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Prevalence of hypertension in Shenzhen, China: a population-based, cross-sectional study

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ABSTRACT

Objective Hypertension (HTN) is an important public health issue worldwide, associated with the rapid economic development and urbanisation over the last decades. This is especially the case in Shenzhen, which has benefited greatly from the reform and opening-up policies. However, there is limited information on the epidemiology of HTN in this region. This study was designed to investigate the prevalence, awareness, treatment and control of HTN and the associated factors among adult residents in Shenzhen, China.

Design Population-based, cross-sectional study.

Participants Through the multistage stratified random sampling method, a representative sample of 10 043 urban population aged ≥18 years were selected. Three consecutive blood pressure (BP) readings were measured after resting for a 5 min seat by trained staff and HTN was defined as mean systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg and/or self-reported current use of antihypertensive drugs. Participants were interviewed using a structured questionnaire. Anthropometric details, BP, blood and urine samples were also collected.

Primary outcome measure Prevalence of HTN.

Results Overall, the weighted prevalence of HTN among residents in Shenzhen was 19.2% (95% CI 18.5 to 20.0). Among patients with HTN, 55.0% (95% CI 52.9 to 57.1) were aware of their condition and 44.9% (95% CI 42.8 to 47.1) were taking antihypertensive medications, but only 21.7% (95% CI 20.0 to 23.5) achieved BP control. Among those who knew their HTN, 81.7% (95% CI 79.3 to 83.8) were under treatment and 48.3% (95% CI 45.1 to 51.5) were controlled among those with treated HTN. Male, older age, lower educational level, overweight and obesity, family history of HTN, tobacco smoking, alcohol intake, diabetes mellitus, dyslipidaemia and high uric acid were associated with HTN.

Conclusions HTN is a major public health concern in Shenzhen, which has low awareness, treatment and control rates, and is associated with several risk factors. Effective multifaceted implementation strategies are highly needed to combat the emerging burden of HTN.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study from a large representative sample provides new information on the status of prevalence, awareness, treatment, control and risk factors associated with hypertension among the urban adult population in Shenzhen.
⇒ Some data were self-reported and thus the study is subject to reporting bias and recall bias.
⇒ The nature of the cross-sectional design prevents us from making causal and temporal inferences between potential risk factors and hypertension.
⇒ We were unable to compare the effect of monotherapy and combined therapy on optimal blood pressure control, which warrants further study.
⇒ This study was conducted only in Shenzhen, which may influence the generalisability and representativeness due to regional variations.

INTRODUCTION

Hypertension (HTN) or raised blood pressure (BP) has become an important global health problem and a huge burden to primary healthcare systems.[1 2] It is also the leading modifiable risk factor for cardiovascular disease, premature death and all-cause mortality worldwide.[2 3] There has been a dramatic increase in the prevalence of HTN across the world, and earlier work estimated that 31.1% of the global adult population, or 1.39 billion people, had HTN,[4] accounting for around 17% of total deaths and 7% of total disability adjusted life years.[5] More importantly, HTN disproportionately influences populations in low-income and middle-income countries (LMICs), and not only is HTN more prevalent in LMICs, there are also more people affected living in these countries than in high-income countries (HICs).[6] Worse still, HICs experienced a substantial increase in the proportion of HTN awareness, treatment and control, whereas in LMICs these increased slightly or even decreased.[4]

Once an underdeveloped region, Shenzhen has benefited from the implementation of the reform and opening-up policies in the 1980s, which has led to its extremely significant economic and infrastructural development. At the same time, however, these transitions in Shenzhen have provoked sweeping changes

in the lifestyle of the residents, involving increased intake of dietary salt and fat and reduced participation in physical activity (PA), which in turn have undoubtedly contributed to the significant increase in BP and body weight.[7 8] Such unhealthy lifestyle changes are affecting numerous young people around the world. This is especially the case in Shenzhen, where the age structure of the population is quite young and the proportion of individuals at least 60 years old is only 5.36%.[9] In addition, prior literature indicated that the prevalence of HTN among young people increases more dramatically than among the elderly.[10 11]

HTN is a preventable public health concern and is linked with individual unhealthy behaviours such as tobacco smoking, alcohol consumption and physical inactivity.[5] Other risk factors have also been found to be associated with HTN, including lower educational level and household income, urban residence, higher body mass index (BMI), higher salt intake and consumption of fatty foods, and insufficient intake of fruits and vegetables.[10–16] There are also marked gender and age differences in the prevalence of HTN.[10–13]

However, studies about the epidemiological characteristics of HTN in Shenzhen are lacking and evidence between HTN and potential risk factors from Shenzhen's adult population is scarce. We thereby conducted a cross-sectional study to investigate HTN prevalence, awareness, treatment and control and further identify the risk factors associated with HTN event that could serve for the implementation of effective prevention and intervention strategies.

METHODS

Study design and participants

Conducted from September to December 2018, this was the third population-based, cross-sectional study designed to determine the prevalence of chronic noncommunicable diseases and their risk factors in Shenzhen, China. In order to obtain enough sample size, the prevalence of diabetes mellitus (DM), which is significantly lower than of HTN and dyslipidaemia, that found in the preinvestigation was used to calculate. The α value, the prevalence of DM, the relative error and the design effect were 0.05, 8.3%, 10% and 2, respectively, with a non-response rate of 15%. This resulted in a final sample size for the present study of 9761.

Based on feasibility and cost-effectiveness, a multistage stratified sampling method was adopted for the whole sampling process to select communities, households and eligible individuals. First, 10 communities were randomly chosen from 10 administrative districts, respectively. Second, from each selected community, 100 representative households were chosen randomly. Third, from each of the selected household, eligible participants aged ≥18 years old living in Shenzhen for over 6 of the past 12 months were selected on the basis of the Kish selection table. Finally, a sample size of 10043 participants were

enrolled, with 3 excluded due to missing data on covariates and BP measurement.

Written informed consent was obtained from each participant. The purpose and meaning of the study were explained verbally to consenting participants by trained staff prior to the study.

Data collection

Participants were interviewed by trained personnel using a structured questionnaire to collect demographic characteristics, PA involvement, tobacco smoking, alcohol intake and dietary behaviours. Basic details included ethnicity, sex, age, educational level, marital status, health insurance status, and personal and family histories of diseases.

The Global Physical Activity Questionnaire was used to evaluate participants' PA levels, and sufficient PA was defined as at least 150 min of moderate-intensity PA or at least 75 min of vigorous-intensity PA per week, or an equivalent combination of moderate-intensity and vigorous-intensity PA.[17]

Current smokers were defined as participants who have smoked at least one cigarette per day in the last 6 months and currently smoke any tobacco products, former smokers as participants who have smoked at least one cigarette each day in the past half year but quit smoking for 1 month or above, and never smokers as participants who never smoked. Drinkers were defined as participants who have drunk an average of at least one alcoholic beverage per week and currently consume alcohol.

Dietary behaviours were also evaluated. (1) Consumption of soft drink was asked based on the number of times in a typical week, with participants classified into ≥6 times/week, 3–5 times/week or ≤2 times/week. (2) Daily salt intake was calculated from the volume of salt consumed per day divided by the number of family members and was classified into ≥5 g/day or <5 g/day. (3) Daily consumption of oil was calculated from the volume of oil consumed per day divided by the number of family members and was classified into <25 g/day, 25–35 g/day or >35 g/day. (4) Daily fruit and vegetable intake was calculated from the number of servings of fruits and vegetables consumed per day in a typical week and was classified into ≥5 servings/day or <5 servings/day.[6]

Height and weight of participants were uniformly measured without shoes and heavy clothing, following common standard protocols. BMI was defined as weight divided by height squared (kg/m^2) and was further classified into four categories: underweight ($<18.5\,kg/m^2$), normal ($18.5–23.9\,kg/m^2$), overweight ($24.0–27.9\,kg/m^2$) and obesity ($≥28.0\,kg/m^2$).[18]

The subjects themselves took at least 30 mL morning mid-urine and sealed and handed it to the staff investigators for test. Overnight fasting blood samples were drawn after a 15 min rest, in the sitting position, by venipuncture to measure blood glucose, serum total cholesterol, total triglycerides, low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol.

Blood and urine specimens were kept at 2°C–8°C and sent within 2 hours to the Shenzhen laboratory of Guangzhou KingMed Diagnostics Center, where the specimens were processed and stored frozen at −80°C until laboratory assays could be performed. Based on the Guidelines for the Prevention and Treatment of Dyslipidemia in Adults in China (2016 Revised Version), participants who met one of the following criteria were considered to have dyslipidaemia: total triglycerides ≥2.3 mmol/L, serum total cholesterol ≥6.2 mmol/L, LDL cholesterol ≥4.1 mmol/L, HDL cholesterol <1.04 mmol/L[19] and a diagnosis of dyslipidaemia. Participants were defined to have high uric acid if their uric acid was >420 µmol/L[20] and DM if fasting plasma glucose was ≥7.0 mmol/L, self-reported current use of insulin or oral hypoglycaemic drugs or a history of diagnosis of diabetes.[21 22]

The subjects were told not to smoke, exercise, and drink coffee, alcohol or tea at least 30 min before examination. Measurement of BP was performed before blood draw and three consecutive readings of BP were measured using a validated and standardised mercury sphygmomanometer (HEM-7124, OMRON) on the same arm after a 5 min seated rest, with 1 min between each measurement. The average of the three readings was considered as each participant's BP. Consistent with the US Eighth Joint National Committee standards[1] and Chinese guidelines,[23] HTN was defined as an average systolic BP of ≥140 mm Hg and/or an average diastolic BP of ≥90 mm Hg and/or self-reported current use of antihypertensive drugs. Awareness of HTN was defined as self-report of any prior diagnosis of HTN by a doctor among participants identified as hypertensive, treatment as the use of prescribed antihypertensive medication within 2 weeks at the time of the interview, and control as an average systolic BP of <140 mm Hg and an average diastolic BP of <90 mm Hg; patients not meeting these criteria were considered unaware, untreated and uncontrolled, respectively.

Patient and public involvement
No patients were involved.

Quality control
To ensure the quality of the survey and physical measurements, staff investigators were trained uniformly in accordance with the study protocol to be familiar with the specific methodologies and tools employed. Height, weight and BP were measured and obtained repeatedly from 5% of participants by quality control staff. Also, the staff validated the members from 5% of the selected family and reinterviewed 10% of the subjects by telephone based on the abbreviated version of the main questionnaire.

Statistical analysis
Categorical variables were presented as number (percentage) and tested for between-group differences using χ^2 test. HTN prevalence, awareness, treatment and control were expressed as percentage with 95% CI and weights were calculated according to the 2010 Chinese census. All significant variables (including ethnicity, sex, age, educational level, marital status, BMI, health insurance status, family history of HTN, family history of cancer, smoking status, alcohol consumption, soft drinks intake, cancer, chronic obstructive pulmonary disease, DM, dyslipidaemia and high uric acid) tested by χ^2 test were included in the multivariable logistic regression model to explore the potential risk factors associated with HTN, where OR and the corresponding 95% CI of significant variables were calculated, using forward conditional manner and selection criteria of α_{in}=0.05 and α_{out}=0.10. SPSS V.26.0 was used for statistical analyses and a two-tailed P value <0.05 was considered statistically significant.

RESULTS
Overall, 10 043 participants were aged 18–95 years old, with a mean age of 43.4 years (SD=12.64). More participants were Han, female, married, had normal weight, well educated with a high school degree or higher, and had various types of health insurance. Majority of the participants did not have a family history of any chronic diseases, including HTN, coronary heart disease, cerebrovascular disease, DM and cancer. Of the whole sample, the crude and weighted prevalence of HTN were 21.3% (n=2143, 95% CI 20.5 to 22.2) and 19.2% (95% CI 18.5 to 20.0), respectively. Ethnicity, sex, age, educational level, marital status, BMI, health insurance status, and family history of HTN and cancer were significantly associated with HTN (table 1).

As presented in table 2, significant differences in individual lifestyle variables between participants with and without HTN included smoking status, alcohol consumption and soft drinks intake. Moreover, whether participants had any chronic diseases including cancer, chronic obstructive pulmonary disease, DM and dyslipidaemia or high uric acid were significantly linked with HTN (table 2).

Based on the significant variables tested by χ^2 test, a multivariate logistic regression analysis was performed to estimate their ORs for HTN and the results are displayed in table 3. Male, older age, lower educational level, overweight or obesity, family history of HTN, DM, dyslipidaemia and high uric acid were positively associated with HTN. In addition, participants who were smokers or alcohol drinkers had higher odds of HTN.

Among those with HTN, 55.0% (n=1179, 95% CI 52.9 to 57.1) were aware of their status and 44.9% (n=963, 95% CI 42.8 to 47.1) were taking antihypertensive medications, but only 21.7% (n=465, 95% CI 20.0 to 23.5) achieved BP control. Among those who knew their HTN, 81.7% (95% CI 79.3 to 83.8) were under treatment to lower their BP and 48.3% (95% CI 45.1 to 51.5) were controlled among those with treated HTN. There were significant differences in awareness, treatment and control rates among participants of various sexes, ages and educational levels (table 4).

Table 1 Comparison of baseline characteristics of study participants with and without hypertension

Characteristics	All (N=10 043)	Hypertension		χ^2
		No (n=7900)	Yes (n=2143)	
Ethnicity				6.168*
Han	9725 (96.8)	7632 (78.5)	2093 (21.5)	
Non-Han	318 (3.2)	268 (84.3)	50 (15.7)	
Sex				128.551***
Male	4346 (43.3)	3188 (73.4)	1158 (26.6)	
Female	5697 (56.7)	4712 (82.7)	985 (17.3)	
Age, years				1387.535***
18–24	297 (3.0)	289 (97.3)	8 (2.7)	
25–34	2445 (24.3)	2284 (93.4)	161 (6.6)	
35–44	3296 (32.8)	2836 (86.0)	460 (14.0)	
45–54	1995 (19.9)	1427 (71.5)	568 (28.5)	
55–64	1293 (12.9)	746 (57.7)	547 (42.3)	
≥65	717 (7.1)	318 (44.4)	399 (55.6)	
Educational level				355.738***
Primary school or below	1349 (13.4)	837 (62.0)	512 (38.0)	
Middle school	2694 (26.8)	2048 (76.0)	646 (24.0)	
High school	2898 (28.9)	2327 (80.3)	571 (19.7)	
College or above	3102 (30.9)	2688 (86.7)	414 (13.3)	
Marital status				105.253***
Unmarried	698 (7.0)	644 (92.3)	54 (7.7)	
Married	8958 (89.2)	6993 (78.1)	1965 (21.9)	
Other	387 (3.9)	263 (68.0)	124 (32.0)	
BMI, kg/m^2				706.961***
Underweight	491 (4.9)	461 (93.9)	30 (6.1)	
Normal	5391 (53.7)	4673 (86.7)	718 (13.3)	
Overweight	3239 (32.3)	2239 (69.1)	1000 (30.9)	
Obesity	918 (9.1)	523 (57.0)	395 (43.0)	
Health insurance status				6.838**
Uninsured	266 (2.6)	192 (72.2)	74 (27.8)	
Insured	9777 (97.4)	7708 (78.8)	2069 (21.2)	
Family history of hypertension				99.671***
No	6228 (62.0)	5098 (81.9)	1130 (18.1)	
Yes	3815 (38.0)	2802 (73.4)	1013 (26.6)	
Family history of CHD				0.506
No	9131 (90.9)	7191 (78.8)	1940 (21.2)	
Yes	912 (9.1)	709 (77.7)	203 (22.3)	
Family history of CVD				1.837
No	9287 (92.5)	7320 (78.8)	1967 (21.2)	
Yes	756 (7.5)	580 (76.7)	176 (23.3)	
Family history of DM				1.279
No	8603 (85.7)	6751 (78.5)	1852 (21.5)	
Yes	1440 (14.3)	1149 (79.8)	291 (20.2)	
Family history of cancer				6.829**
No	9333 (92.9)	7314 (78.4)	2019 (21.6)	
Yes	710 (7.1)	586 (82.5)	124 (17.5)	

Figures in parentheses indicate percentage.
*P<0.05, **P<0.01, ***P<0.001.
*P<0.05, **P<0.01, ***P<0.001.
BMI, body mass index; CHD, coronary heart disease; CVD, cerebrovascular disease; DM, diabetes mellitus.

Table 2 Comparison of individual behavioural and clinical factors in study participants with and without hypertension

Characteristics	All (N=10043)	Hypertension		χ²
		No (n=7900)	Yes (n=2143)	
Smoking status				84.090***
Current	1764 (17.6)	1341 (76.0)	423 (24.0)	
Former	504 (5.0)	322 (63.9)	182 (36.1)	
Never	7775 (77.4)	6237 (80.2)	1538 (19.8)	
Alcohol use				41.215***
No	8759 (87.2)	6978 (79.7)	1781 (20.3)	
Yes	1284 (12.8)	922 (71.8)	362 (28.2)	
Fruits and vegetables, servings/day				0.829
<5	4777 (47.6)	3739 (78.3)	1038 (21.7)	
≥5	5266 (52.4)	4161 (52.7)	1105 (21.0)	
Soft drinks intake, times/week				17.841***
≥6	311 (3.1)	255 (82.0)	56 (18.0)	
3–5	371 (3.7)	322 (86.8)	49 (13.2)	
≤2	9325 (93.2)	7292 (78.2)	2033 (21.8)	
Salt intake, g/day				1.159
<5	7100 (73.1)	5600 (78.9)	1500 (21.1)	
≥5	2611 (26.9)	2033 (77.9)	578 (22.1)	
Oil consumption, g/day				2.417
<25	4088 (42.0)	3236 (79.2)	852 (20.8)	
25–35	3205 (32.9)	2527 (78.8)	678 (21.2)	
>35	2438 (25.1)	1891 (77.6)	547 (22.4)	
Sufficient PA				0.089
No	1605 (16.0)	1267 (78.9)	338 (21.1)	
Yes	8438 (84.0)	6633 (78.6)	1805 (21.4)	
Cancer				4.876*
No	9828 (97.9)	7744 (78.8)	2084 (21.2)	
Yes	215 (2.1)	156 (72.6)	59 (27.4)	
COPD				15.852***
No	9856 (98.1)	7775 (78.9)	2081 (21.1)	
Yes	187 (1.9)	125 (66.8)	62 (33.2)	
DM				337.552***
No	9291 (92.5)	7507 (80.8)	1784 (19.2)	
Yes	752 (7.5)	393 (52.3)	359 (47.7)	
Dyslipidaemia				260.155***
No	5980 (59.5)	5029 (84.1)	951 (15.9)	
Yes	4063 (40.5)	2871 (70.7)	1192 (29.3)	
High uric acid				94.105***
No	8890 (88.5)	7120 (80.1)	1770 (19.9)	
Yes	1153 (11.5)	780 (67.6)	373 (32.4)	

The value for some variables is not equal to the total due to missing data.
Figures in parentheses indicate percentage.
*P<0.05, **P<0.01, ***P<0.001.
COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; PA, physical activity.

Table 3 Multivariable logistic regression to estimate potential risk factors for hypertension

Variables	β	SE	Wald	OR	95% CI	P value
Sex						
Male	0.619	0.073	72.253	1.858	1.611 to 2.143	<0.001
Female				1 (ref)		
Age, years						
18–24				1 (ref)		
25–34	0.787	0.376	4.379	2.197	1.051 to 4.591	0.036
35–44	1.394	0.371	14.144	4.030	1.949 to 8.334	<0.001
45–54	2.177	0.371	34.422	8.820	4.262 to 18.251	<0.001
55–64	2.844	0.373	58.177	17.179	8.273 to 35.674	<0.001
≥65	3.432	0.377	82.969	30.933	14.782 to 64.733	<0.001
Educational level						
Primary school or below	0.571	0.096	35.315	1.769	1.466 to 2.136	<0.001
Middle school	0.434	0.081	28.916	1.543	1.317 to 1.807	<0.001
High school	0.181	0.080	5.064	1.198	1.024 to 1.403	0.024
College or above				1 (ref)		
BMI, kg/m^2						
Normal				1 (ref)		
Underweight	−0.358	0.206	3.011	0.699	0.467 to 1.047	0.083
Overweight	0.783	0.062	160.505	2.189	1.939 to 2.471	<0.001
Obesity	1.305	0.088	220.019	3.687	3.103 to 4.381	<0.001
Family history of hypertension						
No				1 (ref)		
Yes	0.690	0.057	144.335	1.994	1.782 to 2.232	<0.001
Smoking status						
Current	0.224	0.124	3.242	1.251	0.980 to 1.597	0.072
Former	0.269	0.085	10.110	1.308	1.109 to 1.544	0.001
Never				1 (ref)		
Alcohol use						
No				1 (ref)		
Yes	0.305	0.082	13.846	1.357	1.155 to 1.593	<0.001
DM						
No				1 (ref)		
Yes	0.603	0.088	46.495	1.828	1.537 to 2.174	<0.001
Dyslipidaemia						
No				1 (ref)		
Yes	0.284	0.058	23.820	1.329	1.186 to 1.490	<0.001
High uric acid						
No				1 (ref)		
Yes	0.312	0.081	14.642	1.366	1.164 to 1.602	<0.001

BMI, body mass index; DM, diabetes mellitus; ref, reference.

DISCUSSION

This survey from a large representative sample provides new information on the status of prevalence, awareness, treatment, control and risk factors associated with HTN among the urban adult population in Shenzhen. Overall, the prevalence of HTN in Shenzhen was lower than the national level and urban residents in the top developed provinces in China, but higher than in Hunan, Hainan and Guangxi.[10] With the rapid economic growth over the past decades, ageing, urbanisation and associated

Table 4 Awareness, treatment and control among adults with hypertension in Shenzhen

Variables	Aware	Treatment Among all with hypertension	Among those aware	Control Among all with hypertension	Among those treated
All	55.0 (52.9 to 57.1)	44.9 (42.8 to 47.1)	81.7 (79.3 to 83.8)	21.7 (20.0 to 23.5)	48.3 (45.2 to 51.5)
Sex					
Male	51.8 (48.9 to 54.7)	40.9 (38.1 to 43.8)	79.0 (75.5 to 82.2)	20.4 (18.1 to 22.8)	49.8 (45.2 to 54.4)
Female	58.8 (55.6 to 61.9)	49.6 (46.5 to 52.8)	84.5 (81.2 to 87.3)	23.2 (20.7 to 26.0)	46.8 (42.4 to 51.4)
χ^2	10.443**	16.327***	5.861*	2.578	0.844
Age, years					
18–24	12.5 (0.7 to 53.3)	0 (0 to 40.2)	0 (0 to 94.5)	0 (0 to 40.2)	0 (0 to 94.5)
25–34	26.1 (19.6 to 33.7)	8.7 (5.0 to 14.4)	33.3 (20.0 to 49.6)	2.5 (0.8 to 6.6)	28.6 (9.6 to 58.0)
35–44	45.7 (41.1 to 50.3)	28.5 (24.4 to 32.9)	62.4 (55.4 to 68.9)	12.4 (9.6 to 15.8)	43.5 (35.0 to 52.4)
45–54	54.8 (50.6 to 58.9)	46.0 (41.8 to 50.2)	83.9 (79.3 to 87.7)	22.2 (18.9 to 25.9)	48.3 (42.1 to 54.5)
55–64	65.6 (61.5 to 69.6)	59.2 (55.0 to 63.4)	90.3 (86.6 to 93.0)	30.0 (26.2 to 34.0)	50.6 (45.1 to 56.2)
≥65	64.2 (59.2 to 68.8)	58.4 (53.4 to 63.3)	91.0 (86.7 to 94.1)	28.6 (24.2 to 33.3)	48.9 (42.4 to 55.5)
χ^2	114.985***	216.972***	155.909***	93.914***	4.119
Educational level					
Primary school or below	60.2 (55.8 to 64.4)	52.0 (47.5 to 56.3)	86.4 (81.9 to 89.9)	20.7 (17.3 to 24.5)	39.8 (34.0 to 46.0)
Middle school	50.6 (46.7 to 54.5)	42.0 (38.1 to 45.9)	82.9 (78.3 to 86.7)	20.1 (17.1 to 23.5)	48.0 (41.9 to 54.1)
High school	56.2 (52.0 to 60.3)	43.4 (39.3 to 47.6)	77.3 (72.2 to 81.7)	22.2 (18.9 to 25.9)	51.2 (44.8 to 57.6)
College or above	53.9 (48.9 to 58.7)	43.0 (38.2 to 47.9)	79.8 (73.8 to 84.8)	24.6 (20.6 to 29.1)	57.3 (49.7 to 64.6)
χ^2	11.067*	13.668**	9.536*	3.445	14.238**

Data are presented as percentages and figures in parentheses indicate 95% CI.
*P<0.05, **P<0.01, ***P<0.001.

unhealthy lifestyle and diet may explain the dramatic increase in the prevalence of HTN.[12 24 25] Also, residents in developed areas tend to suffer from higher psychosocial stress, coupled with individual unhealthy lifestyle, contributing to the development of HTN.[26 27] This is especially the case in Shenzhen, which has turned from a small fishing village to a prosperous modern metropolis in the last four decades.

In line with other research,[10 12 28 29] our study revealed that there was a significant between-gender difference and male residents were at higher risk of HTN than female residents. Several possibilities might contribute to this gender disparity. First, individual unhealthy behaviours such as tobacco smoking, physical inactivity and alcohol consumption are associated with HTN, which could be found more frequently in men than in women.[6 30 31] This is supported partly by the present study—tobacco smoking and alcohol intake could increase the risk of HTN. Second, an increase in body weight has been identified as another contributing factor for elevated BP and previous study indicated that the prevalence of obesity and overweight among men was higher than among women.[6 16 31 32] In this study, overweight and obesity increased the odds of HTN, which was aligned with other studies.[10 12 16] Third, people in developed areas often live

a stressful life and men were more likely to be exposed to higher relationship and occupational stress than their counterparts, resulting in the rapid increase in the prevalence of HTN.[27 33] Collectively, there is an urgent call for effective sex-specific interventions to address this discrepancy, and long-established lifestyle modification programmes are highly required to help residents adopt healthy behaviours to prevent the development of HTN and its complications.

Consistent with previous findings,[10 12] this study found that age was positively associated with HTN and the likelihood increased dramatically with age. More importantly, however, the younger population experienced a more rapid growth in the prevalence of HTN in comparison with the elderly.[10 11] This means that more attention should be paid to changes in the prevalence of HTN in Shenzhen because the age structure of its residents is quite young. Aligned with other results,[34 35] our study also revealed that lower educational level could increase the odds of developing HTN. In addition, family history of HTN is a significant independent risk factor for HTN.[12] This could be observed in the present study. Therefore, it is of great significance for these key populations to seek early BP monitoring because HTN is a silent killer without symptoms mostly during the early stages.

Excess weight has been accepted as a primary determinant of HTN.[6 16 32] Earlier research indicated that it is possible that obesity is correlated independently with HTN but may be mediated by physical inactivity and unhealthy diet.[36] However, unlike other results,[6 14 15] we did not find an association between HTN and intake of fruits and vegetables, salt intake and insufficient PA in the present study. Such an association needs to be studied further. Moreover, other metabolic risk factors including DM and dyslipidaemia were also associated with HTN,[6] which was confirmed in this study. These findings reflect the complexity of the risk factors linked with HTN, and bespoke intervention strategies for specific population subgroups will be better choices to effectively control HTN and its consequences.

High or elevated BP, as a large global health burden, is closely and strongly related with cardiovascular disease and kidney disease.[28] HTN is a silent and invisible killer that rarely shows symptoms, so increasing public awareness about knowing their BP level is key, as is access to early detection.[6] However, awareness, treatment and control of HTN are unacceptably low across the world, particularly in LMICs.[16 28] In this study, we found that awareness, treatment and control rates among individuals with HTN exceeded the national levels[10 11] and were higher than other regional results in China.[12 29] This may be partially attributed to the healthcare reform and comprehensive strategies at the community level initiated by the Shenzhen government in the past decade, resulting in significant improvement in healthcare access and affordability. Moreover, we found that the rate of treatment and control was markedly higher among those who knew their condition. This might suggest that higher level of awareness and knowledge of HTN is of great help to improve patient adherence to antihypertensive medications, acting as a significant facilitator of HTN control. Ultimately, large-scale, community-based BP screening and education programmes could be a cost-effective approach to improve individual awareness, with parallel efforts to deliver multifaceted interventions to enforce patient compliance with medications and physician compliance with recommended clinical guidelines, translating into better HTN treatment and control. Nonetheless, it is worthwhile noting that the awareness, treatment and control rates in this study remain lower than in HICs,[4 28] where strong and effective public health policies and interventions have begun to launch to address HTN and its complications and to modify other risk determinants.[28] This highlights the need to deepen the primary healthcare reform, and innovative integrated strategies for HTN prevention and control are urgently required to illuminate impediments at the patient, provider, system and community levels. Also, consistent with other findings,[10–12] significant differences in the awareness, treatment and control rates among participants of different sexes, ages and educational levels were observed in our study. It is thus essential to quickly identify effective ways to address these gaps in an affordable and sustainable manner, and the enormous benefits of BP control to public health make a compelling case for action.[37]

This study provides up-to-date information on the epidemiology of HTN in an immigrant and 'young people' city. However, several potential limitations need to be considered. First, except for blood and urine chemistry, anthropometric and BP measurements, other information was self-reported, resulting in recall bias and reporting bias. It is possible that participants might over-report or under-report their individual lifestyles, especially for socially desirable behaviours such as PA involvement and fruit and vegetable intake, which may limit us from further exploring their association with HTN. Second, the nature of cross-sectional design prevents us from making causal and temporal inferences between potential risk factors and HTN. Third, earlier literature indicated that combined therapy might be more effective than monotherapy to achieve optimal BP control,[11] but we were unable to compare them due to the absence of medication data. Fourth, this study was conducted only in Shenzhen, which may influence the study's representativeness and generalisability due to regional variations. Future study should take these limitations into consideration.

CONCLUSIONS

With a crude and weighted prevalence of 21.3% and 19.2%, respectively, and with low awareness, treatment and control rates, HTN is a major public health problem among adult residents in Shenzhen. Several risk factors for HTN were identified, including male, older age, lower educational level, overweight and obesity, family history of HTN, tobacco smoking, alcohol intake, DM, dyslipidaemia and high uric acid. These findings provide insights into the importance of HTN prevention and control, and effective multifaceted implementation strategies need to be developed to prevent individuals from developing HTN and reduce the burden of this condition.

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