*The Journal of Clinical Hypertension*

WILEY

ORIGINAL ARTICLE OPEN ACCESS

# Diabetes Mellitus and Hyperlipidemia Status Among Hypertensive Patients in the Community and Influencing Factors Analysis of Blood Pressure Control

Shijia Zhang[1,2] | Yunou Yang[1] | Xiongfei Chen[1] | Liumei Fan[3] | Jiagang Wu[1] | Xiangyi Liu[1] | Weiquan Lin[1] | Zhiyu Zhai[2] | Guozhen Lin[1] | Hui Liu[1] | Qin Zhou[1,2]

[1]Department of Chronic Diseases Control and Prevention, Guangzhou Center for Disease Control and Prevention, Guangzhou, China | [2]Department of Public Health and Preventive Medicine, School of Medicine, Jinan University, Guangzhou, China | [3]Department of Chronic Diseases Control and Prevention, Guangzhou Baiyun District Center for Disease Control and Prevention, Guangzhou, China

**Correspondence:** Hui Liu (gzcdc_liuh@gz.gov.cn) | Qin Zhou (273142563@qq.com) | Liumei Fan (659626123@qq.com)

**Received:** 23 September 2024 | **Revised:** 3 December 2024 | **Accepted:** 10 December 2024

**Funding:** This research was funded by the Key Project of Medicine Discipline of Guangzhou (No. 2021–2023-12) and the Basic Research Project of Key Laboratory of Guangzhou (No. 2021BRP004).

**Keywords:** blood pressure control | diabetes | hyperlipidemia | hypertension

## Abstract

To evaluate the prevalence of type 2 diabetes mellitus (T2DM) and hyperlipidemia in hypertensive patients in South China and assess the relationship between these comorbidities and blood pressure control to develop targeted strategies for hypertension management. Data from the 2020 Guangzhou National Basic Public Health Service Program were analyzed using Chi-square tests, *t*-tests, and logistic regression with R 4.1.2. Among 275,789 hypertensive patients, the blood pressure control rate was 51.51%. The prevalence of T2DM and hyperlipidemia comorbidities was 12.79%, with 12.78% for T2DM alone, 33.54% for hyperlipidemia alone, and 40.89% with no comorbidities. Blood pressure control rates significantly differed by comorbidity ($p < 0.05$): 52.84% for those without T2DM/hyperlipidemia, 54.18%, 49.25% for T2DM or hyperlipidemia alone, and 50.52% for both conditions. Multivariate analysis indicated a lower blood pressure control rate in patients with hyperlipidemia alone (OR = 1.144) or both T2DM and hyperlipidemia (OR = 1.082), and a higher rate in those with T2DM alone (OR = 0.936). Subgroup analysis revealed that males, older age, higher education, obesity, alcohol use, lack of physical activity, and poor medication adherence were associated with lower control rates. This study found a high prevalence of diabetes and hyperlipidemia among hypertensive patients in Guangzhou. Additionally, hypertensive patients with hyperlipidemia had poorer blood pressure control compared to other diabetic patients. Key factors such as obesity, being overweight, and unhealthy lifestyle choices significantly impact blood pressure management in this population. Therefore, comprehensive measures should be implemented to integrate lipid management into community health efforts and to effectively control blood pressure levels among hypertensive patients.

**Abbreviations:** BMI, body mass index; CVD, cardiovascular disease; DBP, diastolic blood pressure; HDL, high-density lipoprotein; HTN, hypertension; LDL, low-density lipoprotein; T2DM, type 2 diabetes.

## 1 | Introduction

Hypertension (HTN) is the most common condition in primary care and can lead to myocardial infarction, stroke, renal failure, and death if not detected early and treated appropriately. The importance of HTN as a major risk factor for cardiovascular disease (CVD) cannot be ignored. According to Agata Buonacera et al., they found a correlation between blood pressure management and the risk of stroke, ischemic heart disease, and heart failure in hypertensive patients [1]. Furthermore, it has been noted that even within the normal interval of the blood pressure range, such as a systolic blood pressure (SBP) of 115 mm Hg or a diastolic blood pressure (DBP) of 75 mm Hg, is still strongly associated with the occurrence of cardiovascular events [2]. With the development of the social economy and the acceleration of population aging and urbanization, the prevalence of HTN in China has been on the rise, especially in rural areas [3]. At present, there are 245 million hypertensive patients in China, and the number of people with blood pressure in the high-normal range (120–139/80–89 mm Hg) is also increasing, which brings an increasing economic burden to the residents and society, and the prevention and control of HTN in China has become a major public health problem [4, 5].

Studies have shown that clinical symptoms in patients with type 2 diabetes, CVD, and hyperlipidemia are often similar to the diagnosis of HTN. Metabolic syndrome is a cluster of conditions that often coexist and include HTN, hyperglycemia, dyslipidemia, and abdominal obesity. These components are not only related symptomatically but also share underlying pathophysiological mechanisms [6–8]. For instance, insulin resistance is a common denominator in many cases. In patients with HTN and type 2 diabetes, insulin resistance can lead to impaired glucose metabolism and increased blood pressure [9]. Additionally, the dysregulation of lipid metabolism seen in hyperlipidemia often coexists with HTN and diabetes, further exacerbating the risk of CVD [10]. Obesity, in particular abdominal obesity, is strongly associated with the development of HTN, diabetes, and dyslipidemia [11]. The excess adipose tissue releases pro-inflammatory cytokines and adipokines that can disrupt normal metabolic processes and contribute to the development of these comorbidities.

There is research evidence that the primary goal of treatment for patients with HTN is to control blood pressure at a relatively good level through active exercise and a healthy diet [12]. However, the factors affecting blood pressure control are multifaceted and complex. For example, obese hypertensive patients have lower rates of blood pressure control compared to patients with normal body mass index (BMI) [13], and HTN control is significantly lower in young and elderly people than in middle-aged people [14]. In the presence of poorly controlled blood pressure, patients are at increased risk of CVD, which can also directly induce encephalopathy, renal insufficiency, and acute heart failure, while its promotion of accelerated atherosclerosis is even more complex, involving lipid atherosclerosis, thrombosis, insulin resistance, and endothelial dysfunction, all of which are affected by blood pressure and its concomitant well-established mechanisms [15].

Guangzhou, a developed city in China, has a prosperous economy and sufficient medical resources. However, it faces an increasing prevalence of chronic non-communicable diseases and an aging population. This study aims to investigate the prevalence and impact of diabetes and hyperlipidemia complications on blood pressure control among hypertensive patients in Guangzhou. It focuses on identifying factors affecting blood pressure control, such as lifestyle, genetics, and treatment compliance, to provide evidence for targeted HTN prevention measures. The conclusions will guide clinical practice, helping clinicians understand risk factors and adopt personalized treatment plans to improve blood pressure control and reduce complications.

## 2 | Research Design and Methods

### 2.1 | Data Sources and Study Population

This study was conducted on hypertensive patients who were included in the management of the National Basic Public Health Service Program in Guangzhou City in 2020. According to the inclusion criteria, the included study subjects must have complete demographic and physical examination data, patients with missing demographic statistics, and those who did not participate in the comprehensive health examination in that year were excluded. The study's data were obtained from the Resident Health Record Information System [16]. This system automatically records residents' health information and healthcare service utilization as they visit healthcare facilities and undergo medical check-ups. The data are collected, stored, and maintained in accordance with national standards, ensuring the quality and security of the information. The system provided access to relevant health records of the population, including detailed information on patients' demographic characteristics and laboratory test results. A total of 275,789 hypertensive patients with complete physical examination data were included in this study.

### 2.2 | Research Method

Gender, age, education, smoking status, alcohol consumption, physical activity, history of diabetes, history of hyperlipidemia, history of HTN, and medical compliance were collected from the study participants through health records, questionnaires, health checkups, as well as laboratory tests: fasting blood glucose, SBP, DBP, total cholesterol, triglycerides, low-density lipoprotein (LDL), and high-density lipoprotein (HDL).

### 2.3 | Measurements and Definitions

(1) Smoking: people who were still smoking (not quit) at the time of the survey, regardless of whether they smoked daily or not [17]; (2) Alcohol consumption: defined as having consumed alcohol in the past 12 months [18]; (3) Physical activity: appropriate physical activity was defined as 150–300 min/week of moderate-intensity physical activity, or 75–150 min/week of vigorous-intensity physical activity, or an equivalent combination of moderate- and vigorous-intensity equivalent combination of aerobic physical activity. Physical inactivity was defined as being physically active but not meeting the criteria for appropriate exercise. Physical inactivity is defined as not being physically active [19]; (4) HTN is diagnosed by a hospital at or above the township (community) level [20]; (5) Type 2 diabetes mellitus (T2DM) is identified by

**TABLE 1** | Basic information on type 2 diabetes mellitus and dyslipidemia in hypertensive patients in Guangzhou [n (%)].

| | Male ($n$ = 110 376) | | Female ($n$ = 165 413) | | Total ($n$ = 275 789) | |
|---|---|---|---|---|---|---|
| **Variable category** | **Number of people** | **Composition ratio %** | **Number of people** | **Composition ratio %** | **Number of people** | **Composition ratio %** |
| No diabetes or hyperlipidemia | 46 571 | 42.19 | 66 200 | 40.02 | 112 771 | 40.89 |
| Combined diabetes alone | 13 913 | 12.61 | 21 339 | 12.90 | 35 252 | 12.78 |
| Combined hyperlipidemia alone | 36 037 | 32.65 | 56 459 | 34.13 | 92 496 | 33.54 |
| Combined diabetes, hyperlipidemia | 13 855 | 12.55 | 21 415 | 12.95 | 35 270 | 12.79 |
| $t/X^2$ | 419.54 | | | | | |
| $p$ | <0.001 | | | | | |

medical facilities at the township (community) level or higher; (6) Dyslipidemia was defined as a change in at least one of the four parameters above triglycerides ≥2.26 mmol/L, total cholesterol ≥6.22 mmol/L, high-density lipoprotein cholesterol <1.04 mmol/L, and low-density lipoprotein cholesterol ≥4.14 mmol/L on the first physical examination [21]; (7) BMI = Weight/height$^2$ (kg/m$^2$), and according to the recommendations of the "Guidelines for the Prevention and Control of Overweight and Obesity in Adults in China", BMI < 18.5 kg/m$^2$ is considered low body weight, 18.5 kg/m$^2$ ≤ BMI ≤ 23.9 kg/m$^2$ is considered normal weight, 24.0 kg/m$^2$ ≤ BMI ≤ 27.9 kg/m$^2$ is considered overweight, and BMI ≥ 28 kg/m$^2$ is considered obese [22]; (8) Blood pressure control rate: the percentage of hypertensive patients found in this survey whose blood pressure is currently controlled below 140/90 mm Hg. For hypertensive patients with comorbid diabetes, the standard for blood pressure control is set at a percentage of those whose blood pressure is currently controlled below 130/80 mm Hg [23]; (9) Medication adherence: In the annual physical examination of the National Basic Public Health Service Project, we conduct a questionnaire survey on the medication frequency of patients. We evaluate medication adherence through the patients' medication frequency. Taking medications in accordance with the prescriptions of clinicians is defined as regular medication-taking. Taking medications less frequently than the prescribed frequency is defined as occasional medication-taking. Taking zero doses of medications is defined as non-medication-taking.

### 2.4 | Statistical Analysis

Statistical analysis of the data was performed using R4.1.2 software. Count data were expressed as rates and/or composition ratios with Chi-square tests for comparison between groups, while measurement data were expressed as mean ± standard deviation with $t$-tests for comparison between groups. Multifactor unconditional logistic regression analysis was used to analyze the factors affecting the rate of blood pressure control, followed by subgroup analysis for the presence of diabetes mellitus as well as hyperlipidemia, and the included variables with corresponding assignments are shown in Table S1. Differences were considered statistically significant at $p < 0.05$.

## 3 | Results

### 3.1 | Baseline Information for People With HTN

The age of the 275,789 hypertensive patients in this study was (72.2 ± 9.6) years, including (72.0 ± 9.8) years for males and (72.3 ± 9.4) years for females, and the BMI of the investigated population was (24.8 ± 3.5) kg/m$^2$, and the duration of HTN was (11.3 ± 8.0) years. The study population was predominantly married and of middle school or lower education. In this study, there were 142,061 (51.51%) in the group with standardized blood pressure control and 133,728 (48.49%) in the group with substandard blood pressure control. The difference between those who had achieved the standard of HTN control and those who had not achieved the standard was statistically significant ($p < 0.05$) in terms of age, gender, educational level, marital status, dietary habits, and poor lifestyle.

### 3.2 | Comorbidity of Diabetes Mellitus and Hyperlipidemia in Hypertensive Patients

In this study, 12.78% of hypertensive patients exhibited diabetes mellitus, while 33.54% manifested hyperlipidemia alone. Additionally, 12.79% of participants presented with both diabetes mellitus and hyperlipidemia, in contrast to 40.89% of patients without either condition (Table 1).

### 3.3 | Blood Pressure Control in Hypertensive Patients Combined With Diabetes Mellitus and Hyperlipidemia

The difference in the history of comorbid diabetes and hyperlipidemic complications between the different blood pressure control groups was statistically significant ($p < 0.05$). In this study, hypertensive patients without comorbidities exhibited a blood pressure control rate of 52.84%. In comparison, hypertensive patients with either diabetes or hyperlipidemia alone had control rates of 54.18% and 49.25%, respectively. Hypertensive patients with both diabetes mellitus and hyperlipidemia showed a blood pressure control rate of 50.52% (Table 2).

**TABLE 2** | Univariate analysis of blood pressure control in hypertensive patients in Guangzhou.

| Variable category | Satisfactory control | Unsatisfactory control | $t/X^2$ | $p$ |
|---|---|---|---|---|
| All | 142 061(51.51%) | 133 728(48.49%) | | |
| Age (SD) (year) | 71.75(9.8) | 72.66(9.3) | −24.918 | <0.001 |
| BMI(SD) (kg/m$^2$) | 24.63(3.5) | 24.93(3.5) | −22.792 | <0.001 |
| Years since diagnosis of hypertension, year | | | −7.4312 | <0.001 |
| <5 | 13 120(48.86%) | 13 730(51.14%) | | |
| >=5 | 128 941(51.80%) | 119 998(48.20%) | | |
| Sex | | | 5.3342 | 0.02091 |
| Male | 56 053(50.78%) | 54 323(49.22%) | | |
| Female | 84 908(51.33%) | 80 505(48.67%) | | |
| Education level | | | 1316.4 | <0.001 |
| Lower secondary and below | 66 196(52.10%) | 60 852(47.90%) | | |
| High school/Secondary | 30 921(57.14%) | 23 190(42.86%) | | |
| College and above | 44 944(47.49%) | 49 686(52.51%) | | |
| Marital status | | | 90.271 | <0.001 |
| Unmarried | 1003(52.98%) | 890(47.02%) | | |
| Married | 127 011(51.58%) | 119 228(48.42%) | | |
| Widowed | 1053(61.40%) | 662(38.60%) | | |
| Divorced | 12 994(50.09%) | 12 948(49.91%) | | |
| Smoking | | | 1168.4 | <0.001 |
| Yes | 32 373(57.97%) | 23 474(42.03%) | | |
| No | 109 688(49.87%) | 110 254(50.13%) | | |
| Drinking alcohol | | | 156.79 | <0.001 |
| Yes | 5654(45.99%) | 6640(54.01%) | | |
| No | 136 407(51.77%) | 127 088(48.23%) | | |
| Physical activity | | | 187.48 | <0.001 |
| No exercise | 39 831(49.61%) | 40 453(50.39%) | | |
| Less exercise | 24 798(53.28%) | 21 742(46.72%) | | |
| Frequent exercise | 77 432(51.98%) | 71 533(48.02%) | | |
| Family history of hypertension | | | 18.683 | <0.001 |
| Yes | 21 456(52.50%) | 19 414(47.50%) | | |
| No | 120 605(51.34%) | 114 314(48.66%) | | |
| Disease comorbidity status | | | 384.78 | <0.001 |
| No diabetes or hyperlipidemia | 59 593(52.84%) | 53 178(47.16%) | | |
| Combined diabetes alone | 19 100(54.18%) | 16 152(45.82%) | | |
| Combined hyperlipidemia alone | 45 551(49.25%) | 46 945(50.75%) | | |
| Combined diabetes, hyperlipidemia | 17 817(50.52%) | 17 453(49.48%) | | |
| Medication compliance | | | 574.51 | <0.001 |
| Good | 138 613(51.93%) | 128 331(48.07%) | | |
| Fair | 1587(39.28%) | 2453(60.72%) | | |
| Poor | 1861(38.73%) | 2944(61.27%) | | |

**TABLE 3** | A multifactorial analysis of blood pressure control in patients with hypertension combined with triple high co-morbidities in Guangzhou.

| | OR | OR 95% CI | *p* value |
|---|---|---|---|
| Model 1 | | | |
| No diabetes or hyperlipidemia | Reference | | |
| Combined diabetes alone | 0.948 | (0.925, 0.971) | <0.001 |
| Combined hyperlipidemia alone | 1.155 | (1.135, 1.175) | <0.001 |
| Combined diabetes, hyperlipidemia | 1.098 | (1.072, 1.124) | <0.001 |
| Model 2 | | | |
| No diabetes or hyperlipidemia | Reference | | |
| Combined diabetes alone | 0.942 | (0.920, 0.965) | <0.001 |
| Combined hyperlipidemia alone | 1.161 | (1.141, 1.181) | <0.001 |
| Combined diabetes, hyperlipidemia | 1.095 | (1.069, 1.121) | <0.001 |
| Model3 | | | |
| No diabetes or hyperlipidemia | Reference | | |
| Combined diabetes alone | 0.936 | (0.914, 0.959) | <0.001 |
| Combined hyperlipidemia alone | 1.144 | (1.124, 1.164) | <0.001 |
| Combined diabetes, hyperlipidemia | 1.082 | (1.056, 1.109) | <0.001 |

*Notes:* Model 1: Unadjusted. Model 2: Adjusted for age, gender, Education level, Marital status. Model 3: Adjusted for Model 2+ years of diagnosis of hypertension, BMI, physical activity, smoking status, alcohol consumption, family history of hypertension, medication compliance.
Abbreviations: CI, confidence intervals; OR, odds ratio.

By adjusting for age, gender, literacy level, marital status, years of HTN diagnosis, BMI, physical activity, smoking status, alcohol consumption, family history of HTN, and medication adherence, we found that hypertensive patients with T2DM had better blood pressure control compared to hypertensive patients without complications (OR = 0.936, 95% CI = 0.914–0.959, and $p < 0.001$). Conversely, hypertensive patients with hyperlipidemia alone (OR = 1.144, 95% CI = 1.124–1.164, $p < 0.001$), as well as those with a combination of diabetes mellitus and hyperlipidemia (OR = 1.082, 95% CI = 1.056–1.109, $p < 0.001$), demonstrated poor blood pressure control (Table 3).

### 3.4 | Factors Influencing Blood Pressure Control in Patients With HTN

The multivariate unconditional logistic regression analysis was performed with the attainment of blood pressure control status of hypertensive patients as the dependent variable and 11 factors as independent variables. The results showed that those with female gender (OR = 0.950, 95% CI = 0.934–0.966, $p < 0.001$), those with high school/secondary education (OR = 0.831, 95% CI = 0.814–0.849, $p < 0.001$), those with lower BMI (OR = 0.874, 95% CI = 0.833–0.917, $p < 0.001$), smokers (OR = 0.708, 95% CI = 0.694–0.722, $p < 0.001$), those who exercised appropriately (OR = 0.973, 95% CI = 0.953–0.994, $p < 0.05$), and those who had been diagnosed with HTN for ≥5 years (OR = 0.859, 95% CI = 0.837–0.881, $p < 0.001$) had higher rates of blood pressure control. College/university education (OR = 1.163, 95% CI = 1.143–1.183, $p < 0.001$), overweight and obesity (OR = 1.132, 95% CI = 1.113–1.151, $p < 0.001$) and (OR = 1.273, 95% CI = 1.245–1.301, $p < 0.001$), alcohol consumption (OR = 1.378, 95% CI = 1.326–1.431, $p < 0.001$), average adherence to medication (OR = 1.629, 95% CI = 1.528–1.738, $p < 0.001$), and no medication (OR = 1.632, 95% CI = 1.539–1.732, $p < 0.001$), had lower rates of blood pressure control in patients with HTN (Table 4).

### 3.5 | Subgroup Analysis

This study also analyzed subgroups of people with and without complications of type 2 diabetes and hyperlipidemia. The results showed that age ≥60, education level of university/college, overweight, obesity, alcohol consumption, poor adherence to medication, and non-adherence to medication were risk factors for blood pressure control in all hypertensive patients, regardless of the presence or absence of diabetes and hyperlipidemia complications (Figures 1–4, Tables S2 and S3).

## 4 | Discussion

This study assessed the blood pressure control rate of hypertensive patients with combined T2DM and hyperlipidemia in Guangzhou City in 2020 and the factors affecting the blood pressure control rate. The results showed that the overall blood pressure control of hypertensive patients in Guangzhou in 2020 was 51.51%, whereas previous surveys have shown that the blood pressure control rate of the Chinese hypertensive population ranges from 29.6% to 67.8% [24–27]. This suggests that the overall

**TABLE 4** | Multivariate unconditional logistic regression analysis of factors influencing blood pressure control in hypertensive patients in Guangzhou.

| Variable category | | References | $\beta$ | Wald value | $p$ value | OR | OR 95% CI |
|---|---|---|---|---|---|---|---|
| Gender | Female | Male | −0.052 | 36.902 | <0.001 | 0.950 | (0.934, 0.966) |
| Age | >=60 | <60 | 0.312 | 557.265 | <0.001 | 1.366 | (1.331, 1.402) |
| Education level | High school/Secondary | Lower secondary and below | −0.185 | 304.829 | <0.001 | 0.831 | (0.814, 0.849) |
| | College and above | | 0.151 | 298.204 | <0.001 | 1.163 | (1.143, 1.183) |
| Marital status | Unmarried | Married | 0.025 | 0.283 | 0.5945 | 1.025 | (0.936, 1.123) |
| | Divorced | | −0.306 | 20.148 | <0.001 | 0.736 | (0.644, 0.841) |
| | Widowed | | 0.071 | 2.142 | 0.1433 | 1.073 | (0.976, 1.180) |
| BMI (kg/m$^2$) | <18.5 | 18.5-24 | −0.134 | 30.178 | <0.001 | 0.874 | (0.833, 0.917) |
| | 24-28 | | 0.124 | 209.244 | <0.001 | 1.132 | (1.113, 1.151) |
| | >28 | | 0.241 | 456.593 | <0.001 | 1.273 | (1.245, 1.301) |
| Smoking | Yes | No | −0.346 | 1153.188 | <0.001 | 0.708 | (0.694, 0.722) |
| Drinking alcohol | Yes | No | 0.320 | 271.748 | <0.001 | 1.378 | (1.326, 1.431) |
| Physical activity | Proper exercise | Adequate | −0.027 | 6.444 | 0.0111 | 0.973 | (0.953, 0.994) |
| | No exercise | | 0.075 | 71.893 | <0.001 | 1.078 | (1.060, 1.097) |
| Family history of hypertension | Yes | No | −0.030 | 7.408 | 0.0065 | 0.971 | (0.950, 0.992) |
| Years since diagnosis of hypertension (years) | >=5 | <5 | −0.152 | 134.904 | <0.001 | 0.859 | (0.837, 0.881) |
| Medical compliance | Fair | Good | 0.488 | 222.798 | <0.001 | 1.629 | (1.528, 1.738) |
| | Poor | | 0.490 | 262.965 | <0.001 | 1.632 | (1.539, 1.732) |

blood pressure control of hypertensive patients in Guangzhou is more general. We need to start from the weak points of HTN management in the community to improve the blood pressure control rate of hypertensive patients.

Findings have shown that hypertensive patients with comorbid hyperlipidemia have lower rates of BP control compared to hypertensive patients without any comorbidities (49.25% vs. 52.84%), while some population-based epidemiologic studies have also reported that progressively higher blood pressure is associated with elevated lipid levels [28]. One possible explanation for these relationships is that HTN and dyslipidemia share common pathophysiologic etiologies, such as obesity and the resulting dysregulation of adipocytokine release from adipose tissue [29]. In addition, dyslipidemia adversely affects the functional and structural properties of arteries and promotes atherosclerosis [30]. These changes may impair blood pressure regulation, which in turn may make the blood pressure situation more difficult to control in patients with HTN combined with dyslipidemia, requiring hypertensive patients to be aware of their lipid metabolism abnormalities daily while controlling their blood pressure.

Previous studies have shown that diabetes mellitus is an independent risk factor for HTN, and hypertensive patients tend to exhibit insulin resistance and are at a greater risk of developing diabetes mellitus compared to those with normal blood pressure [31]. As a result of impaired glucose tolerance and early diabetes, patients exhibit hyperinsulinemia and insulin resistance, increased sodium reabsorption in the renal tubules, and an increase in fluid volume due to high osmolality induced by hyperglycemia, leading to HTN [32]. Upon entering the middle stages of diabetes, vascular remodeling occurs and peripheral vascular resistance also contributes to HTN. Both of these mechanisms increase systemic blood pressure [33]. The findings of this study indicate that hypertensive patients with comorbid diabetes exhibit a relatively high rate of blood pressure control. Prior research has indicated that patients with HTN and diabetes comorbidity tend to exhibit less optimal outcomes with regard to blood pressure levels, and these patients are at elevated risk [34]. The Guangzhou community healthcare system will implement a classification-based intervention and management strategy for hypertensive patients with comorbid diabetes, thereby providing enhanced proactive medical services to patients [35]. For instance, a combination therapy approach is employed in the treatment of patients, with the objective of simultaneously controlling blood pressure and blood sugar levels. It may therefore be concluded that the relatively high blood pressure control rate of hypertensive patients with comorbid type 2 diabetes is the result of their receiving more aggressive treatment rather than being solely caused by diabetes itself.

In this study, we analyzed the factors affecting blood pressure control in patients with HTN and patients with hypertensive comorbidities, and the results showed that different factors have different effects on blood pressure control. The rate of blood pressure control is higher in women with HTN than in men. This difference may be explained by variations in sex hormone

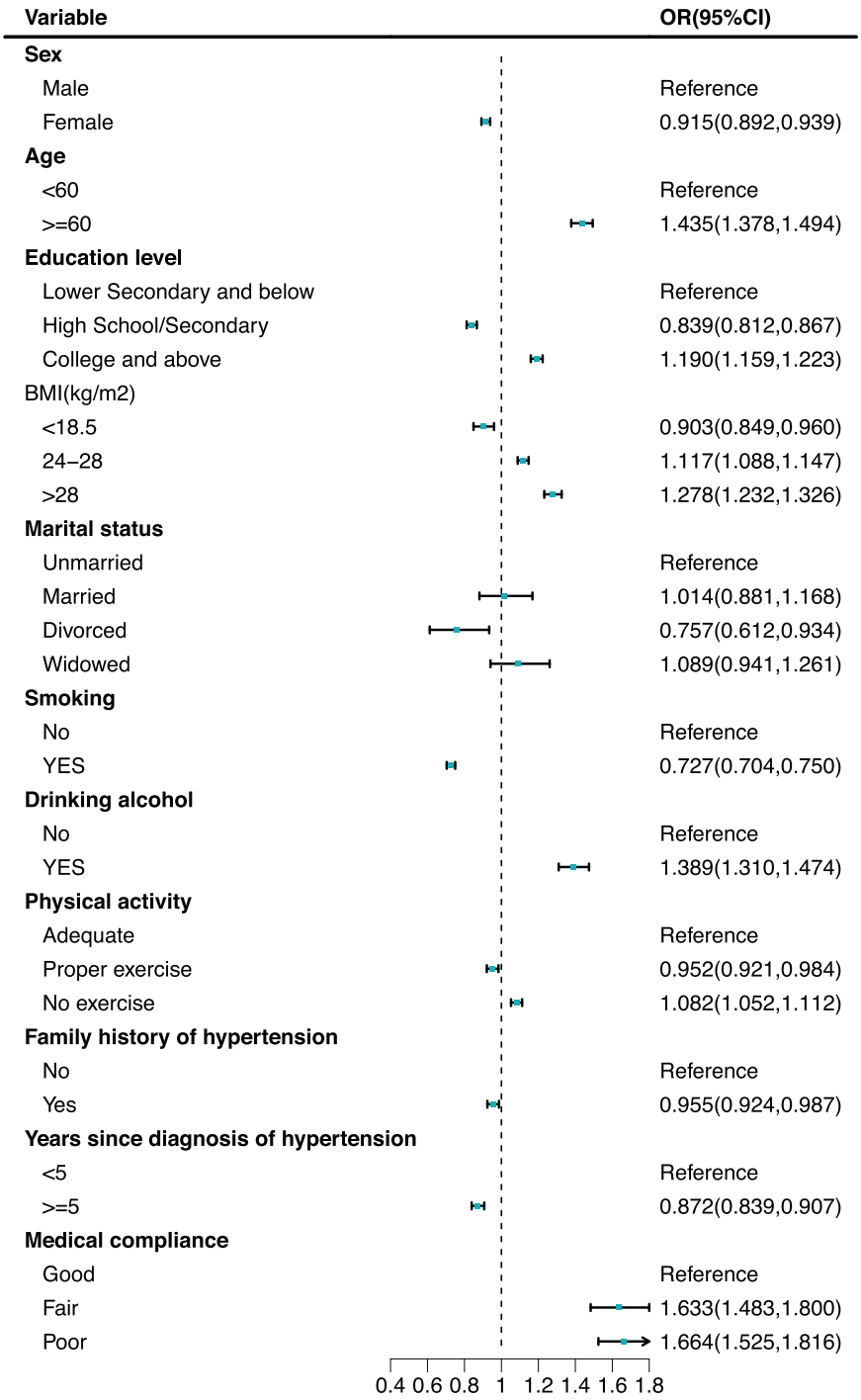


**FIGURE 1** | Forest plot for subgroup analysis of blood pressure control in hypertensive patients without diabetes and hyperlipidemia.

levels, endothelin-1 levels, the role of sympathetic nerve activity, and differences in HTN awareness between men and women [36]. With increasing age, the blood pressure control rate in hypertensive patients tends to decline. This may be due to age-related cognitive decline, which is exacerbated by elevated SBP and pulse pressure, further reducing patients' attention to their blood pressure management [37]. Additionally, the deterioration of physical functions leads to reduced frequency and intensity of daily physical activities, which negatively affects blood pressure control [38]. In this study, it was also observed that the likelihood of poor blood pressure control was higher in more educated individuals. This finding deviated from previous studies, possibly due to differences in the lifestyles of more educated individuals. Factors such as increased work stress, more complex relationships, and fewer opportunities for exercise among this demographic may contribute to the adverse effects on blood pressure [39–41]. Hypertensive patients with a longer disease duration generally have a higher blood pressure control rate. This can be attributed to several factors. Patients with an extended disease course have a deeper understanding of their condition and are more psychologically accepting of it. They have also accumulated rich coping experiences. This psychological adaptation helps them

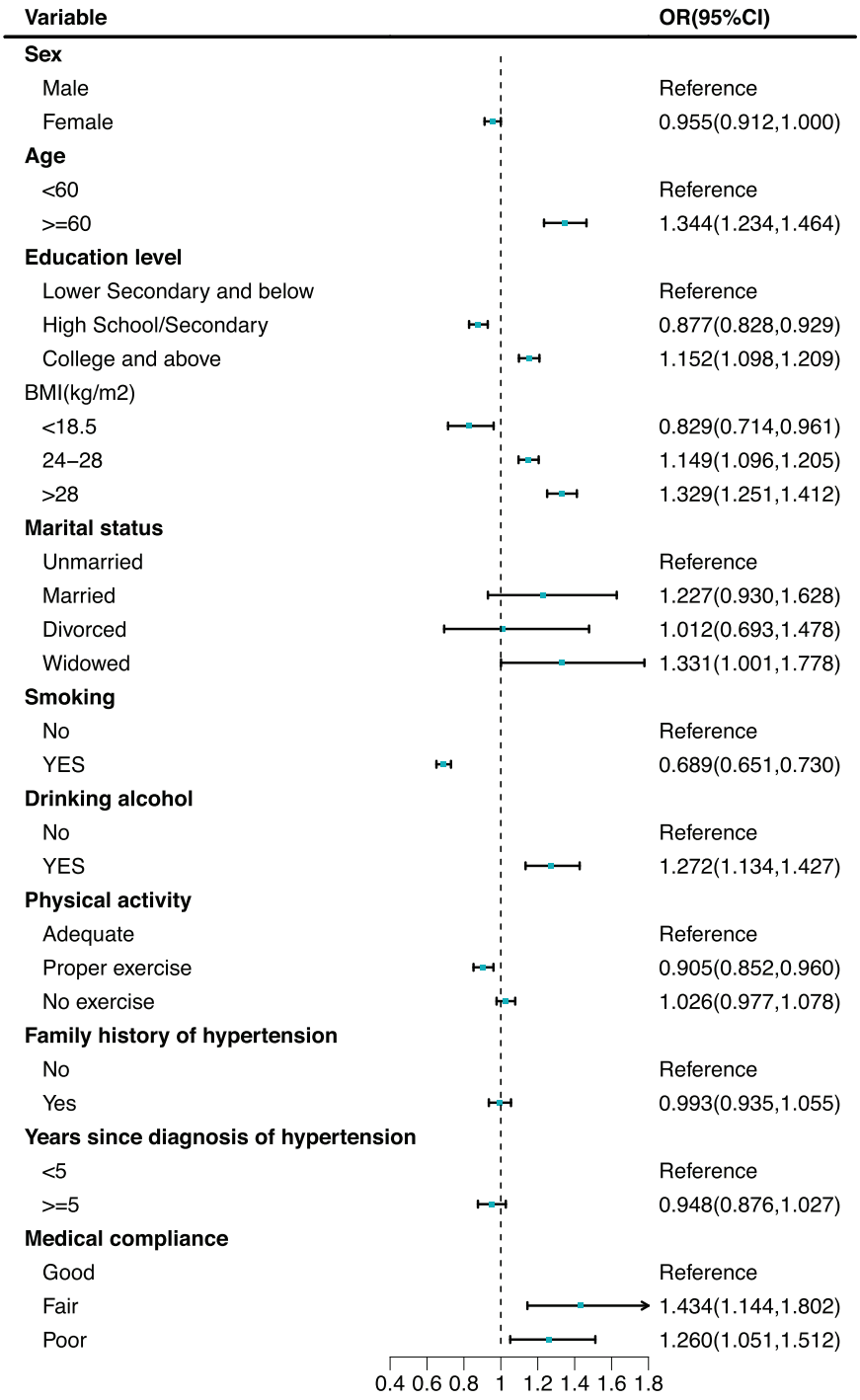


**FIGURE 2** | Forest plot for subgroup analysis of blood pressure control in hypertensive patients with comorbid diabetes.

adhere better to medical advice and reduces the adverse impact of negative emotions on blood pressure [42]. As a result of prolonged treatment, these patients have acquired the ability to regulate their lives in a more systematic manner, including the implementation of a reasonable schedule for rest and exercise, as well as the adoption of a balanced diet [43]. In addition, healthcare providers continuously optimize drug combinations according to patients' responses. The synergistic effect of multiple drugs may be more fully realized in these patients, thereby improving blood pressure control [44]. The results of this study also showed that overweight and obese individuals have lower rates of blood pressure control, which may be associated with the accumulation and dilation of arterial fat accelerating the progression of arterial HTN in patients [45], as well as overactivation of the renin–angiotensin–aldosterone system/sympathetic nervous system and overstimulation of adipokines in overweight and obese patients that negatively affects the health of the vasculature and leads to elevated blood pressure [46]. In addition, excessive alcohol consumption leads to an increased risk of poor blood pressure control in hypertensive patients, which is consistent with previous epidemiologic findings [47]. Poor medication adherence is a risk factor for poor blood pressure

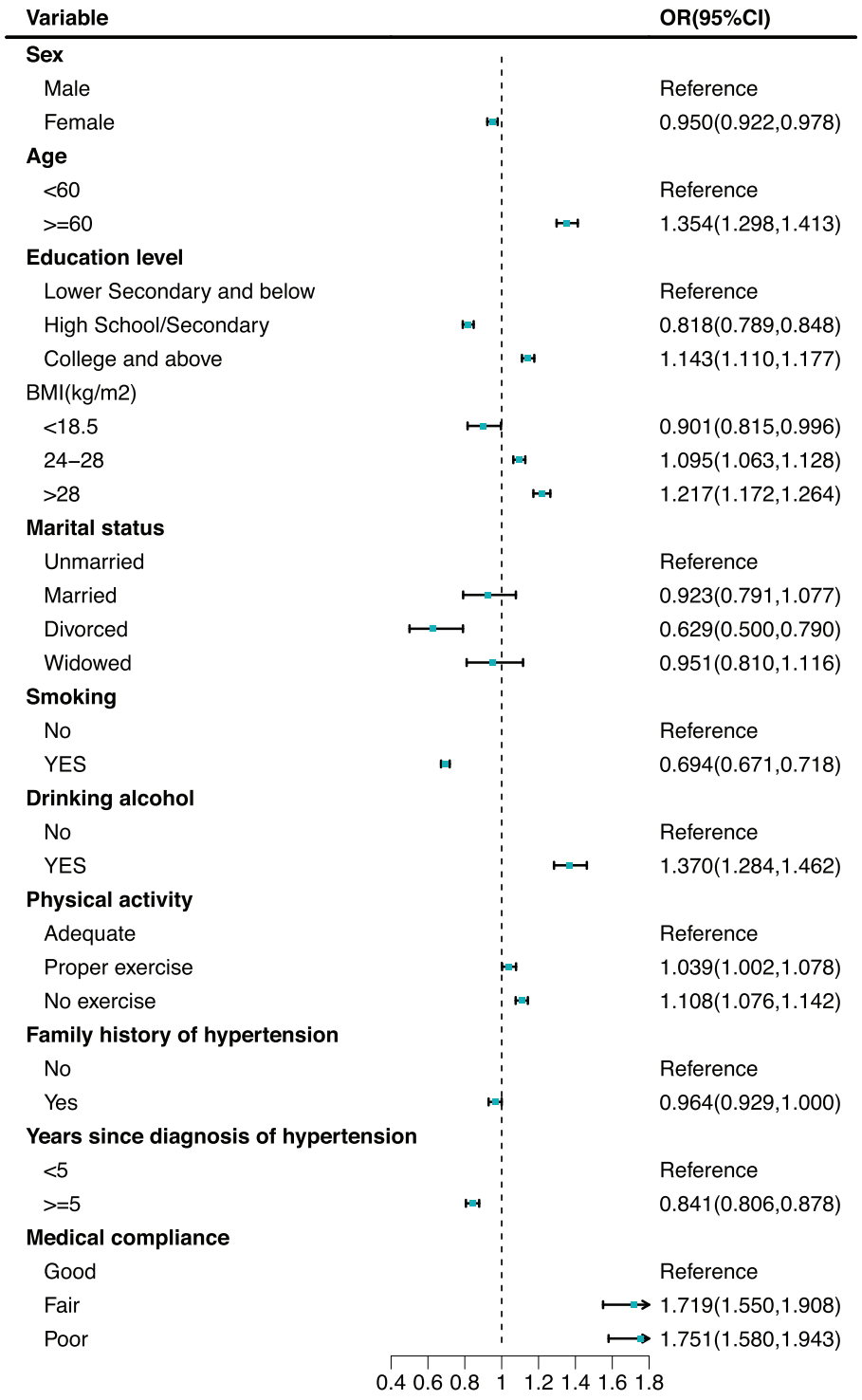


**FIGURE 3** | Forest plot for subgroup analysis of blood pressure control in hypertensive patients with comorbid hyperlipidemia.

control in hypertensive patients, which is consistent with the results of previous studies [48], which may reflect the fact that in the process of long-term treatment, some patients have irregular or untimely medication, which affects the effective control of blood pressure by medication. At the same time, we also observed that some of the patients were not taking their medication, which further exacerbated the difficulty of blood pressure control. In our study, smoking was a risk factor for the rate of blood pressure control in hypertensive patients, which is inconsistent with the results of previous studies, probably because of the relatively high number of female patients in this study; On the one hand, the relatively low smoking prevalence in women may have reduced the effect of smoking on the overall hypertensive patient population. On the other hand, the effect of passive smoking on women may be more significant [49], and the differences between smokers and passive smokers were not strictly differentiated in this study, and there was information bias or confounding bias in the collection of information on hypertensive patients, and the

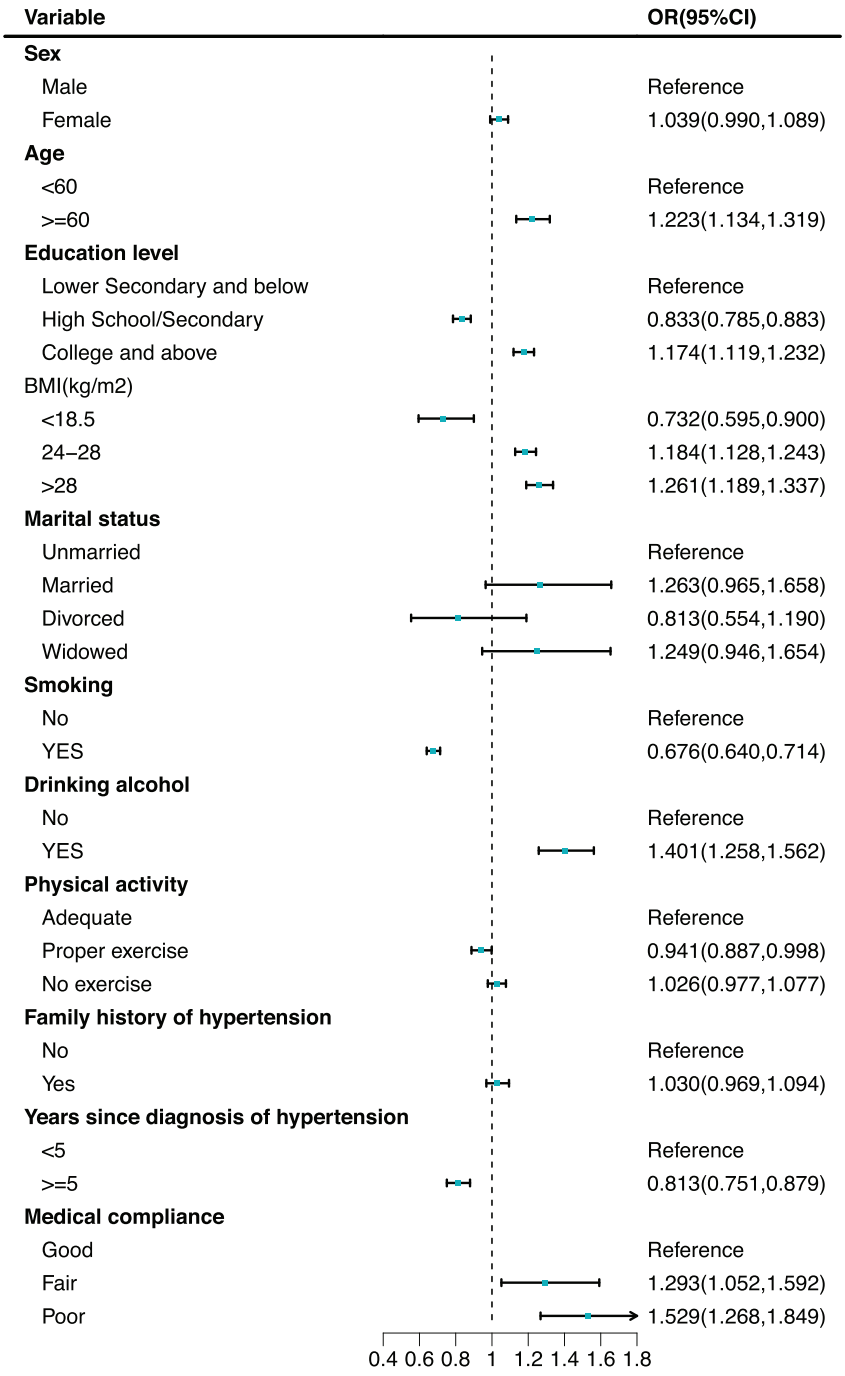


**FIGURE 4** | Forest plot for subgroup analysis of blood pressure control in hypertensive patients with combined diabetes and hyperlipidemia.

content and methodology of the survey should be improved in the future to obtain more accurate data.

## 5 | Limitations and Strengths

The significant advantage of this study is its relatively large sample size, which provides us with more realistic and convincing data to get a more comprehensive picture of blood pressure control in hypertensive patients. In this study, multiple blood pressure measurements were taken while the patients were resting and the average value was calculated to improve the accuracy of the measurements, and the average value of the blood pressure was used to represent the blood pressure level to show the true level of blood pressure control. In addition, there are some limitations to this study. First, some subjects were excluded because they did not fit the purpose of the study, and/or their blood pressure or other data were incomplete, so there may have been selection bias. Second, the data in this study were obtained through a cross-sectional survey. Therefore, further studies are needed to explore the correlations in the longitudinal setting. Additionally, as the data were sourced from individuals participating in our public health program, all of whom were diagnosed hypertensive or diabetic patients aged 35 years and

older, the average age of the study population was relatively high. Older patients tend to have multiple comorbidities, which may have influenced the study outcomes, particularly when interpreting the impact of individual factors on blood pressure control. Nonetheless, we were able to obtain a comprehensive picture of the current status and blood pressure control rates of patients with three-high syndrome in Guangzhou and to identify risk factors for disease management and other aspects affecting blood pressure control.

## 6 | Conclusion

In conclusion, the prevalence of diabetes and hyperlipidemia among hypertensive patients in Guangzhou is concerning. This study highlights the vital role of the Public Health Program in improving patient health. By offering lifestyle guidance and interventions for blood pressure control, the program enhances patients' understanding of their conditions, which subsequently improves blood pressure management and quality of life while reducing the risk of HTN and related complications. Therefore, regular blood pressure monitoring and screening for complications are essential, especially for patients with comorbid diabetes and hyperlipidemia, emphasizing the need for strengthened standardized management and follow-up. Integrating patients with dyslipidemia into the community chronic disease management system for the co-management of HTN, diabetes, and hyperlipidemia has significant implications for healthcare practices globally. These measures are not only relevant to Guangzhou but also serve as valuable references for the medical community in other regions, contributing to overall improvements in health outcomes.

### Author Contributions

Q.Z. and H.L. are responsible for the conceptualization, methodology, project management, supervision, validation, and review and editing sections. S.Z. is responsible for the data collation, formal analysis, investigation, visualization, and original writing sections. L.F. and X.C. are responsible for the investigation and validation sections. Y.Y. and Z.Z. is responsible for the methodology and validation sections. G.L. and W.L. are responsible for the project management and validation sections. J.W. and X.L. are responsible for the software and validation sections. All authors read and approved the final manuscript.


### Acknowledgments

The authors have nothing to report.


### Ethics Statement

The study protocol was approved by the ethics committee of each participating institution.

### Consent

Informed consent for the procedure was obtained from each participant.

### Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Data Availability Statement

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

### References


1. A. Buonacera, B. Stancanelli, and L. Malatino, "Stroke and Hypertension: An Appraisal From Pathophysiology to Clinical Practice," *Current Vascular Pharmacology* 17, no. 1 (2019): 72–84.

2. F. D. Fuchs and P. K. Whelton, "High Blood Pressure and Cardiovascular Disease," *Hypertension* 75, no. 2 (2020): 285–292.

3. K. T. Mills, A. Stefanescu, and J. He, "The Global Epidemiology of Hypertension," *Nature Reviews Nephrology* 16, no. 4 (2020): 223–237.

4. Z. Wang, Z. Chen, L. Zhang, et al., "Status of Hypertension in China: Results From the China Hypertension Survey, 2012–2015," *Circulation* 137, no. 22 (2018): 2344–2356.

5. L. Ma, Z. Wang, J. Fan, et al., "Epidemiology and Management of Hypertension in China: An Analysis Using Data From the Annual Report on Cardiovascular Health and Diseases in China (2021)," *Chinese General Practice* 2022; 25(30): 3715, https://doi.org/10.12114/j.issn.1007-9572.2022.0502.

6. J. R. Petrie, T. J. Guzik, and R. M. Touyz, "Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms," *Canadian Journal of Cardiology* 34, no. 5 (2018): 575–584.

7. A. Ajoolabady, M. Chiong, S. Lavandero, D. J. Klionsky, and J. Ren, "Mitophagy in Cardiovascular Diseases: Molecular Mechanisms, Pathogenesis, and Treatment," *Trends in Molecular Medicine* 28, no. 10 (2022): 836–849.

8. M. Hedayatnia, Z. Asadi, R. Zare-Feyzabadi, et al., "Dyslipidemia and Cardiovascular Disease Risk Among the MASHAD Study Population," *Lipids in Health and Disease* 19, no. 1 (2020): 42.

9. G. M. Reaven, "Banting Lecture 1988. Role of Insulin Resistance in Human Disease," *Diabetes* 37, no. 12 (1988): 1595–1607.

10. G. E. Shaya, T. M. Leucker, S. R. Jones, et al., "Coronary Heart Disease Risk: Low-Density Lipoprotein and Beyond," *Trends in Cardiovascular Medicine* 32, no. 4 (2022): 181–194.

11. M. Litwin and Z. Kułaga, "Obesity, Metabolic Syndrome, and Primary Hypertension," *Pediatric Nephrology* 36, no. 4 (2021): 825–837.

12. J. Pan, L. Wu, H. Wang, et al., "Determinants of Hypertension Treatment Adherence Among a Chinese Population Using the Therapeutic Adherence Scale for Hypertensive Patients," *Medicine* 98, no. 27 (2019): e16116.

13. X. Lv, H. Niu, Y. Qu, et al., "Awareness, Treatment and Control of Hypertension Among Hypertensive Patients Aged 18 to 59 Years Old in the Northeast of China," *Scientific Reports* 8, no. 1 (2018): 17019.

14. P. Muntner, S. T. Hardy, L. J. Fine, et al., "Trends in Blood Pressure Control Among US Adults With Hypertension, 1999–2000 to 2017–2018," *Jama* 324, no. 12 (2020): 1190–1200.

15. B. Zhou, P. Perel, G. A. Mensah, and M. Ezzati, "Global Epidemiology, Health Burden and Effective Interventions for Elevated Blood Pressure and Hypertension," *Nature Reviews Cardiology* 18, no. 11 (2021): 785–802.

16. Z. Jiang, L. You, S. Yang, et al., "Creation and Utilization of the Health Records in Residents: A Demand-Side Survey in Three Eastern, Central and Western Chinese Provinces," *Chinese General Practice* 25, no. 13 (2022): 1539–1544, doi:10.12114/j.issn.1007-9572.2022.00.010.

17. J. Mallol, M. Urrutia-Pereira, M. J. Mallol-Simmonds, L. Calderón-Rodríguez, F. Osses-Vergara, and A. Matamala-Bezmalinovic, "Prevalence and Determinants of Tobacco Smoking Among Low-Income Urban Adolescents," *Pediatric Allergy, Immunology, and Pulmonology* 34, no. 2 (2021): 60–67.

18. J. E. Yoo, K. Han, D. W. Shin, et al., "Association Between Changes in Alcohol Consumption and Cancer Risk," *JAMA Network Open* 5, no. 8 (2022): e2228544.

19. F. C. Bull, S. S. Al-Ansari, S. Biddle, et al., "World Health Organization 2020 Guidelines on Physical Activity and Sedentary Behaviour," *British Journal of Sports Medicine* 54, no. 24 (2020): 1451–1462.

20. J. Liu, "Highlights of the 2018 Chinese Hypertension Guidelines," *Clinical Hypertension* 26 (2020): 8.

21. H. Zhang, W. R. Kwapong, M. M. Shao, et al., "Predictors of the Prevalence of Dyslipidemia and Influencing Factors for Young Health Examination Cohort: A Cross-Sectional Survey," *Frontiers in Public Health* 8 (2020): 400.

22. Q. Zhou, X. Liu, Y. Zhao, et al., "BMI and Risk of All-Cause Mortality in Normotensive and Hypertensive Adults: The Rural Chinese Cohort Study," *Public Health Nutrition* 24, no. 17 (2021): 5805–5814.

23. X. Xie, T. He, J. Kang, D. S. Siscovick, Y. Li, and J. A. Pagán, "Cost-Effectiveness Analysis of Intensive Hypertension Control in China," *Preventive Medicine* 111 (2018): 110–114.

24. S. Ma, L. Yang, M. Zhao, C. G. Magnussen, and B. Xi, "Trends in Hypertension Prevalence, Awareness, Treatment and Control Rates Among Chinese Adults, 1991–2015," *Journal of Hypertension* 39, no. 4 (2021): 740–748.

25. S. Liu, H. Yuan, C. Jiang, J. Xu, X. Qiu, and J. Luo, "The Blood Pressure Control and Arteriosclerotic Cardiovascular Risk Among Chinese Community Hypertensive Patients," *Scientific Reports* 11, no. 1 (2021): 19066.

26. J. W. Zhang, J. Zhang, Y. Jiang, et al. Zhonghua Liu Xing Bing Xue Za Zhi. 2021;42(4):643–650, https://doi.org/10.3760/cma.j.cn112338-20200605-00813.

27. G. Hao, Z. Chen, X. Wang, et al., "Evaluation of the Community-Based Hypertension Management Programs in China," *Frontiers in Public Health* 2022;10:896603.

28. T. Otsuka, H. Takada, Y. Nishiyama, et al., "Dyslipidemia and the Risk of Developing Hypertension in a Working-Age Male Population," *Journal of the American Heart Association* 5, no. 3 (2016): e003053.

29. J. B. McGill, S. Haffner, T. J. Rees, J. R. Sowers, A. M. Tershakovec, and M. Weber, "Progress and Controversies: Treating Obesity and Insulin Resistance in the Context of Hypertension," *Journal of Clinical Hypertension (Greenwich, Conn.)* 11, no. 1 (2009): 36–41.

30. I. B. Wilkinson, K. Prasad, I. R. Hall, et al., "Increased central Pulse Pressure and Augmentation Index in Subjects With Hypercholesterolemia," *Journal of the American College of Cardiology* 39, no. 6 (2002): 1005–1011.

31. G. Jia and J. R. Sowers, "Hypertension in Diabetes: An Update of Basic Mechanisms and Clinical Disease," *Hypertension* 78, no. 5 (2021): 1197–1205.

32. M. Ohishi, "Hypertension With Diabetes Mellitus: Physiology and Pathology," *Hypertension Research* 41, no. 6 (2018): 389–393.

33. S. Kawasoe, Y. Maruguchi, S. Kajiya, et al., "Mechanism of the Blood Pressure-Lowering Effect of Sodium-Glucose Cotransporter 2 Inhibitors in Obese Patients With Type 2 Diabetes," *BMC Pharmacology and Toxicology* 18, no. 1 (2017): 23.

34. L. Lauder, F. Mahfoud, M. Azizi, et al., "Hypertension Management in Patients With Cardiovascular Comorbidities," *European Heart Journal* 44, no. 23 (2023): 2066–2077.

35. X. Li, H. M. Krumholz, W. Yip, et al., "Quality of Primary Health Care in China: Challenges and Recommendations," *Lancet* 395, no. 10239 (2020): 1802–1812.

36. J. J. Song, Z. Ma, J. Wang, L. X. Chen, and J. C. Zhong, "Gender Differences in Hypertension," *Journal of Cardiovascular Translational Research* 13, no. 1 (2020): 47–54.

37. T. Zhang, F. He, J. Hu, et al., "Blood Pressure and Cognitive Decline Over the Course of 2 Years in Elderly People: A Community-Based Prospective Cohort Study," *Aging Clinical and Experimental Research* 33, no. 7 (2021): 1903–1908.

38. V. Arija, F. Villalobos, R. Pedret, et al., "Physical Activity, Cardiovascular Health, Quality of Life and Blood Pressure Control in Hypertensive Subjects: Randomized Clinical Trial," *Health and Quality of Life Outcomes* 16, no. 1 (2018): 184.

39. X. Trudel, C. Brisson, M. Gilbert-Ouimet, and A. Milot, "Psychosocial Stressors at Work and Ambulatory Blood Pressure," *Current Cardiology Reports* 20, no. 12 (2018): 127.

40. F. Unda Villafuerte, J. Llobera Cànaves, P. Lorente Montalvo, et al., "Effectiveness of a Multifactorial Intervention, Consisting of Self-Management of Antihypertensive Medication, Self-Measurement of Blood Pressure, Hypocaloric and Low Sodium Diet, and Physical Exercise, in Patients With Uncontrolled Hypertension Taking 2 or More Antihypertensive Drugs: The MEDICHY Study," *Medicine* 99, no. 17 (2020): e19769.

41. M. Munakata, "Clinical Significance of Stress-Related Increase in Blood Pressure: Current Evidence in Office and Out-of-Office Settings," *Hypertension Research* 41, no. 8 (2018): 553–569.

42. A. Pathak, N. R. Poulter, M. Kavanagh, R. Kreutz, and M. Burnier, "Improving the Management of Hypertension by Tackling Awareness, Adherence, and Clinical Inertia: A Symposium Report," *American Journal of Cardiovascular Drugs* 22, no. 3 (2022): 251–261.

43. J. A. Blumenthal, P. J. Smith, S. Mabe, et al., "Effects of Lifestyle Modification on Psychosocial Function in Patients With Resistant Hypertension: Secondary Outcomes From the Triumph Randomized Clinical Trial," *Journal of Cardiopulmonary and Rehabilitation and Prevention* 44, no. 1 (2024): 64–70.

44. O. M. Ballut, A. A. Alzahrani, R. A. Alzahrani, et al., "The Impact of Non-Pharmacological Interventions on Blood Pressure Control in Patients With Hypertension: A Systematic Review," *Cureus* 15, no. 11 (2023): e48444.

45. K. Ayinapudi, T. Singh, A. Motwani, T. H. Le Jemtel, and S. Oparil, "Obesity and Pulmonary Hypertension," *Current Hypertension Reports* 20, no. 12 (2018): 99.

46. E. Shams, V. Kamalumpundi, J. Peterson, et al., "Highlights of Mechanisms and Treatment of Obesity-Related Hypertension," *Journal of Human Hypertension* 36, no. 9 (2022): 785–793.

47. E. Day and J. H. F. Rudd, "Alcohol Use Disorders and the Heart," *Addiction* 114, no. 9 (2019): 1670–1678.

48. N. K. Choudhry, I. M. Kronish, W. Vongpatanasin, et al., "Medication Adherence and Blood Pressure Control: A Scientific Statement From the American Heart Association," *Hypertension* 79, no. 1 (2022): e1–e14.

49. M. Yarlioglues and A. Oguzhan, "Attention to an Important Public Health Issue: Deleterious Vascular Effects of Acute Exposure to Passive Smoking in Adult Young Females," *Journal of Hypertension* 42, no. 1 (2024): 185.

## Supporting Information

Additional supporting information can be found online in the Supporting Information section.