epidemiology

Introduction

Hypertension is recognized as the most common risk factor of cardiovascular and renal diseases. Long-term cases of hypertension may cause serious damage to the heart, brain, kidney and other target organs. Its complications, such as coronary heart disease, stroke and kidney failure, have a high disability and mortality rate. The World Health Organization has listed hypertension as the No. 1 risk factor of mortality and the No. 3 factor of disease burden [1]. According to statistical data, a quarter of the world's adults suffered from hypertension (nearly one billion) in 2000 and this number is expected to grow 60% by 2025 [2]. The awareness, treatment, and control of hypertension indicate the rate of prevention and the effectiveness of community response to hypertension. According to studies from Tulane University, awareness, treatment and control rates differ in various regions of the world [3], and are relatively higher in developed countries but lower in most developing countries. China is a developing country, and its awareness, treatment, and control rates have been historically low; therefore, it would be greatly beneficial to enhance the people's awareness and understanding of hypertension and the factors related to hypertension, as well as strengthening prevention and treatment measures.

This study comprised of an epidemiological survey of populations 25 years of age and older from four large communities in the Changning District of Shanghai, and sought to expose the prevalence, awareness and control rates of hypertension among community residents, so as to provide a theoretical basis for the implementation of a comprehensive prevention and control program.

Subjects and methods

Surveyed subjects and sampling method

This study has been approved by "Institutional Review Board of Huadong Hospital, Fudan University" (No. [2007]010). The surveyed subjects were 25 years of age and older and permanent residents of the four communities of Zunyi, Xinhua, Chengjiaqiao, and Beixinjing, in the Changning District of Shanghai. The inclusion criteria: Age ≥25 years and the residence time ≥5 years.

A multi-stage random sampling on was performed on eligible subjects. Six neighborhood subdivisions were randomly selected from each community and 1,000 people were randomly selected from each neighborhood committee. All subjects gave their informed consent and signature.

Survey methods and contents

A standard uniform epidemiological questionnaire was used. Trained and qualified investigators conducted the inquiries and filled out the questionnaires. Contents of the questionnaires included: general information (name, gender, nationality, date of birth, home address, work, occupation status, annual household income), habits (smoking, alcohol usage, amount of exercise), salt intake, a personal medical history of hypertension, diabetes, hyperlipidemia, stroke, organic heart disease, peripheral vascular disease, severe liver and kidney function damage, tumors, respiratory diseases or other conditions, a medical history of direct relatives (whether the parents of the subject experienced hypertension, cardiovascular and cerebrovascular disease, diabetes or other conditions). Classifications are defined as follows:

Smoking is divided into daily smoking ≥10 cigarettes, continuous smoking >1 month. Drinking indicates average liquor drinking ≥100 g/day. Salt intake is divided into a per day intake <6 g, 6-12 g, and >12 g (taking a 2 g salt-measuring spoon provided by a neighborhood committee as the standard). A family history of hypertension indicates that at least one of the parents has a history of hypertension. Diabetes includes type 1 and type 2 diabetes. Hyperlipidemia indicates that serum low-density lipoprotein cholesterol (LDL-C) ≥4.14 mmol/L or high-density lipoprotein cholesterol (HDL-C) ≤1.04 mmol/L or serum triglyceride (TG) ≥2.27 mmol/L or serum total cholesterol (TC) ≥6.19 mmol/L. Previous stroke history includes a hemorrhagic stroke or an ischemic stroke, subject to a provided CT or MRI report. Organic heart diseases refer to coronary artery disease, rheumatic heart disease, cardiomyopathy, congenital heart disease and severe heart rhythm disorder history. Peripheral vascular disease refers to vascular diseases except those originating in the heart and cerebral vessels, such as arterial stenosis occlusive disease, arterial dilatation lesion, arterial inflammation, peripheral arterial disorder, shallow varicosity, deep vein thrombosis, deep venous valve incompetence or history of other related diseases. Severe liver dysfunction means that the ALT or AST is four times greater than the normal upper limit or other indicators, resulting in an impairment of liver function, for example, a total bilirubin count greater than 20 umol/L, and cholestasis. Severe renal dysfunction indicates that the creatinine clearance rate is <0.6 ml/min or serum creatinine >265 umol/L (≥3.0 mg/dl). A tumor indicates that patients have had a history of malignant tumors and those who are suffering from malignant tumors. Respiratory disease refers to asthma, chronic obstructive pulmonary disease, sleep apnea syndrome, interstitial lung lesion and other related diseases.

Determination of basic parameters

Body mass index (BMI)=weight (kg)/height $(m)^2$ represents the overall obesity status. In accordance with the standard of *Hypertension Prevention Guide of China* (Revision 2005), a standard uniformly-calibrated desktop mercury sphygmomanometer is used for measurement; measuring method of blood pressure: sit quietly for 5 minutes before measurement, take the subject's blood pressure twice while he or she is seated, when the difference between systolic blood pressures or diastolic blood pressures is more than 4 mmHg, measure blood pressure for a third time, taking the average value. When systolic blood pressure ≥140 mmHg and (or) diastolic blood pressure ≥90 mmHg, or when blood pressure <140/90 mmHg with an intake of antihypertensive drugs during the previous two weeks, it is judged as high blood pressure.

Table 1. Composition ratio of gender and age

Age grouping	Gender		Total N (%)
	Men N (%)	Women N (%)	
25-34 years old	122 (0.56)	159 (0.73)	281 (1.28)
35-44 years old	940 (4.29)	1000 (4.56)	1940 (8.85)
45-54 years old	1799 (8.20)	2214 (10.10)	4013 (18.30)
55-64 years old	2484 (11.33)	2977 (13.58)	5461 (24.90)
65-74 years old	1466 (6.68)	1935 (8.82)	3401 (15.51)
75-84 years old	2063 (9.41)	2691 (12.27)	4754 (21.68)
85 years old and above	884 (4.03)	1046 (4.77)	1930 (8.80)
Pooled	9816 (44.76)	12114 (55.24)	21930 (100.00)

Note: There were 58 and 92 cases of missing subject data for men and women respectively.

Table 2. Prevalence of hypertension distribution with the age growth

	With hypertension		Total
	Number	Proportion (100%)	
25-34 years old	20	7.12	281
35-44 years old	82	4.23	1940
45-54 years old	715	17.82	4013
55-64 years old	1658	30.36	5461
65-74 years old	1812	53.28	3401
75-84 years old	3033	63.80	4754
85 years old and over	1212	62.80	1930
Total	8604	39.23	21930

Note: In the crosstab test of each age group, *P* value was <0.01. Age trend analysis, trend x^2=3771.750, P=0.000. There were 72 cases of missing subject data with hypertension in this table above.

Statistical analysis

A database was established and all data was recorded and placed in uniform record forms, coded and entered twice by trained staff members. Two-sided *P* values were used. The prevalence of hypertension was calculated by age groups and gender. X^2-tests were used to compare hypertension prevalence rates for different age and gender groups. Associations between hypertension and socio-economic status, age, personal habits and other variables were tested using an unadjusted odds ratio (OR). Multivariate regression analysis was carried out between dependent variables (hypertension) and independent variables (socio-economic status and age, personal habits and other variables). All statistical analyses were conducted using SPSS (Window Version 16.0), and an Epiinfo analysis module was used for the analysis of an age trend. Significance was specified as a *p*-value of less than 0.05.

Results

General conditions

The sampled number in this community who met the eligibility criteria was 24,000 persons. A total of 21,930 persons accepted the survey in this study, and response rate of the survey was 91.38%, totaling to 9,816 men and 12,114 women, with a men/women ratio of 1:1.23. The average age of the study was 64.19 ± 15.04: 63.87 ± 15.12 and 64.45 ± 14.97 for men and women, respectively. Composition ratio of gender and age was shown in **Table 1**.

Prevalence condition of hypertension

The overall prevalence of hypertension among the surveyed community residents was 39.32%. For men and women respectively, the prevalence rate was 38.2% and 40.1%. There was a statistical difference of prevalence between genders (x^2=7.613, P=0.006).

Residents were divided into groups in intervals of 10 years of age, with residents over 85 years old as a single group. The prevalence of hypertension increased with age from 7.12% among 25-34 year olds to 63.80% among 75-84 year olds. The chi-square test of trend showed statistic significance (x^2=3771.750, *P*=0.000 Shown in **Table 2**).

Awareness of hypertension

Awareness rate was defined as the proportion of subjects who know of their condition before being surveyed. In the present study, 7284 of the total 8604 hypertensive participants were aware of their hypertension. So the awareness rate was 84.66%.

Control of hypertension

According to an analysis on the control of blood pressure in 7,284 hypertension participants, classifying blood pressure under 140/90 mmHg as controlled and higher readings as uncontrolled, the control rate was 56.08%.

Table 3. Univariate logistic regression analysis on correlations between hypertension and various influence factors

Influence factor	Regression coefficient b	OR	*P* value	95.0% CI for OR	
				Lower	Upper
Community	0.031	1.031	0.100	0.994	1.069
Employment status	0.351	1.420	<0.01	1.341	1.504
Vocation type	-0.015	0.985	0.193	0.963	1.008
Household income	-0.004	0.996	0.930	0.911	1.089
Family history of hypertension	1.173	3.233	<0.01	3.012	3.469
Family history of cardiovascular and cerebrovascular diseases	0.890	2.435	<0.01	2.226	2.663
Family history of diabetes mellitus	0.485	1.624	<0.01	1.443	1.827
Diabetes mellitus	1.233	3.432	<0.01	2.994	3.933
Hyperlipoidemia	1.287	3.621	<0.01	3.088	4.246
Previous stroke	1.539	4.660	<0.01	3.688	5.887
Organic heart disease	1.338	3.812	<0.01	3.212	4.524
Peripheral vascular diseases	0.767	2.153	<0.01	1.154	4.017
Serious dysfunction of liver and kidney	0.882	2.415	0.002	1.393	4.187
Tumor	0.591	1.805	<0.01	1.351	2.411
Disease of the respiratory system	-0.045	0.956	0.644	0.792	1.155
Smoke	-0.040	0.961	0.088	0.917	1.006
Drink	0.153	1.165	0.124	0.959	1.415
Salt intake	0.464	1.591	<0.01	1.514	1.671
Amount of physical exercise	0.290	1.336	<0.01	1.257	1.420
BMI	0.641	1.899	<0.01	1.815	1.987
WHR	0.074	1.077	0.098	0.986	1.176
Awareness	0.007	1.040	<0.05	1.035	1.890
Control	0.190	1.289	<0.05	1.138	1.980

Correlations between hypertension and different personal habits, family history and personal medical history

Single factor logistic regression analysis on correlations between hypertension and various influence factors showed that employment status, a family history of hypertension, a family history of cardiovascular and cerebrovascular diseases, a family history of diabetes mellitus, diabetes mellitus, hyperlipidemia, previous stroke (s), organic heart disease, peripheral vascular diseases, serious dysfunction of liver or kidney, tumors, salt intake, amount of physical exercise and BMI were in positive correlation with hypertension ($P<0.05$, OR>1); while community, vocation type, household income, disease of respiratory system, smoking, drinking and waist to hip ratio (WHR) had no correlation with hypertension ($P>0.05$). Details are shown in **Table 3**.

In order to eliminate the bias caused by the influences of various factors on each other, using the results of the single factor Logistic regression analysis, multivariate logistic regression analysis was carried out by factoring in the employment status of the participant, a family history of hypertension, a family history of cardiovascular and cerebrovascular diseases, a family history of diabetes mellitus, diabetes mellitus, hyperlipidemia, previous stroke (s), organic heart disease, peripheral vascular diseases, serious dysfunction of liver and kidney, tumors, salt intake, amount of physical exercise, BMI, age and gender. For some factors, 2-3 categories were established. Employment status was classified into the following groups: employed, retired, and unemployed, using those who are unemployed but have no desire to work as the control group; Salt intake level includes salt intake <6 g/day and >12 g/day, using salt intake 6 g-12 g/day as the control group. The final model indicates that a family history of hypertension ($P<0.05$, OR=2.611, 95% CI 2.395-2.846), a family history of cardiovascular and cerebrovascular diseases ($P<0.05$, OR=1.142, 95% CI

Table 4. Multivariate logistic regression analysis on correlations between hypertension and various influence factors

Influence factors	Regression coefficient b	OR	*P* value	95.0% CI for OR	
				Lower	Upper
Employment status					
Employed	1.001	0.491	P<0.05	0.328	0.735
Retired	0.987	1.029	0.189	0.689	1.537
Unemployed	-0.001	1.681	P<0.05	1.099	2.571
Family history of hypertension	0.987	2.611	P<0.05	2.395	2.846
Family history of cardiovascular and cerebrovascular diseases	1.002	1.142	P<0.05	1.019	1.279
Family history of diabetes mellitus	0.783	0.790	0.067	0.685	0.911
Diabetes mellitus	0.792	2.790	P<0.05	2.401	3.243
Hyperlipoidemia	-0.001	2.077	P<0.05	1.740	2.480
Previous stroke (s)		3.143	P<0.05	2.448	4.035
Organic heart disease		2.733	P<0.05	2.243	3.330
Peripheral vascular diseases	-0.005	1.471	0.367	0.705	3.068
Serious dysfunction of liver and kidney	0.886	1.615	0.165	0.740	3.523
Tumor	0.897	1.440	P<0.05	1.037	1.999
Salt intake					
Salt intake <6 g/day	-0.050	0.703	0.059	0.614	0.806
Salt intake >12 g/day	0.987	1.167	P<0.05	1.012	1.344
Amount of physical exercise	1.001	1.058	0.099	0.987	1.134
BMI	1.051	1.646	P<0.05	1.545	1.754
Age	0.789	1.055	P<0.05	1.051	1.059
Gender (male/female)	0.959	1.097	P<0.05	1.031	1.160

1.019-1.279), employed status (P<0.05, OR= 0.491, 95% CI 0.328-0.735), unemployed status (*P*<0.05, OR=1.681, 95% CI 1.099-2.571), salt intake >12 g/day (*P*<0.05, OR= 1.167, 95% CI 1.012-1.344), BMI (*P*<0.05, OR=1.646, 95% CI 1.545-1.754), age (*P*<0.05, OR=1.055, 95% CI 1.051-1.059), gender (female/male, *P*<0.05, OR=1.097, 95% CI (1.031-1.160), diabetes mellitus (*P*<0.05, OR=2.790, 95% CI 2.401-3.243), hyperlipidemia (*P*< 0.05, OR=2.077, 95% CI 1.740-2.480), previous stroke (s) (*P*<0.05, OR=3.143, 95% CI 2.448-4.035), organic heart disease (*P*<0.05, OR=2.733, 95% CI 2.243-3.330) and tumors (*P*<0.05, OR=1.440, 95% CI 1.037-1.999) were significantly associated with hypertension. Details were shown in **Table 4**.

Discussion

This investigation found the total prevalence of hypertension to be 39.23%, which is higher than the 20% value in the MONICA information given by the World Health Organization [4] and higher than the value of 18.8% concluded from the last sample investigation of hypertension in China from 2002 [5]. We believe that the larger value found in this study is closely associated with both the increasing number of patients with hypertension worldwide and also the areas that the investigation was conducted in. Currently, Shanghai is one of the most developed cities of China, while these areas which are located in the center are the most developed part of the city. In addition, the incidence of hypertension is closely related to the age of the patients. The prevalence of hypertension among residents of North America or Europe who are 65 years of age or older are greater than 50% [6, 7]. In this investigation, the average age of the surveyed subjects was 64.19±15.04, which explains a larger value.

The prevalence of hypertension between men and women varies between investigations. The data given by NHANES shows that, from 1999-2000, 2003-2006, and 2007-2010, women constituted the majority of the patients with hypertension [8]. A recent large-scale epidemiological investigation in Japan indicates that

men have a higher rate of hypertension than women [9]. This investigation found difference results, with the prevalence of hypertension for women being 40.1%, and for men, 38.2% ($P<0.05$). We also found a trend that the prevalence of hypertension increases as people gets older, which is supported by a number of publications from many countries and regions [10, 11]. It is essential for the Chinese community to prevent and control hypertension in the elderly population, especially with older women.

The results of this investigation were an awareness rate of 84.66%, and a control rate of 56.4%, which is far higher than Greece's 60.2% and 32.8% [12], respectively, and far higher than Finland's results from a statistical sample of 16775, which are 68.0% and 37%, respectively [6]. All four communities are in the central urban area of Shanghai, the most developed area, with an established medical system, which may explain the higher rates of awareness and control.

Logistic regression analysis data showed that the following factors may influence the prevalence of hypertension: a family history of hypertension, a family history of cardiovascular and cerebrovascular diseases, employment status, salt intake, BMI, chronic diseases (including diabetes mellitus, hyperlipidemia, stroke, organic heart disease, tumors, etc), $P<0.05$, $OR>1$. A number of studies have shown that people whose BMI exceeds the normal range are more likely to suffer from hypertension [13, 14], suggesting that weight control is an important factor in preventing hypertension. It is generally accepted that a high salt diet is unfavorable for controlling blood pressure [15], in this investigation; subjects were divided into groups according to their salt intake. The results show that people who consume more than 12 grams of salt a day are more likely to suffer from hypertension.

Based on the epidemiological investigation and multivariate regression analysis results, we postulate that a family history of hypertension, cardiovascular disease, or cerebrovascular disease is correlated with the incidence of hypertension. Some clinical research provides evidence for our hypothesis [16-18]. As for an individual history of disease, there is abundant evidence showing that diabetes mellitus, hyperlipidemia, stroke, and organic heart disease are closely linked to the occurrence of hypertension [19-22]. Results of this investigation also demonstrate a relationship with hypertension (both the $OR>2$). Diabetes mellitus and hyperlipidemia should be regarded as concomitant diseases of hypertension, which act as both a cause and a symptom [20, 21]; therefore, strict control over blood glucose and blood lipid levels can help control the hypertension. Stroke and organic heart disease should be treated as long-term complications of hypertension, namely due to target-organ damage. Hypertension is among the leading causes of stroke and coronary heart disease [19, 21]; this investigation also found that blood pressure level is in a continuous, independent and direct positive correlation to stroke and CHD. Furthermore, our investigation also shows that presence of tumors is positively correlated to hypertension ($OR=1.99$), a detail seldom presented in other domestic and foreign reports. Upon consideration, we recognize that, for a patient with tumors, long-term stress may be the reason for the correlation, but it needs further investigation.

Conclusion

In conducting this investigation, we followed the traditional epidemiological investigating method, collecting all statistical data with the help of the community Health Care Service System. Using a large sample size when applying a multistage sampling method can reduce the system error to some extent, making the statistical data more accurate in reflecting the situation of patients with hypertension in central urban areas of developed cities. The investigation shows that people in the central urban area have higher awareness control rates, but also a higher rate of prevalence. The data demonstrated that hypertension is closely correlated to age, gender (female), a family history of hypertension, a family history of cardiovascular and cerebrovascular diseases, unemployment, a high salt diet, obesity, diabetes mellitus, hyperlipidemia, stroke (s), organic heart disease, presence of tumors, etc. Therefore, it is essential to standardize community health care, improve health education, regularly monitor blood pressure, and advocate for weight

control, a limited salt intake, and control of blood glucose and blood lipid levels, in order to control and prevent hypertension among community residents.

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Disclosure of conflict of interest

None.

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