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# Factors associated with treatment and control of hypertension in Shenzhen elderly adults



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# Factors associated with treatment and control of hypertension in Shenzhen elderly adults

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## Abstract

**Objective**: Hypertension has become the leading cause of death worldwide; data on hypertension management among Shenzhen elderly are sparse. Our study aims to estimate treated and controlled hypertension and relevant predictors in Shenzhen elderly.

**Design**: A cross-sectional study.

**Setting**: Communities in Shenzhen, Guangdong, China.

**Participants**: 124007 participants aged 65 years old and older were recruited from January 2018 through December 2018 at local community health service centers in Shenzhen.

**Main outcome measures**: Data on management and influencing factors were obtained from a standard questionnaire and physical measurements. Logistic regression was used to assess the predictors of hypertension treatment and control.

**Results**: Prevalence of hypertension was 55.81%. Among hypertensive patients, treatment, and control of hypertension were 54.43%, and 32.32%, respectively. In multivariate analysis, significant associations were found between treatment and older age, junior school education and above, being widowed rather than being married or cohabiting, ex-smoker, drinker, physical activity, history of cardiovascular disease (CVD), and comorbidities, with a higher probability for those who had obesity, central obesity, diabetes and dyslipidemia. Male sex, attended junior school education and above, aged 65-79 years, having physical activity, being non-drinker, history of CVD and individuals who had normal waist circumference, diabetes and dyslipidemia had higher odds of control.

**Conclusions**: We found a high prevalence of hypertension and a low prevalence of treatment and control among Shenzhen elderly. The health policy department should develop effective strategies aimed at improving health care management of hypertension in elderly adults.


**Keywords:** Hypertension; Treatment; Control; Elderly

**Strengths and limitations of this study**

■ This study is the first to evaluate the prevalence, treatment and control of hypertension in a sample aged ⩾65years from general communities in Shenzhen.

■ Our focus on older adults, which is considered to be a vulnerable group, is especially important in China where the proportion of older adults is increasing.

■Our research enrolled the elderly population by convenience sampling.

■We did not collect data on dietary and family history of hypertension, which may play a role in the treatment and control of hypertension.

## 1. Introduction

Hypertension is an important public-health challenge worldwide and a major risk factor leading to stroke, myocardial infarction, and heart failure.[1] As in many conditions, hypertension increases with age, with its prevalence increasing from 27% in patients aged younger than 60 years to 74% in those aged older than 80 years.[2] The Framingham Heart Study showed than more than 90% of the participants with a normal blood pressure at age 55 years eventually develop hypertension.[3] By the year 2020, the projected number of people living age 60 years or older will comprise 17.8% of China.[4] With this rapidly aging population, the prevalence of hypertension can only be expected to rise. Therefore, it is crucial to understand the current management of hypertension in elderly adults.

The management of hypertension in the elderly has many challenges, including agreement on threshold and target blood pressure levels, and the balancing of adverse effects and potential benefits of treatment.[5] While extensive studies have been undertaken to identify risk factors for hypertension in predominantly middle-aged populations, gaps in our understanding of risk profiles and management of hypertension amongst older still exist. A better understanding of the factors impacting treatment and control hypertension in older adults is crucial to the development of interventions to manage high blood pressure in this growing sector of the population. Therefore, our study aimed to investigate the treatment, and control rate of hypertension among elderly population in Shenzhen and also identified related risk factors to provide evidence for disease prevention and help elevate the life quality of older hypertension patients. Strategies targeting hypertension in the elderly population should be proposed.

## 2. Material and methods

### 2.1Study population

We recruited people 65 years old and above from the lists of all residents registered at local community health service centers from January 2018 through December 2018 in Shenzhen by convenience sampling. Participants eligibility criteria were as follows: (1) lived in Shenzhen for more than 6 months, (2) living in community. 141,684 were recruited into the study, which accounted for 36.9% (141,684/383,700) of the resident population of elderly adults in Shenzhen based on data from the 2015 population census. Data were collected in examination centers at local community health service centers in the participants' residential areas. We asked the participants to complete a questionnaire, provide a fasting blood sample and attend physical examinations. There were 17,677 participants excluded because they did not complete the questionnaire, provide fasting blood sample or were unable to attend physical examinations. At last, 124,007 participants (87.52%) were included in the final data analysis. The study received ethnicity approval of the Center for Chronic Disease Control of Shenzhen. A written informed consent was given by all participants before the collection of data and conduction of the research. If the participants were illiterate, we obtained the written informed consents from their proxies.

### 2.2 Questionnaire survey

Before the survey began, all investigators completed a training programme that taught the methods and process of the study. A manual of procedures was distributed, and detailed instructions for administration of the questionnaires, taking of blood pressure and anthropometric measurements, and biological specimen collection and processing were provided.

Data were recorded by face-to-face interview in person 1 hour after blood collection. All participants completed a standardized questionnaire including socio-demographic status (e.g., date of birth, gender, education level, marital status, etc.), previous history (e.g., history of previous disease, operation history, history of trauma, etc.), family health history (e.g., hypertension, diabetes, coronary heart disease, malignant tumor, stroke, etc.), lifestyle (smoking, physical activity, and alcohol consumption, etc.), and medication use under the supervision of trained general practitioners and nurses.

In this study, we defined the term 'moderate to vigorous intensity physical activity' as at least some sweating and shortness of breath caused by physical activity, and the term 'light physical activity' as no sweating or shortness of breath caused by physical activity.[6] In addition, moderate to vigorous intensity physical activity at least once a week was classified as 'Yes' in physical activity status. For alcohol drinking habits, participants reported themselves as habitual drinker (drink once a day or more), non-habitual drinker (six times a week to once a month) or non-drinker (almost never).[7] For cigarette smoking, we categorised participants as current smoker, ex-smoker and never-smoker, as described elsewhere.[8]

**2.3 Physical examination**

Anthropometric examinations were administered in the morning on participants who had fasted overnight, following which body measurements were taken by trained examiners based on a standardised protocol. Height and weight were measured with the participants wearing light dress without shoes using analogue scales. Waist circumference (WC) was measured, at the end of normal expiration, at the midpoint level of midaxillary line between the 12th rib head and the superior anterior iliac spine. Body mass index (BMI) was calculated by dividing body weight (in kilograms) by the square of height (in metres). Calibrated electronic sphygmomanometers were used to measure blood pressure on the right arm supported at heart level with sitting position for two times. The average of the two measurements was used for the statistic analysis. To have accurate readings, the participants were asked to have a rest for at least 5 min, or excessive physical activity for at least 30 min or longer before the measurement.

**2.4 Blood sample collection and biochemical analyses**

Participants' vein blood samples were taken after at least 8 h of overnight fasting. All blood samples were analyzed at the clinical laboratories of grade 2 hospitals (to which the community health service centers are directly affiliated). All the laboratories involved had successfully completed a standardization and competency program. Fasting venous blood was drawn from subjects for the measurements of levels of total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) by automatic biochemistry analyzer. TC and TG were estimated using enzymatic method with

commercially available reagents while HDL and LDL using a timed-endpoint colorimetric method. Fresh fasting blood samples were biochemically analysed within a maximum of 4 hours. Glucose oxidase measurements were used to ascertain the fasting blood glucose (FBG) level.

**2.5 Definitions**

Hypertension was defined as a systolic or diastolic blood pressure of ≥140/90 mmHg or self-reported treatment with antihypertensive medication within 2 weeks [9]. Participants were considered to be treated if they answered "yes" to the question "Because of your high blood pressure/hypertension, are you now taking prescribed medicine?". Controlled hypertension was defined as measured blood pressure below 140/90 mmHg at the time of the interview. [9, 10] Participants were regarded as diabetes if one of the following three conditions was met: (1) previously diagnosed by professional doctors, (2) FBG ≥ 7.0 mmol/L, (3) 2-h plasma glucose level ≥ 11.1 mmol/L.[11] TC, LDL-C, HDL-C and TG levels were classified on the basis of the 2016 Chinese Guideline for the Management of Dyslipidemia in Adults.[12] It defines high TC as TC ≥ 6.22 mmol/L, High LDL-C as LDL-C ≥ 4.14 mmol/L, low HDL-C as LDL-C < 1.04 mmol/L, and high TG as TG ≥ 2.26 mmol/L. In the present study, we define dyslipidemia as the presence of one or more abnormal serum lipid concentrations or use of anti-dyslipidemia medications in the past two weeks.

Based on the Criteria of Weight for Adults released by the Ministry of Health of China (WS/T 428-2013), individuals were categorized into four groups: BMI < 18.5 kg/m$^2$ (low weight), 18.5 kg/m$^2$ ≤ BMI < 24.0 kg/m$^2$ (normal weight), 24.0 kg/m$^2$ ≤ BMI < 28.0 kg/m$^2$ (overweight) and BMI ≥ 28.0 kg/m$^2$ (obesity). Men with WC ≥ 90 cm or women with WC≥ 85 cm was defined as central obesity.

**2.6 Statistical analyses**

We collected descriptive statistics for all the variables, including continuous variables (expressed as means and standard deviations) and categorical variables (expressed as numbers and percentages). Categorical variables between groups were compared using Chi-square test. Multivariate logistic regression analysis was performed to explore the Management of hypertension and associated Risk Factors. Covariates included in the multivariable logistic regression models were age, gender, education level, marital status, smoking status, drinking habit, physical activity status, BMI, central obesity, diabetes, dyslipidemia, history of CVD. The SAS software, version 9.4 (SAS Institute, Cary, NC, USA), was used to perform all statistical analyses. A level of two-sided $P$<0.05 was considered to be statistically significant.

**2.7Participant and public involvement**

The participants and the public were not involved in the design, recruitment and conduct of the study. All the participants had the option to receive the health check and biochemical results when they visited community health service centers.

**3.0 Results**

**3.1 Socio-demographic and other characteristics of participants**

Of the 124,007 participants, 44.06 % (n =54,649) were male, 55.94 % (n = 69,358) were female, the mean age was 71.28±5.59; 56.33% attained a junior school education and above; 96.22 % were married or cohabiting; 76.88 % reported having

regular physical activities; and 4.19% reported having the history of CVD (As shown in Table 1). The rate of current smoking was 8.20 %, and that of habitual drinking was 6.36% (As shown in Table 1). In terms of anthropometric, the mean levels of average BMI, SBP, DBP, WC, FBG, TC, TG, LDL-C, and HDL-C for all 124,007 participants were 23.83±3.17 Kg/m2, 134.71±17.67 mm Hg, 77.24±10.30 mm Hg, 85.09±8.82 cm, 5.97±1.91 mmol/ L, 5.21 ± 2.05 mmol/L, 1.58 ± 1.14 mmol/L, 3.08 ± 1.06 mmol/L, and 1.39 ± 0.51 mmol/L, respectively (As shown in Table 1).

### 3.2 Treatment and control rates in different subgroups

The prevalence of hypertension was 55.81%. Of those individuals with hypertension, 54.43% received treatment, and 32.32% had blood pressure control. Table 2 lists the treatment and control of hypertension by sociodemographic, lifestyle, clinical and anthropometric characteristics. The treatment rate had no difference in males and females. However, males have a significantly higher rate of control than females Higher treatment and control rates was found among those who have attended junior school education and above, who engaged in regular physical activity, who were or ex-smoker, who had history of cardiovascular disease (CVD) or diabetes or dyslipidemia. Participants who were single had lowest treatment rates when compared with their counterpart. Participants aged 65～69 years had the lowest treatment rates in contrast to older participants. Habitual drinkers had the lowest treatment and control rate. Participants with obesity or central obesity had the higher treatment rate and the lower control rate.

### 3.3 Results of multivariable analysis of factors associated with treatment and control of hypertension

The results of multivariate logistic regression analysis of hypertension treatment and control according to selected socio-demographic and other potential factors are presented in Table 3. Participants with the highest educational attainment were more likely to be treatment of their blood pressure status compared to participants with low education. Widowed were protective factors of the treatment of hypertension while single was negatively related to the treatment rate. Older age, physical activity, ex-smoker were protective factors of the treatment of hypertension while non-habitual drinker or habitual drinker was negatively related to the treatment rate. History of CVD was more likely to receive treatment for hypertension. Having comorbidities was also associated with higher odds of being treatment: overweight, obesity, central obesity, diabetes and dyslipidemia, compared to individuals without the respective comorbid status. For elders with hypertension, a higher education level, widowed, ,physical activity, history of CVD, diabetes and dyslipideima were positively related to the control rate of hypertension. In contrast, female sex, aged 80-years, non-habitual drinker, habitual drinker and central obesity were negatively related to the control rate.

## 4. Discussion

Hypertension is the leading modifiable risk factor for CVD, which represents the top cause of death in China.[13, 14] The burden of hypertension and CVD in China is increasing along with urbanization, rising incomes, and aging of the population.[15] China have substantive improvements in hypertension treatment indicators such as

blood pressure lowering medication use and blood pressure control over the past decades.[16, 17]However, despite these improvements nearly one-second of the elderly hypertensive participants in our study were not treated with antihypertensives. In addition, nearly half of hypertensives who had previously been diagnosed were uncontrolled.

Several previous epidemiological studies reported the treatment of hypertension in Chinese elderly populations.[18, 19] In those studies, the China Health and Retirement Longitudinal Study measured the treatment of hypertension in a nationally representative sample of 9357 Chinese aged 45 years or above and provided the best comparison data for our study.[18] When compared with the findings from the China Health and Retirement Longitudinal Study, the treatment of hypertension (51.00% vs 54.43% ) in this study did big changes.[18] Also other regional studies have previously examined the treatment of hypertension in local elderly residents. Cao and co-researchers revealed that the treatment of hypertension in Hebei province was 38.20%.[19] Du et al. found that the treatment of hypertension in Zhejiang province was 45.37%.[20] Compared these regional survey, the treatment of hypertension in Shenzhen are higher than those in Hebei and Zhejiang.[19, 20] It could be interpreted that building a people-centred integrated care model in Shenzhen. [21] Under the strong leadership of the district government, the reform adopted comprehensive strategies to strengthen primary care and care coordination, improve the quality and efficiency of health care delivery, and promote population health. [21] Even so, the treatment of hypertension in Shenzhen was still far below elderly from the US, Australia, Germany, and Colombia. [22-24]

Similar to other studies, we found that the treatment of hypertension was significantly higher among older, ex-smoker, non-drinker. [9, 24, 25] In the present study, treatment increased with higher education level. Literature shows consistency in relationship between education level and treatment of hypertension.[19] As for the physical activity, its higher level was associated with higher treatment of hypertension. This is in line with guideline suggesting that the presence of moderate to vigorous physical is associated with an decreased risk of hypertension.[9] It is not surprising, the group with the highest level of physical activity had higher likelihood of being treatment of their hypertension.

There was also a higher level of treatment in individuals with other comorbidities such as overweight, obesity, central obesity, diabetes and dyslipidemia. Often patients with comorbid disease have higher perception of the risk factors and their condition. Hypertension is a common comorbid condition with obesity, central obesity, diabetes and dyslipidemia. These findings are consistent with other studies.[19, 23] Also, in our study, participant with a history of CVD was highly correlated with receiving antihypertensive treatment. Collectively, these findings suggest that physicians are weighing risk/benefit of antihypertensive treatment and individualizing the approach in the elderly. An alternate theory to explain the higher rates of no treatment in individuals with fewer comorbidity is that physicians may be wary of the consequences of initiating medication and quality of life by ‘medicalizing’ an otherwise healthy person.[22]

Compared to previous epidemiological data of hypertension in China, the control rate was significantly higher than the control rate of hypertension among elderly in Hebei province investigated in 2015.[19] This could be due to the fact that the current investigation was conducted in Shenzhen with relatively developed economies, higher levels of education, better community medical equipment, and relatively high levels of diagnosis and treatment for hypertension compared to national averages. However, the control rate of hypertension in Shenzhen eldery remained much lower than those reported in developed countries.[22, 23] Background reasons may include the following: (1)Shenzhen medical institutions are not doing a good job of screening for hypertension.[26] (2) It is widely exists that hypertensive individuals often stop taking agents when blood pressure control was achieved, which would also result in uncontrolled hypertension when checked later.[27](3) Primary care physicians in the China might have been less knowledgeable or experienced compared with developed countries.[27] (4) China's doctors might have been entrenched in traditional prescription habits and lack knowledge or willingness to follow new guidelines due to obstacles in information exchange.[27]

Previous studies revealed that being female had a statistically significant association with the control of hypertension. [24, 25] On the contrary, our study suggest that female is a negative indicator of hypertension control and that it deserves further study. Our study revealed that participants with high education attainment had more than 1.28-fold higher odds of being control of their hypertension status than those with low education. Education is a well elucidated determinant of health disparity, and such disparities have been shown to be more pronounced in later life phases.[28] In the present study, control decreased with aging. Literature shows consistency in relationship between age and control of hypertension. [29] Older are often accompanied by multiple diseases, as well as cognitive decline and low medication compliance, which are all related to the lower control rate of hypertension.[30] Drinking and physical inactivity were correlated with inferior hypertension control. As Gooding and co-researchers reported, patients with more unhealthy behaviors care less about subjective well-being.[31] This may have led to a generally lower control rate. In addition, the control of hypertension decreased with WC in our study, which was consistent with some previous studies.[19, 32] Greater WC is correlated with higher levels of fat mass, an increase in salt retention and insulin resistance which results in an increased high blood pressure.[33]

In our study, patients who had diabetes or dyslipidemia had higher probability of being controled. This finding is consistent with other studies.[25, 34] This might be explained by that when people with diabetes or dyslipidemia, they become more focused on their health, and these populations always were more probably to engage in and comply with blood pressure-lowering drugs or lifestyle intervention for hypertension. Our also study showed that history of CVD is in favor of effective blood pressure control. Physicians use more angiotensin converting enzyme inhibitors, angiotensin receptor blockers or even aldosterone receptor blockers to treat participants with CVD, which all contribute to effective blood pressure reduction. [35]

Our study has some limitations. Firstly, given the cross-sectional nature of the

study design, only associations, rather than causality, could be inferred. Secondly, our research enrolled the elderly population by convenience sampling. Thirdly, patients' previous experience of medications for other conditions could have contributed to their current adherence to treatment. Further studies are needed to evaluate the correlation between patients' previous experience of taking medication and current hypertension treatment.

## 5. Inclusion

In conclusion, we found a high prevalence of hypertension and a low prevalence of treatment and control among Shenzhen elderly, a group at high risk for future cardiovascular disease events. This study represents a warning message for cardiovascular health in Shenzhen elderly. Improvement of hypertension treatment, and control should be a public health priority to reduce the disproportionate burden of CVD in this growing population.

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## Author Contributions

WN and JX: Study conception and design. WN, XY, JZ, PL, MZ, YZ, and JX: Performed research. XY and JZ: Data analysis and interpretation of data. WN: Writing – original draft. WN and JX: Writing – review & editing. All authors have read and agreed to the published version of the manuscript.

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## Conflicts of Interest

The authors declare no conflict of interest.

## Patient consent for publication

Not required.

## Ethics approval

This study was approved by the ethical review committee of the Center for Chronic Disease Control of Shenzhen.

## Data sharing statement

No additional data are available.

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# Tables

**Table 1** Sociodemographic, anthropometric, lifestyle and clinical characteristics of older adults living in Shenzhen community ($N$ = 124,007)

| Characteristics | General($n$=124,007) |
|---|---|
| Age (years) | 71.28±5.59 |
| BMI (Kg/m$^2$) | 23.83±3.17 |
| SBP (mm Hg) | 134.71±17.67 |
| DBP (mm Hg) | 77.24±10.30 |
| WC (cm) | 85.09±8.82 |
| FBG (mmol/L) | 5.97±1.91 |
| TC(mmol/L) | 5.21 ± 2.05 |
| TG(mmol/L) | 1.58 ± 1.14 |
| LDL-C(mmol/L) | 3.08 ± 1.06 |
| HDL-C(mmol/L) | 1.39 ± 0.51 |
| Gender, n(%) | |
| Male | 54649(44.06) |
| Female | 69358(55.94) |
| Education level, n(%) | |
| Illiterate | 10054(8.11) |
| Primary education | 44096(35.56) |
| Junior school education and above | 69857(56.33) |
| Marital status, n(%) | |
| Married or cohabiting | 119314(96.22) |
| Widowed | 3623(2.92) |
| Divorced | 565(0.46) |
| Single | 505(0.41) |
| Physical activity, n (%) | |
| Yes | 95338(76.88) |
| No | 28669(23.12) |
| Smoking status, n (%) | |
| Current smoker | 10163(8.20) |
| Ex-smoker | 7662(6.18) |
| Never-smoker | 106182(85.63) |
| Drinking habit, n (%) | |
| Non-drinker | 103388(83.37) |
| Non-habitual drinker | 12737(10.27) |

| | |
|---|---|
| Habitual drinker | 7882(6.36) |
| History of cardiovascular disease, n (%) | |
| Yes | 5192(4.19) |
| No | 118815(95.81) |

Table 2 Treatment and control of hypertension in older adults living in Shenzhen community, according to sociodemographic, lifestyle, clinical and anthropometric characteristics (*N*=124,007)

| Characteristics | Number of patients | Treatment n(%) | $\chi^2$ Value | *P* Value | Control n(%) | $\chi^2$ Value | *P* Value |
|---|---|---|---|---|---|---|---|
| Total | 69207 | 37669(54.43) | | | 22366(32.32) | | |
| Gender | | | 0.16 | 0.69 | | 56.07 | <0.01 |
| Male | 29919 | 16311(54.52) | | | 10126(33.84) | | |
| Female | 39288 | 21358(54.36) | | | 12240(31.15) | | |
| Education level | | | 183.73 | <0.01 | | 242.41 | <0.01 |
| Illiterate | 5751 | 2992(52.03) | | | 1671(29.06) | | |
| Primary education | 24083 | 12369(51.36) | | | 7022(29.16) | | |
| Junior school education and above | 39373 | 22308(56.66) | | | 13673(34.73) | | |
| Marital status | | | 63.50 | <0.01 | | 7.83 | 0.05 |
| Married or cohabiting | 66220 | 35915(54.24) | | | 21352(32.24) | | |
| Widowed | 2356 | 1436(60.95) | | | 810(34.38) | | |
| Divorced | 377 | 216(57.29) | | | 132(35.01) | | |
| Single | 254 | 102(40.16) | | | 72(28.35) | | |
| Age group | | | 172.39 | <0.01 | | 2.12 | 0.55 |
| 65～ | 30727 | 15965(51.96) | | | 9932(32.32) | | |
| 70～ | 18976 | 10412(54.87) | | | 6151(32.41) | | |
| 75～ | 10774 | 6208(57.62) | | | 3516(32.63) | | |
| 80～ | 8730 | 5084(58.24) | | | 2767(31.70) | | |
| Physical activity | | | 51.09 | <0.01 | | 20.13 | <0.01 |
| Yes | 53528 | 29527(55.16) | | | 17530(32.75) | | |
| No | 15679 | 8142(51.93) | | | 4836(30.84) | | |
| Smoking status | | | 28.06 | <0.01 | | 18.01 | <0.01 |
| Current smoker | 5071 | 2659(52.44) | | | 1678(33.09) | | |
| Ex-smoker | 4427 | 2557(57.76) | | | 1550(35.01) | | |
| Never-smoker | 59709 | 32453(54.35) | | | 19138(32.05) | | |
| Drinking habit | | | 82.92 | <0.01 | | 49.09 | <0.01 |
| Non-drinker | 57976 | 31854(54.94) | | | 18885(32.57) | | |
| Non-habitual drinker | 6838 | 3713(54.30) | | | 2257(33.01) | | |
| Habitual drinker | 4393 | 2102(47.85) | | | 1224(27.86) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| History of cardiovascular disease | | | 545.61 | <0.01 | | 373.78 | <0.01 |
| Yes | 3804 | 2768(72.77) | | | 1772(46.58) | | |
| No | 65403 | 34901(53.36) | | | 20594(31.49) | | |
| BMI | | | 381.72 | <0.01 | | 35.24 | <0.01 |
| Low weight | 1712 | 712(41.59) | | | 531(31.02) | | |
| Normal weight | 31104 | 16056(51.62) | | | 10352(33.28) | | |
| Overweight | 28142 | 15923(56.58) | | | 9004(31.99) | | |
| Obesity | 8249 | 4978(60.35) | | | 2479(30.05) | | |
| Central obesity | | | 253.08 | <0.01 | | 24.23 | <0.01 |
| Yes | 32094 | 18508(57.67) | | | 10070 (31.38) | | |
| No | 37113 | 19161(51.63) | | | 12296(33.13) | | |
| Diabetes | | | 688.03 | <0.01 | | 603.08 | <0.01 |
| Yes | 19263 | 12025(62.43) | | | 7580 (39.35) | | |
| No | 49944 | 25644(51.35) | | | 14786(29.61) | | |
| Dyslipidemia | | | 243.60 | <0.01 | | 30.36 | <0.01 |
| Yes | 33416 | 19210(57.49) | | | 11138 (33.33) | | |
| No | 35791 | 18459(51.57) | | | 11228 (31.37) | | |

Table 3 Risk factors analyses on the treatment and control of hypertension in older adults living in Shenzhen community

| Characteristics | Treatment[a] | | Control[b] | |
|---|---|---|---|---|
| | *OR*(95%*CI*) | *P* Value | *OR*(95%*CI*) | *P* Value |
| Gender | | | | |
| Male | — | — | 1.00(Reference) | |
| Female | — | — | 0.91(0.88-0.95) | <0.01 |
| Education level | | | | |
| Illiterate | 1.00(Reference) | | 1.00(Reference) | |
| Primary education | 1.00(0.95-1.07) | 0.90 | 0.99(0.93-1.06) | 0.84 |
| Junior school education and above | 1.25(1.18-1.32) | <0.01 | 1.28(1.20-1.36) | <0.01 |
| Marital status | | | | |
| Married or cohabiting | 1.00(Reference) | | — | — |
| Widowed | 1.28(1.17-1.40) | <0.01 | — | — |
| Divorced | 1.07(0.87-1.31) | 0.54 | — | — |
| Single | 0.58(0.45-0.74) | <0.01 | — | — |
| Age group | | | | |
| 65～ | 1.00(Reference) | | 1.00(Reference) | |
| 70～ | 1.11(1.07-1.15) | <0.01 | 0.98(0.94-1.02) | 0.23 |
| 75～ | 1.24(1.18-1.30) | <0.01 | 0.96(0.92-1.01) | 0.13 |
| 80～ | 1.32(1.25-1.38) | <0.01 | 0.93(0.88-0.98) | <0.01 |
| Physical activity | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.14(1.10-1.18) | <0.01 | 1.06(1.02-1.10) | <0.01 |
| Smoking status | | | | |
| Never-smoker | 1.00(Reference) | | — | — |
| Current smoker | 1.06(1.00-1.13) | 0.06 | — | — |
| Ex-smoker | 1.19(1.11-1.27) | <0.01 | — | — |
| Drinking habit | | | | |
| Non-drinker | 1.00(Reference) | | 1.00(Reference) | |
| Non-habitual drinker | 0.89(0.85-0.94) | <0.01 | 0.92(0.87-0.97) | <0.01 |
| Habitual drinker | 0.72(0.68-0.77) | <0.01 | 0.73(0.68-0.79) | <0.01 |
| History of cardiovascular disease | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |

| | | | | |
|---|---|---|---|---|
| Yes | 2.20(2.04-2.37) | <0.01 | 1.82(1.71-1.96) | <0.01 |
| BMI | | | | |
| Low weight | 1.00(Reference) | | — | — |
| Normal weight | 1.42(1.28-1.57) | <0.01 | — | — |
| Overweight | 1.64(1.48-1.82) | <0.01 | — | — |
| Obesity | 1.89(1.68-2.11) | <0.01 | — | — |
| Central obesity | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.10(1.06-1.14) | <0.01 | 0.94(0.91-0.98) | <0.01 |
| Diabetes | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.49(1.44-1.54) | <0.01 | 1.52(1.47-1.58) | <0.01 |
| Dyslipidemia | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.20(1.16-1.24) | <0.01 | 1.05(1.03-1.09) | <0.01 |

[a] Adjusted for gender

[b] Adjusted for marital status, smoking status and BMI

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# Factors associated with treatment and control of hypertension among elderly adults in Shenzhen, China: A large-scale cross-sectional study



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# Factors associated with treatment and control of hypertension among elderly adults in Shenzhen, China: A large-scale cross-sectional study

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## Abstract

**Objective**: Hypertension has become the leading cause of death worldwide. Data on hypertension management among Shenzhen elderly are sparse. Our study aims to investigate treated and controlled hypertension in Shenzhen elderly, and identify relevant predictors.

**Design**: A cross-sectional study.

**Setting**: Communities in Shenzhen, Guangdong, China.

**Participants**: A cross-sectional study was conducted. We employed a convenience sampling method to select participants; 124,007 participants aged 65 years and older were recruited from January through December 2018 at local community health centers in Shenzhen.

**Main outcome measures**: Data on treatment, control and influencing factors of hypertension were obtained from a standard questionnaire, physical measurements and biochemical analyses.

**Results**: Prevalence of hypertension was 55.8% among the sample population. Among this group of hypertensive patients, those undergoing hypertension treatment and those with hypertension under control were 54.4% and 32.3%, respectively. Employing multivariate analysis, significant associations were found between treatment and older age, junior high school education and above ($OR$=1.25, $P<0.05$), being widowed rather than being married or cohabiting ($OR$=1.28, $P < 0.05$), engaging in physical activity ($OR$=1.14, $P<0.05$), ex-smoker ($OR$=1.19, $P<0.05$), habitual drinker ($OR$=0.72, $P < 0.05$), history of cardiovascular disease (CVD) ($OR$=2.20, $P < 0.05$), and comorbidities, with a higher probability for those with obesity ($OR$=1.89, $P<0.05$), central obesity ($OR$=1.10, $P<0.05$), diabetes ($OR$=1.49, $P<0.05$) or dyslipidemia ($OR$=1.20, $P<0.05$). Male sex ($OR$=0.91, $P<0.05$), junior high school education and above ($OR$=1.28, $P<0.05$), engaging in physical activity ($OR$=1.06, $P<0.05$), history of CVD ($OR$=1.82, $P<0.05$), and individuals who had

diabetes (*OR*=1.52, $P < 0.05$) or dyslipidemia (*OR*=1.05, $P < 0.05$) were associated with increased likelihood of control. Aged between 65 and 79 (*OR*=0.93, 9 $P < 0.05$), habitual drinker (*OR*=0.73, $P < 0.05$) and central obesity (*OR*=0.94, $P < 0.05$) were negatively associated with control of hypertension.

**Conclusions**: We found a high prevalence of hypertension, but a low prevalence of treatment and control among Shenzhen elderly.

**Keywords:** Hypertension; Treatment; Control; Elderly

**Strengths and limitations of this study**

■ This study is the first to evaluate the prevalence, treatment and control of hypertension in a population sample aged 65 years and older from local communities in Shenzhen.

■Convenience sampling was used to enroll the population sample.

■No data was collected on diet or family history of hypertension, which may play a role in the treatment and control of hypertension.

## 1. Introduction

Hypertension is a global public-health challenge and a major risk factor leading to stroke, myocardial infarction and heart failure.[1] As is the case for many conditions, hypertension increases with age, with prevalence increasing from 27% in patients aged under 60 years to 74% in those aged over 80 years.[2] The Framingham Heart Study[3] showed that more than 90% of participants with normal blood pressure at age 55 years eventually develop hypertension in later years. By the year 2020, the projected number of people living in China aged 60 years or older will comprise 17.8%.[4] With this rapidly aging population, the prevalence of hypertension can only be expected to rise. Therefore, it is crucial to understand the current status of management of hypertension in elderly adults.

The management of hypertension in the elderly has many challenges, including agreement on threshold and target blood pressure levels, and the balancing of adverse effects and potential benefits of treatment.[5] While extensive studies have been undertaken to identify risk factors for hypertension in predominantly middle-aged populations, there exist gaps in our understanding of the risk profiles and management of hypertension amongst the older population. A better understanding of the factors impacting treatment and control of hypertension in older adults is critical to the development of interventions to manage high blood pressure in this growing sector of the population. Therefore, the aim of our study was to investigate the treatment and control rate of hypertension among the elderly population in Shenzhen, China, and identify associated risk factors to provide evidence for disease prevention and control, and improve the quality of life of older hypertension patients. Strategies to target hypertension in the elderly population are additionally proposed.

## 2. Material and methods

### 2.1 Study population

We used convenience sampling to select our population sample by recruiting people aged 65 years and older from the lists of all residents registered at local community health centers in Shenzhen, China, from January 2018 through December 2018. The staff of the local community health centers recruited the elderly adults by telephone, posters, WeChat and so on. The eligibility criteria of participants were as follows: (1) having lived in Shenzhen for more than 6 months; and (2) able to participate in the study and give informed consent. We excluded residents living in prisons. Initially, 141,684 were recruited into the study, accounting for 36.9% (141,684/383,700) of the resident population of elderly adults in Shenzhen based on the data from the 2015 population census. Data were collected in medical examination rooms at local community health centers in the participants" residential areas. We asked the participants to complete a questionnaire, provide a fasting blood sample and

attend physical examinations. Participants excluded from the study, 17,677, were those who did not complete the questionnaire, provide a fasting blood sample or were unable to attend physical examinations. Finally, 124,007 participants (87.5%) were included in the final data analysis. The study received ethnicity approval from the Center for Chronic Disease Control in Shenzhen(Grant No:SZCCC-2020-018-01-PJ). Written informed consent was received by all participants before the collection of data and conducting of the research. Where participants were illiterate, we obtained written informed consent from their proxies.

### 2.2 Questionnaire survey

Before the survey began, all investigators completed a training program on the methods and process of the study. A manual of procedures was distributed, and detailed instructions for administration of the questionnaires, the taking of blood pressure and anthropometric measurements, and biological specimen collection and processing were provided.

Data were obtained during face-to-face interview in person 1 hour after blood collection. All participants completed a standardized questionnaire including socio-demographic status such as date of birth, sex, educational level, and marital status; medical history such as history of previous diseases, operation history and history of trauma; family health history such as incidence of hypertension, diabetes, coronary heart disease, malignant tumor and stroke; lifestyle habits such as smoking status, amount of physical activity and alcohol consumption; and medication use under the supervision of trained general practitioners and nurses. Educational level was categorized into three groups according to the number of years of education: illiterate, no education; primary education, 1–6 years of education; and junior high school education and above, seven or more years of education.

In this study, we define the term “moderate to vigorous physical activity” to refer to at least some sweating and shortness of breath caused by engaging in physical activity, and the term “light physical activity” to refer to no sweating or shortness of breath caused by engaging in physical activity.[6] In addition, moderate to vigorous physical activity at least once a week was classified as “Yes” for physical activity status. For alcohol consumption status, participants reported themselves as habitual drinker (drinking at least once a day), non-habitual drinker (drinking six times a week to once a month) or non-drinker (almost never).[7] For smoking status, we categorized participants as current smoker, ex-smoker and never-smoker, as described elsewhere.[8]

### 2.3 Physical examination

Anthropometric examinations were taken in the morning on participants who had fasted overnight, following which body measurements were taken by trained

examiners based on a standardized protocol. Height and weight were measured using analogue scales with the participants wearing light clothing without footwear. Waist circumference (WC) was measured at the end of normal expiration at the midpoint level of the midaxillary line between the 12th rib head and the superior anterior iliac spine. Body mass index (BMI) was calculated by dividing body weight (in kilograms) by the square of height (in m). Calibrated electronic sphygmomanometers were used to measure blood pressure on the arm supported at heart level with sitting position, carried out twice. The average of the two measurements was used for the statistical analysis. To obtain accurate readings, the participants were asked to rest for at least 5 min before the measurement, or, if having engaged in excessive exercise prior to the visit, for at least 30 min before the measurement. Untreated subjects with a blood pressure of at least 140/90 mm Hg were seen again at a second visit within 2 weeks, and if still ⩾140 and/or 90 mm Hg, they were seen a third time again within 2 further weeks. Those with high blood pressure at the first visit and who had normal blood pressure for both systolic blood pressure (SBP) (<140 mm Hg) and diastolic blood pressure (DBP) (<90 mm Hg) at the second or third visit were considered normotensive.

### 2.4 Blood sample collection and biochemical analyses

Participant venous blood samples were taken after at least 8 h of overnight fasting. All blood samples were analysed at the clinical laboratories of grade 2 hospitals to which the community health centers were directly affiliated. All the laboratories involved had successfully completed a standardization and competency program. Fasting venous blood was drawn from subjects for the measurements of levels of total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) by automatic biochemistry analyzer. TC and TG were estimated using enzymatic methods with commercially available reagents, while HDL and LDL were measured using a timed-endpoint colorimetric method. Fasting blood samples were biochemically analysed within a maximum of 4 hours after being drawn. Glucose oxidase measurements were used to ascertain the fasting blood glucose (FBG) level.

### 2.5 Definitions

A diagnosis of hypertension was considered when three consecutive high readings (≥140 systolic and/or ≥90 mm Hg diastolic) with 2-week intervals were registered or treatment with antihypertensive medication within the previous 2 weeks was self-reported.[9] Participants were considered to be undergoing treatment for hypertension if they answered "Yes" to the question "Because of your high blood pressure/hypertension, are you now taking prescribed medicine?" Controlled hypertension was defined as SBP<140 mm Hg and DBP<90 mm Hg, and reported use

of antihypertensive medication during the survey period.[9,10] Participants were regarded as diabetic if one of the following three conditions was met: (1) previous diagnosis by professional doctors; (2) FBG ⩾7.0 mmol/L; or (3) 2-h plasma glucose level ⩾11.1 mmol/L.[11] TC, LDL-C, HDL-C and TG levels were classified on the basis of the 2016 Chinese Guideline for the Management of Dyslipidemia in Adults.[12] It defines high TC as ⩾6.22 mmol/L, high LDL-C as ⩾4.14 mmol/L, low HDL-C as <1.04 mmol/L, and high TG as ⩾2.26 mmol/L. In the present study, we defined dyslipidemia as the presence of one or more abnormal serum lipid concentrations or use of anti-dyslipidemia medications in the previous 2 weeks.

Based on the Criteria of Weight for Adults released by the Ministry of Health of China (WS/T 428-2013), individuals were categorized into four groups: BMI<18.5 kg/m$^2$, low weight; 18.5 kg/m$^2$ ⩽ BMI<24.0 kg/m$^2$, normal weight; 24.0 kg/m$^2$ ⩽ BMI<28.0 kg/m$^2$, overweight; and BMI ⩾28.0 kg/m$^2$, obese. Men with WC ⩾90 cm and women with WC ⩾85 cm were defined as having central obesity.

### 2.6 Statistical analyses

We collected descriptive statistics for all the variables, including continuous variables, expressed as means and standard deviations, and categorical variables, expressed as numbers and percentages. Categorical variables between groups were compared using a chi-square test. Multivariate logistic regression analysis was performed to explore the association between treatment and control of hypertension, and associated risk factors. In the multivariate logistic regression model, the treatment or control of hypertension was defined as the dependent variable, and age, sex, education level, marital status, smoking status, alcohol consumption, physical activity status, BMI, central obesity, diabetes, diagnosis of dyslipidemia, and history of CVD were defined as the independent variables. SAS software version 9.4 (SAS Institute, Cary, NC, USA) was used to perform all statistical analyses. Tests were two-sided, and $P$<0.05 was considered to be statistically significant.

### 2.7 Participants and public involvement

Neither the study participants nor the public were involved in the design, recruitment or conduct of the study. All the participants had the option of receiving a health check and biochemical results when they visited the local community health centers.

## 3.0 Results

### 3.1 Sociodemographic and other characteristics of participants

Of the 124,007 participants, 44.1% (n=54,649) were male and 55.9% (n=69,358) were female, the mean age was 71.3±5.6, 56.3% had attained a junior school

education or above, 96.2% were married or cohabiting, 76.9% reported engaging in regular physical activities, and 4.2% reported having the history of CVD (Table 1). Current smokers accounted for 8.2%, and habitual drinkers accounted for 6.4% (Table 1). In terms of anthropometric measurements, the means of average BMI, SBP, DBP, WC, FBG, TC, TG, LDL-C and HDL-C levels for all 124,007 participants were 23.8±3.2 kg/m$^2$, 134.7±17.7 mm Hg, 77.2±10.3 mm Hg, 85.1±8.8 cm, 6.0±1.9 mmol/L, 5.2±2.1 mmol/L, 1.6±1.1 mmol/L, 3.1±1.1 mmol/L and 1.4±0.5 mmol/L, respectively (Table 1).

### 3.2 Treatment and control rates in subgroups

The prevalence of hypertension was 55.8%. Of those individuals with hypertension, 54.4% were receiving treatment, and 32.3% had blood pressure under control. Table 2 lists the treatment and control of hypertension by sociodemographic grouping, lifestyle, clinical and anthropometric characteristics. The treatment rate demonstrated no difference between males and females. However, males had a significantly higher rate of control than females. Higher treatment and control rates were also found among those who had attained junior school education or above, engaged in regular physical activity, were ex-smokers and had history of CVD, or diabetes or dyslipidemia. Participants who were single had the lowest treatment rates when compared with their non-treated counterparts. Participants aged 65～69 years had the lowest treatment rates compared with older participants. Habitual drinkers had the lowest treatment and control rates. Participants with obesity or central obesity had higher treatment rates and lower control rates.

### 3.3 Results of multivariate analysis of factors associated with treatment and control of hypertension

The results of multivariate logistic regression of hypertension treatment and control according to selected sociodemographic and other potential factors are presented in Table 3. Participants with the highest educational attainment (*OR*=1.25, 95% *CI*=1.18–1.32) were more likely to be receiving treatment for hypertension compared with participants of low educational level. Being widowed (*OR*=1.28, 95% *CI*=1.17–1.40) was a protective factor for treatment of hypertension while being single (*OR*=0.58, 95% *CI*=0.45–0.74) was negatively associated with hypertension treatment. Older age, engaging in physical activity (*OR*=1.14, 95% *CI*=1.10–1.18), being an ex-smoker (*OR*=1.19, 95% *CI*=1.11–1.27) and history of CVD (*OR*=2.20, 95% *CI*=2.04–2.37) were associated with higher likelihood of receiving treatment for hypertension, while non-habitual drinker (*OR*=0.89, 95% *CI*=0.85–0.94) or habitual drinker (*OR*=0.72, 95% *CI*=0.68-0.77) was associated with lower likelihood of receiving treatment for hypertension. Compared with individuals without comorbidities, having comorbidities was also associated with higher rate of treatment:

overweight (*OR*=1.64, 95% *CI*=1.48–1.82), obesity (*OR*=1.89, 95% *CI*=1.68–2.11), central obesity (*OR*=1.10, 95% *CI*=1.06–1.14), diabetes (*OR*=1.49, 95% *CI*=1.44–1.54) and dyslipidemia (*OR*=1.20, 95% *CI*=1.16–1.24). For those with hypertension, junior school education and above (*OR*=1.28, 95% *CI*=1.20–1.36), engaging in physical activity (*OR*=1.06, 95% *CI*=1.02–1.10), and history of CVD (*OR*=1.82, 95% *CI*=1.71–1.96), diabetes (*OR*=1.52, 95% *CI*=1.47–1.58) or dyslipidemia (*OR*=1.20, 95% *CI*=1.16–1.24) were positively associated with the control of hypertension. In contrast, female sex (*OR*=0.91, 95% *CI*=0.88–0.95), aged 80 or above (*OR*=0.93, 95% *CI*=0.88–0.98), non-habitual drinker (*OR*=0.92, 95% *CI*=0.87–0.97), habitual drinker (*OR*=0.73, 95% *CI*=0.68≤0.79) and central obesity (*OR*=0.94, 95% *CI*=0.91≤0.98) were negatively associated with the control of hypertension.

## 4. Discussion

Hypertension is the leading modifiable risk factor for CVD, which is the leading cause of death in China.[13,14] The burden of hypertension and CVD on the health care system in China is increasing along with urbanization, rising incomes and the aging of the population.[15] China has made substantial improvements in hypertension treatment indicators such as blood pressure lowering medication use and blood pressure control over the past decades.[16,17] However, despite these improvements nearly half of the elderly hypertensive participants in our study were not undergoing treatment with antihypertensive medication. In addition, nearly half of hypertensives who had previously been diagnosed had blood pressure that was uncontrolled.

Several previous epidemiological studies have reported on the treatment of hypertension in Chinese elderly populations.[18,19] One of those studies, the China Health and Retirement Longitudinal Study, measured the treatment of hypertension in a nationally representative sample of 9,357 Chinese aged 45 years or above, which provided the best comparison data for our study.[18] When compared with the findings from that study, the treatment of hypertension in this study indicated higher incidence, 51.0% vs. 54.4%, respectively.[18] Other regional studies have also previously examined the treatment of hypertension in local elderly residents. Cao and co-researchers[19] revealed that the rate of treatment of hypertension in Hebei province was 38.2%, while Du et al. [20] found that rate in Zhejiang province was 45.4%, both lower than in our study in Shenzhen. This could be because Shenzhen has established a people-centered integrated care model comprising local community health centers.[21] Under the strong leadership of the district government, comprehensive strategies have been adopted to strengthen primary care and care coordination, improve the quality and efficiency of health care delivery, and promote population health.[21] Even so, the treatment rate of hypertension in the elderly population in Shenzhen was still far below that of elderly in other countries such as the United States, Australia, Germany

and Colombia.[22-24]

Similar to other studies, we found that the treatment of hypertension was significantly higher among older ex-smoking non-drinkers,[9,24,25] higher education level[19] and those engaging in physical activity.[25] Participants engaged in physical activity may generally pay more attention to their health. Unsurprisingly, therefore, the group with the highest level of physical activity had a higher likelihood of being aware of their hypertension and receiving medication.

Our study revealed a higher level of treatment in individuals with comorbidities such as overweight, obesity, central obesity, diabetes and dyslipidemia, which are common comorbidities with hypertension.[19,23]Moreover, in our study, history of CVD was highly correlated with receiving antihypertensive treatment. Other researchers have confirmed that having another medical condition, for example, diabetes or dyslipidemia, is associated with greater awareness and treatment of hypertension.[26,27] This causes people to go to health centers, and consequently be diagnosed with hypertension sooner, obtaining earlier treatment. Therefore, often patients with comorbid diseases have higher perception of the risk factors and their condition. An alternate theory to explain the higher rates of no treatment in individuals with fewer comorbidities is that physicians may be wary of the consequences of initiating medication and quality of life by "medicalizing" an otherwise healthy person.[22]

Compared to previous epidemiological data of hypertension in China, the control rate in our study was significantly higher than the control rate of hypertension among elderly in Hebei province investigated in 2015.[19] This could be due to the fact that Shenzhen is a relatively well-developed economy with higher levels of education, better community medical facilities and equipment, and relatively high levels of diagnosis and treatment for hypertension compared with the national average. However, the control rate of hypertension in Shenzhen elderly were much lower than those reported in developed countries.[22,23] Possible reasons include the following: (1) Shenzhen medical institutions are not doing a good job of screening for hypertension.[28] (2) Hypertensive individuals often cease taking antihypertensive agents when blood pressure control has been achieved, which may result in uncontrolled hypertension when checked later unless there is regular monitoring.[29](3) Primary care physicians in the China might have been less knowledgeable or experienced in diagnosing and treating hypertension compared with those in developed countries.[29] (4) China"s doctors might have become entrenched in traditional prescription practice and lack knowledge or willingness to follow new guidelines due to obstacles in information exchange.[29] (5) There was a lower rate of out-of-office blood pressure monitoring among hypertensive patients in China than that in developed countries, in spite of recommendations in multiple guidelines.[30,31]

Previous studies have revealed that being female had a statistically significant association with the control of hypertension.[24, 25] On the contrary, our findings suggested that being female was a negative indicator of hypertension control, strongly indicating that it deserves further study. Our study revealed that participants with high educational attainment had more than 1.28-fold higher probability of being in control of their hypertension status than those with low educational level. Education is a well-elucidated determinant of health disparity, and such disparities have been shown to be more pronounced in later life phases.[32] In the present study, hypertension control decreased with age. Literature shows consistency in the association between age and control of hypertension.[33] Older people often have hypertension accompanied by multiple diseases, as well as cognitive decline and low medication compliance, which are all related to the lower control rate of hypertension.[34] Alcohol consumption and physical inactivity have also been correlated with inferior hypertension control. As Gooding and co-researchers[35] reported, patients with more unhealthy behaviors care less about subjective well-being. This may have led to a generally lower control rate. In addition, the control of hypertension was lower with higher WC in our study, consistent with some previous studies.[19,36] Greater WC is correlated with higher levels of fat mass, an increase in salt retention and insulin resistance, which cause increased high blood pressure.[37]

In our study, patients who had diabetes or dyslipidemia had higher probability of having controlled blood pressure, consistent with other studies.[25,38] An explanation might be that when people have diabetes or dyslipidemia, they become more focused on their health, and therefore may be more likely to engage in and comply with blood pressure-lowering drugs or lifestyle intervention for hypertension. Our study additionally showed that history of CVD is a positive factor for effective blood pressure control. Physicians use more angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor blockers or even aldosterone receptor blockers to treat participants with CVD, which all contribute to effective blood pressure reduction.[39]

Our study had some limitations. First, given the cross-sectional nature of the study design, only associations, rather than causality, could be inferred. Second, our research enrolled the elderly population by convenience sampling. This is a major factor preventing true extrapolation of the results to the general population. Third, patient previous experience of medications for other conditions could have contributed to their current adherence to treatment. Further studies are needed to evaluate the correlation between patient previous experience of taking medication and current hypertension treatment. Fourth, the impact of white coat hypertension and masked hypertension could not be excluded as factors affecting the findings in our research.

## 5. Conclusion

In conclusion, we found a high prevalence of hypertension but a low prevalence of treatment and control among Shenzhen elderly, a group at high risk for future CVD events. This study represents a warning for cardiovascular health management in Shenzhen elderly. Improvement in hypertension treatment and control should be a public health priority to reduce the disproportionate burden of CVD in this growing population. Out-of-office blood pressure monitoring is one measure that could be introduced to identify hypertensive patients earlier so as to start treatment more promptly to reduce CVD incidence in this high risk group.

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## Author Contributions

WN and JX: study conception and design. WN, XY, JZ, PL, HZ, YZ, and JX: performance of research. XY and JZ: data analysis and interpretation. WN: writing the original draft. WN and JX: Writing the review and editing. All authors have read and agreed to the published version of the manuscript.

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## Conflicts of Interest

The authors declare no conflict of interest.

## Patient consent for publication

Not required.

## Ethics approval

This study was approved by the ethical review committee of the Center for Chronic Disease Control of Shenzhen.

## Data sharing statement

No additional data are available.

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## Tables

**Table 1** Sociodemographic, anthropometric, lifestyle and clinical characteristics of older adults living in Shenzhen (*n*=124,007)

| Characteristics | General(*n*=124,007) |
|---|---|
| Age (years) | 71.3±5.6 |
| BMI (Kg/m$^2$) | 23.8±3.2 |
| SBP (mm Hg) | 134.7±17.7 |
| DBP (mm Hg) | 77.2±10.3 |
| WC (cm) | 85.1±8.8 |
| FBG (mmol/L) | 6.0±1.9 |
| TC(mmol/L) | 5.2 ± 2.1 |
| TG(mmol/L) | 1.6 ± 1.1 |
| LDL-C(mmol/L) | 3.1 ± 1.1 |
| HDL-C(mmol/L) | 1.4 ± 0.5 |
| Sex, n(%) | |
| Male | 54649(44.1) |
| Female | 69358(55.9) |
| Education level, n(%) | |
| Illiterate | 10054(8.1) |
| Primary education | 44096(35.6) |
| Junior school education and above | 69857(56.3) |
| Marital status, n(%) | |
| Married or cohabiting | 119314(96.2) |
| Widowed | 3623(2.9) |
| Divorced | 565(0.5) |
| Single | 505(0.4) |

| | |
|---|---|
| Physical activity, n (%) | |
| Yes | 95338(76.9) |
| No | 28669(23.1) |
| Smoking status, n (%) | |
| Current smoker | 10163(8.2) |
| Ex-smoker | 7662(6.2) |
| Never-smoker | 106182(85.6) |
| Drinking habit, n (%) | |
| Non-drinker | 103388(83.4) |
| Non-habitual drinker | 12737(10.2) |
| Habitual drinker | 7882(6.4) |
| History of cardiovascular disease, n (%) | |
| Yes | 5192(4.2) |
| No | 118815(95.8) |

Table 2 Treatment and control of hypertension in older adults diagnosed with hypertension living in Shenzhen, according to socio-demographic, lifestyle, clinical and anthropometric characteristics ($n$=69,207)

| Characteristics | Number of hypertension patients | Treatment n(%) | $\chi^2$ Value | $P$ Value | Control n(%) | $\chi^2$ Value | $P$ Value |
|---|---|---|---|---|---|---|---|
| Total | 69207 | 37669(54.4) | | | 22366(32.3) | | |
| Sex | | | 0.16 | 0.69 | | 56.07 | <0.01 |
| Male | 29919 | 16311(54.5) | | | 10126(33.8) | | |
| Female | 39288 | 21358(54.4) | | | 12240(31.2) | | |
| Education level | | | 183.73 | <0.01 | | 242.41 | <0.01 |
| Illiterate | 5751 | 2992(52.0) | | | 1671(29.1) | | |
| Primary education | 24083 | 12369(51.4) | | | 7022(29.2) | | |
| Junior school education and above | 39373 | 22308(56.7) | | | 13673(34.7) | | |
| Marital status | | | 63.50 | <0.01 | | 7.83 | 0.05 |
| Married or cohabiting | 66220 | 35915(54.2) | | | 21352(32.2) | | |
| Widowed | 2356 | 1436(60.9) | | | 810(34.4) | | |
| Divorced | 377 | 216(57.3) | | | 132(35.0) | | |
| Single | 254 | 102(40.2) | | | 72(28.4) | | |
| Age group | | | 172.39 | <0.01 | | 2.12 | 0.55 |
| 65～ | 30727 | 15965(51.9) | | | 9932(32.3) | | |
| 70～ | 18976 | 10412(54.9) | | | 6151(32.4) | | |
| 75～ | 10774 | 6208(57.6) | | | 3516(32.6) | | |
| 80～ | 8730 | 5084(58.2) | | | 2767(31.7) | | |
| Physical activity | | | 51.09 | <0.01 | | 20.13 | <0.01 |
| Yes | 53528 | 29527(55.2) | | | 17530(32.8) | | |
| No | 15679 | 8142(51.9) | | | 4836(30.8) | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Smoking status | | | 28.06 | <0.01 | | 18.01 | <0.01 |
| Current smoker | 5071 | 2659(52.4) | | | 1678(33.1) | | |
| Ex-smoker | 4427 | 2557(57.8) | | | 1550(35.0) | | |
| Never-smoker | 59709 | 32453(54.4) | | | 19138(32.1) | | |
| Drinking habit | | | 82.92 | <0.01 | | 49.09 | <0.01 |
| Non-drinker | 57976 | 31854(54.9) | | | 18885(32.6) | | |
| Non-habitual drinker | 6838 | 3713(54.3) | | | 2257(33.0) | | |
| Habitual drinker | 4393 | 2102(47.9) | | | 1224(27.9) | | |
| History of cardiovascular disease | | | 545.61 | <0.01 | | 373.78 | <0.01 |
| Yes | 3804 | 2768(72.8) | | | 1772(46.6) | | |
| No | 65403 | 34901(53.4) | | | 20594(31.5) | | |
| BMI | | | 381.72 | <0.01 | | 35.24 | <0.01 |
| Low weight | 1712 | 712(41.6) | | | 531(31.0) | | |
| Normal weight | 31104 | 16056(51.6) | | | 10352(33.3) | | |
| Overweight | 28142 | 15923(56.6) | | | 9004(31.9) | | |
| Obesity | 8249 | 4978(60.4) | | | 2479(30.1) | | |
| Central obesity | | | 253.08 | <0.01 | | 24.23 | <0.01 |
| Yes | 32094 | 18508(57.7) | | | 10070 (31.4) | | |
| No | 37113 | 19161(51.6) | | | 12296(33.1) | | |
| Diabetes | | | 688.03 | <0.01 | | 603.08 | <0.01 |
| Yes | 19263 | 12025(62.4) | | | 7580 (39.4) | | |
| No | 49944 | 25644(51.4) | | | 14786(29.6) | | |
| Dyslipidemia | | | 243.60 | <0.01 | | 30.36 | <0.01 |
| Yes | 33416 | 19210(57.5) | | | 11138 (33.3) | | |
| No | 35791 | 18459(51.6) | | | 11228 (31.4) | | |

Definition: A diagnosis of hypertension was considered when three consecutive high readings (≥140 systolic and/or ≥90 mm Hg diastolic) with 2-week intervals were registered or treatment with antihypertensive medication within the previous 2 weeks

was self-reported. Participants were considered to be undergoing treatment if they answered "Yes" to the question "Because of your high blood pressure/hypertension, are you now taking prescribed medicine?" Controlled hypertension was defined as SBP<140 mm Hg and DBP<90 mm Hg, and reported use of antihypertensive medication during the survey.

Table 3 Risk factor analysis on the treatment and control of hypertension in older adults living in Shenzhen

| Characteristics | Treatment[a] | | Control[b] | |
|---|---|---|---|---|
| | *OR*(95%*CI*) | *P* Value | *OR*(95%*CI*) | *P* Value |
| Sex | | | | |
| Male | — | — | 1.00(Reference) | |
| Female | — | — | 0.91(0.88-0.95) | <0.01 |
| Education level | | | | |
| Illiterate | 1.00(Reference) | | 1.00(Reference) | |
| Primary education | 1.00(0.95-1.07) | 0.90 | 0.99(0.93-1.06) | 0.84 |
| Junior school education and above | 1.25(1.18-1.32) | ＜0.01 | 1.28(1.20-1.36) | <0.01 |
| Marital status | | | | |
| Married or cohabiting | 1.00(Reference) | | — | — |
| Widowed | 1.28(1.17-1.40) | ＜0.01 | — | — |
| Divorced | 1.07(0.87-1.31) | 0.54 | — | — |
| Single | 0.58(0.45-0.74) | ＜0.01 | — | — |
| Age group | | | | |
| 65～ | 1.00(Reference) | | 1.00(Reference) | |
| 70～ | 1.11(1.07-1.15) | ＜0.01 | 0.98(0.94-1.02) | 0.23 |
| 75～ | 1.24(1.18-1.30) | ＜0.01 | 0.96(0.92-1.01) | 0.13 |
| 80～ | 1.32(1.25-1.38) | ＜0.01 | 0.93(0.88-0.98) | <0.01 |
| Physical activity | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.14(1.10-1.18) | ＜0.01 | 1.06(1.02-1.10) | <0.01 |
| Smoking status | | | | |
| Never-smoker | 1.00(Reference) | | — | — |
| Current smoker | 1.06(1.00-1.13) | 0.06 | — | — |

| | | | | |
|---|---|---|---|---|
| Ex-smoker | 1.19(1.11-1.27) | <0.01 | — | — |
| Drinking habit | | | | |
| Non-drinker | 1.00(Reference) | | 1.00(Reference) | |
| Non-habitual drinker | 0.89(0.85-0.94) | <0.01 | 0.92(0.87-0.97) | <0.01 |
| Habitual drinker | 0.72(0.68-0.77) | <0.01 | 0.73(0.68-0.79) | <0.01 |
| History of cardiovascular disease | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 2.20(2.04-2.37) | <0.01 | 1.82(1.71-1.96) | <0.01 |
| BMI | | | | |
| Low weight | 1.00(Reference) | | — | — |
| Normal weight | 1.42(1.28-1.57) | <0.01 | — | — |
| Overweight | 1.64(1.48-1.82) | <0.01 | — | — |
| Obesity | 1.89(1.68-2.11) | <0.01 | — | — |
| Central obesity | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.10(1.06-1.14) | <0.01 | 0.94(0.91-0.98) | <0.01 |
| Diabetes | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.49(1.44-1.54) | <0.01 | 1.52(1.47-1.58) | <0.01 |
| Dyslipidemia | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.20(1.16-1.24) | <0.01 | 1.05(1.03-1.09) | <0.01 |

[a]Adjusted for sex.

[b]Adjusted for marital status, smoking status and BMI.

Definition: A diagnosis of hypertension was considered when three consecutive high readings (≥140 systolic and/or ≥90 mm Hg diastolic) with 2-week intervals were registered, or treatment with antihypertensive medication within the previous 2 weeks was self-reported. Participants were considered to be treated if they answered "yes" to

the question “Because of your high blood pressure/hypertension, are you now taking prescribed medicine?” Controlled hypertension was defined as SBP<140 mm Hg and DBP <90 mm Hg, and reported use of antihypertensive medication during the survey.

**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| 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 | Page 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | Page 2-3 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | Page 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | Page 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | Page 5 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | Page 5 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | Page 5 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | Page 6-7 |
| 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 | Page 6-8 |
| Bias | 9 | Describe any efforts to address potential sources of bias | Page 8 |
| Study size | 10 | Explain how the study size was arrived at | Page 5 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | Not applicable |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | Page 8 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | Not applicable |
| | | (*c*) Explain how missing data were addressed | Not applicable |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | Not applicable |
| | | (*e*) Describe any sensitivity analyses | Not applicable |
| **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 | Page 8-9 |
| | | (b) Give reasons for non-participation at each stage | Not applicable |
| | | (c) Consider use of a flow diagram | Not applicable |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | Page 8-9 |
| | | (b) Indicate number of participants with missing data for each variable of interest | Not applicable |
| Outcome data | 15* | Report numbers of outcome events or summary measures | Page 9 |
| 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 | Page 9 |
| | | (*b*) Report category boundaries when continuous variables were categorized | Page 9-10 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | Page 9-10 |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | Not applicable |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | Page 10-12 |
| 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 | Page 12 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | Page 10-12 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | Page 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 | Page 13 |

*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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# Factors associated with treatment and control of hypertension among elderly adults in Shenzhen, China: A large-scale cross-sectional study

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# Factors associated with treatment and control of hypertension among elderly adults in Shenzhen, China: A large-scale cross-sectional study

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## Abstract

**Objective**: Hypertension has become the leading cause of death worldwide. Data on hypertension management among Shenzhen elderly are sparse. Our study aims to investigate treated and controlled hypertension in Shenzhen elderly, and identify relevant predictors.

**Design**: A cross-sectional study.

**Setting**: Communities in Shenzhen, Guangdong, China.

**Participants**: A cross-sectional study was conducted. We employed a convenience sampling method to select participants; 124,007 participants aged 65 years and older were recruited from January through December 2018 at local community health centers in Shenzhen.

**Main outcome measures**: Data on treatment, control and influencing factors of hypertension were obtained from a standard questionnaire, physical measurements and biochemical analyses.

**Results**: Prevalence of hypertension was 55.8% among the sample population. Among this group of hypertensive patients, those undergoing hypertension treatment and those with hypertension under control were 54.4% and 32.3%, respectively. Employing multivariate analysis, significant associations were found between treatment and older age, junior high school education and above ($OR$=1.25, $P<0.05$), being widowed rather than being married or cohabiting ($OR$=1.28, $P < 0.05$), engaging in physical activity ($OR$=1.14, $P<0.05$), ex-smoker ($OR$=1.19, $P<0.05$), habitual drinker ($OR$=0.72, $P < 0.05$), history of cardiovascular disease (CVD) ($OR$=2.20, $P < 0.05$), and comorbidities, with a higher probability for those with obesity ($OR$=1.89, $P<0.05$), central obesity ($OR$=1.10, $P<0.05$), diabetes ($OR$=1.49, $P<0.05$) or dyslipidemia ($OR$=1.20, $P<0.05$). Male sex ($OR$=0.91, $P<0.05$), junior high school education and above ($OR$=1.28, $P<0.05$), engaging in physical activity ($OR$=1.06, $P<0.05$), history of CVD ($OR$=1.82, $P<0.05$), and individuals who had

diabetes (*OR*=1.52, $P < 0.05$) or dyslipidemia (*OR*=1.05, $P < 0.05$) were associated with increased likelihood of control. Aged between 65 and 79 (*OR*=0.93, 9 $P < 0.05$), habitual drinker (*OR*=0.73, $P < 0.05$) and central obesity (*OR*=0.94, $P < 0.05$) were negatively associated with control of hypertension.

**Conclusions**: We found a high prevalence of hypertension, but a low prevalence of treatment and control among Shenzhen elderly.

**Keywords:** Hypertension; Treatment; Control; Elderly

**Strengths and limitations of this study**

■ This study is the first to evaluate the prevalence, treatment and control of hypertension in a population sample aged 65 years and older from local communities in Shenzhen.

■Convenience sampling was used to enroll the population sample.

■No data was collected on diet or family history of hypertension, which may play a role in the treatment and control of hypertension.

## 1. Introduction

Hypertension is a global public-health challenge and a major risk factor leading to stroke, myocardial infarction and heart failure.[1] As is the case for many conditions, hypertension increases with age, with prevalence increasing from 27% in patients aged under 60 years to 74% in those aged over 80 years.[2] The Framingham Heart Study[3] showed that more than 90% of participants with normal blood pressure at age 55 years eventually develop hypertension in later years. By the year 2020, the projected number of people living in China aged 60 years or older will comprise 17.8%.[4] With this rapidly aging population, the prevalence of hypertension can only be expected to rise. Therefore, it is crucial to understand the current status of management of hypertension in elderly adults.

The management of hypertension in the elderly has many challenges, including agreement on threshold and target blood pressure levels, and the balancing of adverse effects and potential benefits of treatment.[5] While extensive studies have been undertaken to identify risk factors for hypertension in predominantly middle-aged populations, there exist gaps in our understanding of the risk profiles and management of hypertension amongst the older population. A better understanding of the factors impacting treatment and control of hypertension in older adults is critical to the development of interventions to manage high blood pressure in this growing sector of the population. Therefore, the aim of our study was to investigate the treatment and control rate of hypertension among the elderly population in Shenzhen, China, and identify associated risk factors to provide evidence for disease prevention and control, and improve the quality of life of older hypertension patients. Strategies to target hypertension in the elderly population are additionally proposed.

## 2. Material and methods

### 2.1 Study population

We used convenience sampling to select our population sample by recruiting people aged 65 years and older from the lists of all residents registered at local community health centers in Shenzhen, China, from January 2018 through December 2018. Recruitment activities include pasting posters or placing foldings in local community health centers and other public places. Electronic posters also be distributed via all the open WeChat groups of local community health centers' staff, to make the survey available to the close contacts easily. Moreover, the staff of the local community health centers recruited the elderly adults in their service community to participate in the survey by telephone. The eligibility criteria of participants were as follows: (1) having lived in Shenzhen for more than 6 months; and (2) able to participate in the study and give informed consent. We excluded residents living in prisons. Initially, 141,684 were recruited into the study, accounting for 36.9%

(141,684/383,700) of the resident population of elderly adults in Shenzhen based on the data from the 2015 population census. Data were collected in medical examination rooms at local community health centers in the participants'residential areas. We asked the participants to complete a questionnaire, provide a fasting blood sample and attend physical examinations. Participants excluded from the study, 17,677, were those who did not complete the questionnaire, provide a fasting blood sample or were unable to attend physical examinations. Finally, 124,007 participants (87.5%) were included in the final data analysis.

### 2.2 Questionnaire survey

Before the survey began, all investigators completed a training program on the methods and process of the study. A manual of procedures was distributed, and detailed instructions for administration of the questionnaires, the taking of blood pressure and anthropometric measurements, and biological specimen collection and processing were provided.

Data were obtained during face-to-face interview in person 1 hour after blood collection. All participants completed a standardized questionnaire including socio-demographic status such as date of birth, sex, educational level, and marital status; medical history such as history of previous diseases, operation history and history of trauma; family health history such as incidence of hypertension, diabetes, coronary heart disease, malignant tumor and stroke; lifestyle habits such as smoking status, amount of physical activity and alcohol consumption; and medication use under the supervision of trained general practitioners and nurses. Educational level was categorized into three groups according to the number of years of education: illiterate, no education; primary education, 1–6 years of education; and junior high school education and above, seven or more years of education.

In this study, we define the term "moderate to vigorous physical activity" to refer to at least some sweating and shortness of breath caused by engaging in physical activity, and the term "light physical activity" to refer to no sweating or shortness of breath caused by engaging in physical activity.[6] In addition, moderate to vigorous physical activity at least once a week was classified as "Yes" for physical activity status. For alcohol consumption status, participants reported themselves as habitual drinker (drinking at least once a day), non-habitual drinker (drinking six times a week to once a month) or non-drinker (almost never).[7] For smoking status, we categorized participants as current smoker, ex-smoker and never-smoker, as described elsewhere.[8]

### 2.3 Physical examination

Anthropometric examinations were taken in the morning on participants who had fasted overnight, following which body measurements were taken by trained

examiners based on a standardized protocol. Height and weight were measured using analogue scales with the participants wearing light clothing without footwear. Waist circumference (WC) was measured at the end of normal expiration at the midpoint level of the midaxillary line between the 12th rib head and the superior anterior iliac spine. Body mass index (BMI) was calculated by dividing body weight (in kilograms) by the square of height (in m). Blood pressure were measured in both arms and recorded the higher one. Calibrated electronic sphygmomanometers were used to measure blood pressure on the arm supported at heart level with sitting position, carried out twice. The average of the two measurements was used for the statistical analysis. To obtain accurate readings, the participants were asked to rest for at least 5 min before the measurement, or, if having engaged in excessive exercise prior to the visit, for at least 30 min before the measurement. Untreated subjects with a blood pressure of at least 140/90 mm Hg were seen again at a second visit within 2 weeks, and if still ⩾140 and/or 90 mm Hg, they were seen a third time again within 2 further weeks. Those with high blood pressure at the first visit and who had normal blood pressure for both systolic blood pressure (SBP) (<140 mm Hg) and diastolic blood pressure (DBP) (<90 mm Hg) at the second or third visit were considered normotensive.

### 2.4 Blood sample collection and biochemical analyses

Participant venous blood samples were taken after at least 8 h of overnight fasting. All blood samples were analysed at the clinical laboratories of grade 2 hospitals to which the community health centers were directly affiliated. All the laboratories involved had successfully completed a standardization and competency program. Fasting venous blood was drawn from subjects for the measurements of levels of total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) by automatic biochemistry analyzer. TC and TG were estimated using enzymatic methods with commercially available reagents, while HDL and LDL were measured using a timed-endpoint colorimetric method. Fasting blood samples were biochemically analysed within a maximum of 4 hours after being drawn. Glucose oxidase measurements were used to ascertain the fasting blood glucose (FBG) level.

### 2.5 Definitions

A diagnosis of hypertension was considered when three consecutive high readings (≥140 systolic and/or ≥90 mm Hg diastolic) with 2-week intervals were registered or treatment with antihypertensive medication within the previous 2 weeks was self-reported.[9] Participants were considered to be undergoing treatment for hypertension if they answered “Yes” to the question “Because of your high blood pressure/hypertension, are you now taking prescribed medicine?” Controlled

hypertension was defined as SBP<140 mm Hg and DBP<90 mm Hg, and reported use of antihypertensive medication during the survey period.[9,10] Participants were regarded as diabetic if one of the following three conditions was met: (1) previous diagnosis by professional doctors; (2) FBG ⩾ 7.0 mmol/L; or (3) 2-h plasma glucose level ⩾ 11.1 mmol/L.[11] TC, LDL-C, HDL-C and TG levels were classified on the basis of the 2016 Chinese Guideline for the Management of Dyslipidemia in Adults.[12] It defines high TC as ⩾ 6.22 mmol/L, high LDL-C as ⩾ 4.14 mmol/L, low HDL-C as <1.04 mmol/L, and high TG as ⩾ 2.26 mmol/L. In the present study, we defined dyslipidemia as the presence of one or more abnormal serum lipid concentrations or use of anti-dyslipidemia medications in the previous 2 weeks.

Based on the Criteria of Weight for Adults released by the Ministry of Health of China (WS/T 428-2013), individuals were categorized into four groups: BMI<18.5 kg/m$^2$, low weight; 18.5 kg/m$^2$ ⩽ BMI<24.0 kg/m$^2$, normal weight; 24.0 kg/m$^2$ ⩽ BMI<28.0 kg/m$^2$, overweight; and BMI ⩾ 28.0 kg/m$^2$, obese. Men with WC ⩾ 90 cm and women with WC ⩾ 85 cm were defined as having central obesity.

### 2.6 Statistical analyses

We collected descriptive statistics for all the variables, including continuous variables, expressed as means and standard deviations, and categorical variables, expressed as numbers and percentages. Categorical variables between groups were compared using a chi-square test. Multivariate logistic regression analysis was performed to explore the association between treatment and control of hypertension, and associated risk factors. In the multivariate logistic regression model, the treatment or control of hypertension was defined as the dependent variable, and age, sex, education level, marital status, smoking status, alcohol consumption, physical activity status, BMI, central obesity, diabetes, diagnosis of dyslipidemia, and history of CVD were defined as the independent variables. SAS software version 9.4 (SAS Institute, Cary, NC, USA) was used to perform all statistical analyses. Tests were two-sided, and $P$<0.05 was considered to be statistically significant.

### 2.7 Participants and public involvement

Neither the study participants nor the public were involved in the design, recruitment or conduct of the study. All the participants had the option of receiving a health check and biochemical results when they visited the local community health centers.

### 2.8 Ethical Approval Statement

The study received ethnicity approval from the Center for Chronic Disease Control in Shenzhen(Grant No: SZCCC-201802, SZCCC-2020-018-01-PJ). Written informed consent was received by all participants before the collection of data and

conducting of the research. Where participants were illiterate, we obtained written informed consent from their proxies.

## 3.0 Results

### 3.1 Sociodemographic and other characteristics of participants

Of the 124,007 participants, 44.1% (n=54,649) were male and 55.9% (n=69,358) were female, the mean age was 71.3±5.6, 56.3% had attained a junior school education or above, 96.2% were married or cohabiting, 76.9% reported engaging in regular physical activities, and 4.2% reported having the history of CVD (Table 1). Current smokers accounted for 8.2%, and habitual drinkers accounted for 6.4% (Table 1). In terms of anthropometric measurements, the means of average BMI, SBP, DBP, WC, FBG, TC, TG, LDL-C and HDL-C levels for all 124,007 participants were 23.8±3.2 kg/m$^2$, 134.7±17.7 mm Hg, 77.2±10.3 mm Hg, 85.1±8.8 cm, 6.0±1.9 mmol/L, 5.2±2.1 mmol/L, 1.6±1.1 mmol/L, 3.1±1.1 mmol/L and 1.4±0.5 mmol/L, respectively (Table 1).

### 3.2 Treatment and control rates in subgroups

The prevalence of hypertension was 55.8%. Of those individuals with hypertension, 54.4% were receiving treatment, and 32.3% had blood pressure under control. Table 2 lists the treatment and control of hypertension by sociodemographic grouping, lifestyle, clinical and anthropometric characteristics. The treatment rate demonstrated no difference between males and females. However, males had a significantly higher rate of control than females. Higher treatment and control rates were also found among those who had attained junior school education or above, engaged in regular physical activity, were ex-smokers and had history of CVD, or diabetes or dyslipidemia. Participants who were single had the lowest treatment rates when compared with their non-treated counterparts. Participants aged 65～69 years had the lowest treatment rates compared with older participants. Habitual drinkers had the lowest treatment and control rates. Participants with obesity or central obesity had higher treatment rates and lower control rates.

### 3.3 Results of multivariate analysis of factors associated with treatment and control of hypertension

The results of multivariate logistic regression of hypertension treatment and control according to selected sociodemographic and other potential factors are presented in Table 3. Participants with the highest educational attainment (*OR*=1.25, 95% *CI*=1.18–1.32) were more likely to be receiving treatment for hypertension compared with participants of low educational level. Being widowed (*OR*=1.28, 95% *CI*=1.17–1.40) was a protective factor for treatment of hypertension while being single (*OR*=0.58, 95% *CI*=0.45–0.74) was negatively associated with hypertension

treatment. Older age, engaging in physical activity (*OR*=1.14, 95% *CI*=1.10–1.18), being an ex-smoker (*OR*=1.19, 95% *CI*=1.11–1.27) and history of CVD (*OR*=2.20, 95% *CI*=2.04–2.37) were associated with higher likelihood of receiving treatment for hypertension, while non-habitual drinker (*OR*=0.89, 95% *CI*=0.85–0.94) or habitual drinker (*OR*=0.72, 95% *CI*=0.68-0.77) was associated with lower likelihood of receiving treatment for hypertension. Compared with individuals without comorbidities, having comorbidities was also associated with higher rate of treatment: overweight (*OR*=1.64, 95% *CI*=1.48–1.82), obesity (*OR*=1.89, 95% *CI*=1.68–2.11), central obesity (*OR*=1.10, 95% *CI*=1.06–1.14), diabetes (*OR*=1.49, 95% *CI*=1.44–1.54) and dyslipidemia (*OR*=1.20, 95% *CI*=1.16–1.24). For those with hypertension, junior school education and above (*OR*=1.28, 95% *CI*=1.20–1.36), engaging in physical activity (*OR*=1.06, 95% *CI*=1.02–1.10), and history of CVD (*OR*=1.82, 95% *CI*=1.71–1.96), diabetes (*OR*=1.52, 95% *CI*=1.47–1.58) or dyslipidemia (*OR*=1.20, 95% *CI*=1.16–1.24) were positively associated with the control of hypertension. In contrast, female sex (*OR*=0.91, 95% *CI*=0.88–0.95), aged 80 or above (*OR*=0.93, 95% *CI*=0.88–0.98), non-habitual drinker (*OR*=0.92, 95% *CI*=0.87–0.97), habitual drinker (*OR*=0.73, 95% *CI*=0.68≤0.79) and central obesity (*OR*=0.94, 95% *CI*=0.91≤0.98) were negatively associated with the control of hypertension.

## 4. Discussion

Hypertension is the leading modifiable risk factor for CVD, which is the leading cause of death in China.[13,14] The burden of hypertension and CVD on the health care system in China is increasing along with urbanization, rising incomes and the aging of the population.[15] China has made substantial improvements in hypertension treatment indicators such as blood pressure lowering medication use and blood pressure control over the past decades.[16,17] However, despite these improvements nearly half of the elderly hypertensive participants in our study were not undergoing treatment with antihypertensive medication. In addition, nearly half of hypertensives who had previously been diagnosed had blood pressure that was uncontrolled.

Several previous epidemiological studies have reported on the treatment of hypertension in Chinese elderly populations.[18,19] One of those studies, the China Health and Retirement Longitudinal Study, measured the treatment of hypertension in a nationally representative sample of 9,357 Chinese aged 45 years or above, which provided the best comparison data for our study.[18] When compared with the findings from that study, the treatment of hypertension in this study indicated higher incidence, 51.0% vs. 54.4%, respectively.[18] Other regional studies have also previously examined the treatment of hypertension in local elderly residents. Cao and co-researchers[19] revealed that the rate of treatment of hypertension in Hebei province was 38.2%, while Du et al. [20] found that rate in Zhejiang province was 45.4%, both lower than in our study in Shenzhen. This could be because Shenzhen has established

a people-centered integrated care model comprising local community health centers.[21] Under the strong leadership of the district government, comprehensive strategies have been adopted to strengthen primary care and care coordination, improve the quality and efficiency of health care delivery, and promote population health.[21] Even so, the treatment rate of hypertension in the elderly population in Shenzhen was still far below that of elderly in other countries such as the United States, Australia, Germany and Colombia.[22-24]

Similar to other studies, we found that the treatment of hypertension was significantly higher among older, ex-smokers, non-drinkers,higher education leveland those engaging in physical activity. [9, 19, 24, 25] Participants engaged in physical activity may generally pay more attention to their health. Unsurprisingly, therefore, the group with the highest level of physical activity had a higher likelihood of being aware of their hypertension and receiving medication.

Our study revealed a higher level of treatment in individuals with comorbidities such as overweight, obesity, central obesity, diabetes and dyslipidemia, which are common comorbidities with hypertension.[19,23]Moreover, in our study, history of CVD was highly correlated with receiving antihypertensive treatment. Other researchers have confirmed that having another medical condition, for example, diabetes or dyslipidemia, is associated with greater awareness and treatment of hypertension.[26,27] This causes people to go to health centers, and consequently be diagnosed with hypertension sooner, obtaining earlier treatment. Therefore, often patients with comorbid diseases have higher perception of the risk factors and their condition. An alternate theory to explain the higher rates of no treatment in individuals with fewer comorbidities is that physicians may be wary of the consequences of initiating medication and quality of life by “medicalizing” an otherwise healthy person.[22]

Compared to previous epidemiological data of hypertension in China, the control rate in our study was significantly higher than the control rate of hypertension among elderly in Hebei province investigated in 2015.[19] This could be due to the fact that Shenzhen is a relatively well-developed economy with higher levels of education, better community medical facilities and equipment, and relatively high levels of diagnosis and treatment for hypertension compared with the national average. However, the control rate of hypertension in Shenzhen elderly were much lower than those reported in developed countries.[22,23] Possible reasons include the following: (1) Shenzhen medical institutions are not doing a good job of screening for hypertension.[28] (2) Hypertensive individuals often cease taking antihypertensive agents when blood pressure control has been achieved, which may result in uncontrolled hypertension when checked later unless there is regular monitoring.[29](3) Primary care physicians in the China might have been less knowledgeable or experienced in diagnosing and treating hypertension compared with those in

developed countries.[29] (4) China"s doctors might have become entrenched in traditional prescription practice and lack knowledge or willingness to follow new guidelines due to obstacles in information exchange.[29] (5) There was a lower rate of out-of-office blood pressure monitoring among hypertensive patients in China than that in developed countries, in spite of recommendations in multiple guidelines.[30,31]

Previous studies have revealed that being female had a statistically significant association with the control of hypertension.[24, 25] On the contrary, our findings suggested that being female was a negative indicator of hypertension control, strongly indicating that it deserves further study. Our study revealed that participants with high educational attainment had more than 1.28-fold higher probability of being in control of their hypertension status than those with low educational level. Education is a well-elucidated determinant of health disparity, and such disparities have been shown to be more pronounced in later life phases.[32] In the present study, hypertension control decreased with age. Literature shows consistency in the association between age and control of hypertension.[33] Older people often have hypertension accompanied by multiple diseases, as well as cognitive decline and low medication compliance, which are all related to the lower control rate of hypertension.[34] Previous studies have found that older age was independently associated with greater hypertension awareness and treatment but poorer hypertension control, which is in accordance with the current report.[35,36]

Alcohol consumption and physical inactivity have also been correlated with inferior hypertension control. As Gooding and co-researchers[37] reported, patients with more unhealthy behaviors care less about subjective well-being. This may have led to a generally lower control rate. In addition, the control of hypertension was lower with higher WC in our study, consistent with some previous studies.[19,38] Greater WC is correlated with higher levels of fat mass, an increase in salt retention and insulin resistance, which cause increased high blood pressure.[39]

In our study, patients who had diabetes or dyslipidemia had higher probability of having controlled blood pressure, consistent with other studies.[25,40] An explanation might be that when people have diabetes or dyslipidemia, they become more focused on their health, and therefore may be more likely to engage in and comply with blood pressure-lowering drugs or lifestyle intervention for hypertension. Our study additionally showed that history of CVD is a positive factor for effective blood pressure control. Physicians use more angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor blockers or even aldosterone receptor blockers to treat participants with CVD, which all contribute to effective blood pressure reduction.[41]

Our study had some limitations. First, given the cross-sectional nature of the study design, only associations, rather than causality, could be inferred. Second, our

research enrolled the elderly population by convenience sampling. This is a major factor preventing true extrapolation of the results to the general population. Third, patient previous experience of medications for other conditions could have contributed to their current adherence to treatment. Further studies are needed to evaluate the correlation between patient previous experience of taking medication and current hypertension treatment. Fourth, the impact of white coat hypertension and masked hypertension could not be excluded as factors affecting the findings in our research.

## 5. Conclusion

In conclusion, we found a high prevalence of hypertension but a low prevalence of treatment and control among Shenzhen elderly, a group at high risk for future CVD events. This study represents a warning for cardiovascular health management in Shenzhen elderly. Improvement in hypertension treatment and control should be a public health priority to reduce the disproportionate burden of CVD in this growing population. Out-of-office blood pressure monitoring is one measure that could be introduced to identify hypertensive patients earlier so as to start treatment more promptly to reduce CVD incidence in this high risk group.

## Acknowledgments

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## Author Contributions

WN and JX: study conception and design. WN, XY, JZ, PL, HZ, YZ, and JX: performance of research. XY and JZ: data analysis and interpretation. WN: writing the original draft. WN and JX: Writing the review and editing. All authors have read and agreed to the published version of the manuscript.

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## Conflicts of Interest

The authors declare no conflict of interest.

## Patient consent for publication

Not required.

## Ethics approval

This study was approved by the ethical review committee of the Center for Chronic Disease Control of Shenzhen.

## Data sharing statement

No additional data are available.

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## Tables

**Table 1** Sociodemographic, anthropometric, lifestyle and clinical characteristics of older adults living in Shenzhen (*n*=124,007)

| Characteristics | General(*n*=124,007) | Characteristics | General(*n*=124,007) |
|---|---|---|---|
| Age (years) | 71.3±5.6 | Physical activity, n (%) | |
| BMI (Kg/m$^2$) | 23.8±3.2 | Yes | 95338(76.9) |
| SBP (mm Hg) | 134.7±17.7 | No | 28669(23.1) |
| DBP (mm Hg) | 77.2±10.3 | History of cardiovascular disease, n (%) | |
| WC (cm) | 85.1±8.8 | Yes | 5192(4.2) |
| FBG (mmol/L) | 6.0±1.9 | No | 118815(95.8) |
| TC(mmol/L) | 5.2 ± 2.1 | Smoking status, n (%) | |
| TG(mmol/L) | 1.6 ± 1.1 | Current smoker | 10163(8.2) |
| LDL-C(mmol/L) | 3.1 ± 1.1 | Ex-smoker | 7662(6.2) |
| HDL-C(mmol/L) | 1.4 ± 0.5 | Never-smoker | 106182(85.6) |
| Sex, n(%) | | Drinking habit, n (%) | |
| Male | 54649(44.1) | Non-drinker | 103388(83.4) |
| Female | 69358(55.9) | Non-habitual drinker | 12737(10.2) |
| Education level, n(%) | | Habitual drinker | 7882(6.4) |
| Illiterate | 10054(8.1) | | |
| Primary education | 44096(35.6) | | |
| Junior school education and above | 69857(56.3) | | |
| Marital status, n(%) | | | |
| Married or cohabiting | 119314(96.2) | | |
| Widowed | 3623(2.9) | | |
| Divorced | 565(0.5) | | |
| Single | 505(0.4) | | |

Table 2 Treatment and control of hypertension in older adults diagnosed with hypertension living in Shenzhen, according to socio-demographic, lifestyle, clinical

and anthropometric characteristics ($n$=69,207)

| Characteristics | Number of hypertension patients | Treatment n(%) | $\chi^2$ Value | $P$ Value | Control n(%) | $\chi^2$ Value | $P$ Value |
|---|---|---|---|---|---|---|---|
| Total | 69207 | 37669(54.4) | | | 22366(32.3) | | |
| Sex | | | 0.16 | 0.69 | | 56.07 | <0.01 |
| Male | 29919 | 16311(54.5) | | | 10126(33.8) | | |
| Female | 39288 | 21358(54.4) | | | 12240(31.2) | | |
| Education level | | | 183.73 | <0.01 | | 242.41 | <0.01 |
| Illiterate | 5751 | 2992(52.0) | | | 1671(29.1) | | |
| Primary education | 24083 | 12369(51.4) | | | 7022(29.2) | | |
| Junior school education and above | 39373 | 22308(56.7) | | | 13673(34.7) | | |
| Marital status | | | 63.50 | <0.01 | | 7.83 | 0.05 |
| Married or cohabiting | 66220 | 35915(54.2) | | | 21352(32.2) | | |
| Widowed | 2356 | 1436(60.9) | | | 810(34.4) | | |
| Divorced | 377 | 216(57.3) | | | 132(35.0) | | |
| Single | 254 | 102(40.2) | | | 72(28.4) | | |
| Age group | | | 172.39 | <0.01 | | 2.12 | 0.55 |
| 65～ | 30727 | 15965(51.9) | | | 9932(32.3) | | |
| 70～ | 18976 | 10412(54.9) | | | 6151(32.4) | | |
| 75～ | 10774 | 6208(57.6) | | | 3516(32.6) | | |
| 80～ | 8730 | 5084(58.2) | | | 2767(31.7) | | |
| Physical activity | | | 51.09 | <0.01 | | 20.13 | <0.01 |
| Yes | 53528 | 29527(55.2) | | | 17530(32.8) | | |
| No | 15679 | 8142(51.9) | | | 4836(30.8) | | |
| Smoking status | | | 28.06 | <0.01 | | 18.01 | <0.01 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Current smoker | 5071 | 2659(52.4) | | | 1678(33.1) | | |
| Ex-smoker | 4427 | 2557(57.8) | | | 1550(35.0) | | |
| Never-smoker | 59709 | 32453(54.4) | | | 19138(32.1) | | |
| Drinking habit | | | 82.92 | <0.01 | | 49.09 | <0.01 |
| Non-drinker | 57976 | 31854(54.9) | | | 18885(32.6) | | |
| Non-habitual drinker | 6838 | 3713(54.3) | | | 2257(33.0) | | |
| Habitual drinker | 4393 | 2102(47.9) | | | 1224(27.9) | | |
| History of cardiovascular disease | | | 545.61 | <0.01 | | 373.78 | <0.01 |
| Yes | 3804 | 2768(72.8) | | | 1772(46.6) | | |
| No | 65403 | 34901(53.4) | | | 20594(31.5) | | |
| BMI | | | 381.72 | <0.01 | | 35.24 | <0.01 |
| Low weight | 1712 | 712(41.6) | | | 531(31.0) | | |
| Normal weight | 31104 | 16056(51.6) | | | 10352(33.3) | | |
| Overweight | 28142 | 15923(56.6) | | | 9004(31.9) | | |
| Obesity | 8249 | 4978(60.4) | | | 2479(30.1) | | |
| Central obesity | | | 253.08 | <0.01 | | 24.23 | <0.01 |
| Yes | 32094 | 18508(57.7) | | | 10070 (31.4) | | |
| No | 37113 | 19161(51.6) | | | 12296(33.1) | | |
| Diabetes | | | 688.03 | <0.01 | | 603.08 | <0.01 |
| Yes | 19263 | 12025(62.4) | | | 7580 (39.4) | | |
| No | 49944 | 25644(51.4) | | | 14786(29.6) | | |
| Dyslipidemia | | | 243.60 | <0.01 | | 30.36 | <0.01 |
| Yes | 33416 | 19210(57.5) | | | 11138 (33.3) | | |
| No | 35791 | 18459(51.6) | | | 11228 (31.4) | | |

Definition: A diagnosis of hypertension was considered when three consecutive high readings (≥140 systolic and/or ≥90 mm Hg diastolic) with 2-week intervals were registered or treatment with antihypertensive medication within the previous 2 weeks was self-reported. Participants were considered to be undergoing treatment if they

answered “Yes” to the question “Because of your high blood pressure/hypertension, are you now taking prescribed medicine?” Controlled hypertension was defined as SBP<140 mm Hg and DBP<90 mm Hg, and reported use of antihypertensive medication during the survey.

Table 3 Risk factor analysis on the treatment and control of hypertension in older adults living in Shenzhen

| Characteristics | Treatment[a] | | Control[b] | |
|---|---|---|---|---|
| | *OR*(95%*CI*) | *P* Value | *OR*(95%*CI*) | *P* Value |
| Sex | | | | |
| Male | — | — | 1.00(Reference) | |
| Female | — | — | 0.91(0.88-0.95) | <0.01 |
| Education level | | | | |
| Illiterate | 1.00(Reference) | | 1.00(Reference) | |
| Primary education | 1.00(0.95-1.07) | 0.90 | 0.99(0.93-1.06) | 0.84 |
| Junior school education and above | 1.25(1.18-1.32) | <0.01 | 1.28(1.20-1.36) | <0.01 |
| Marital status | | | | |
| Married or cohabiting | 1.00(Reference) | | — | — |
| Widowed | 1.28(1.17-1.40) | <0.01 | — | — |
| Divorced | 1.07(0.87-1.31) | 0.54 | — | — |
| Single | 0.58(0.45-0.74) | <0.01 | — | — |
| Age group | | | | |
| 65～ | 1.00(Reference) | | 1.00(Reference) | |
| 70～ | 1.11(1.07-1.15) | <0.01 | 0.98(0.94-1.02) | 0.23 |
| 75～ | 1.24(1.18-1.30) | <0.01 | 0.96(0.92-1.01) | 0.13 |
| 80～ | 1.32(1.25-1.38) | <0.01 | 0.93(0.88-0.98) | <0.01 |
| Physical activity | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.14(1.10-1.18) | <0.01 | 1.06(1.02-1.10) | <0.01 |
| Smoking status | | | | |
| Never-smoker | 1.00(Reference) | | — | — |
| Current smoker | 1.06(1.00-1.13) | 0.06 | — | — |

| | | | | |
|---|---|---|---|---|
| Ex-smoker | 1.19(1.11-1.27) | <0.01 | — | — |
| Drinking habit | | | | |
| Non-drinker | 1.00(Reference) | | 1.00(Reference) | |
| Non-habitual drinker | 0.89(0.85-0.94) | <0.01 | 0.92(0.87-0.97) | <0.01 |
| Habitual drinker | 0.72(0.68-0.77) | <0.01 | 0.73(0.68-0.79) | <0.01 |
| History of cardiovascular disease | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 2.20(2.04-2.37) | <0.01 | 1.82(1.71-1.96) | <0.01 |
| BMI | | | | |
| Low weight | 1.00(Reference) | | — | — |
| Normal weight | 1.42(1.28-1.57) | <0.01 | — | — |
| Overweight | 1.64(1.48-1.82) | <0.01 | — | — |
| Obesity | 1.89(1.68-2.11) | <0.01 | — | — |
| Central obesity | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.10(1.06-1.14) | <0.01 | 0.94(0.91-0.98) | <0.01 |
| Diabetes | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.49(1.44-1.54) | <0.01 | 1.52(1.47-1.58) | <0.01 |
| Dyslipidemia | | | | |
| No | 1.00(Reference) | | 1.00(Reference) | |
| Yes | 1.20(1.16-1.24) | <0.01 | 1.05(1.03-1.09) | <0.01 |

[a]Adjusted for sex.

[b]Adjusted for marital status, smoking status and BMI.

Definition: A diagnosis of hypertension was considered when three consecutive high readings (≥140 systolic and/or ≥90 mm Hg diastolic) with 2-week intervals were registered, or treatment with antihypertensive medication within the previous 2 weeks was self-reported. Participants were considered to be treated if they answered "yes" to

the question “Because of your high blood pressure/hypertension, are you now taking prescribed medicine?” Controlled hypertension was defined as SBP<140 mm Hg and DBP <90 mm Hg, and reported use of antihypertensive medication during the survey.

**STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies***

| 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 | Page 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | Page 2-3 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | Page 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | Page 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | Page 5 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | Page 5 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants | Page 5 |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | Page 6-7 |
| 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 | Page 6-8 |
| Bias | 9 | Describe any efforts to address potential sources of bias | Page 8 |
| Study size | 10 | Explain how the study size was arrived at | Page 5 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | Not applicable |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | Page 8 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | Not applicable |
| | | (*c*) Explain how missing data were addressed | Not applicable |
| | | (*d*) If applicable, describe analytical methods taking account of sampling strategy | Not applicable |
| | | (*e*) Describe any sensitivity analyses | Not applicable |
| **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 | Page 8-9 |
| | | (b) Give reasons for non-participation at each stage | Not applicable |
| | | (c) Consider use of a flow diagram | Not applicable |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | Page 8-9 |
| | | (b) Indicate number of participants with missing data for each variable of interest | Not applicable |
| Outcome data | 15* | Report numbers of outcome events or summary measures | Page 9 |
| 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 | Page 9 |
| | | (*b*) Report category boundaries when continuous variables were categorized | Page 9-10 |
| | | (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | Page 9-10 |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | Not applicable |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | Page 10-12 |
| 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 | Page 12 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | Page 10-12 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | Page 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 | Page 13 |

*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.