# Prevalence, Awareness, Treatment, and Control of Hypertension in Northern China: a Cross-Sectional Study

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## Abstract

# Aims

Hypertension has always been a worldwide health concern. The purpose of this study was to investigate the prevalence, awareness, treatment, and control rates of hypertension among adult residents of northern China, where people usually have a high-fat, high-salt diet and heavy alcohol consumption.

# Methods

Through the Early Screening and Comprehensive Intervention Project for High Risk Groups of Cardiovascular Diseases in the Inner Mongolia Autonomous Region of northern China, we collected data of 70,380 residents and assessed the prevalence, awareness, treatment, and control of hypertension in the total population and subpopulations.

# Results

Among participants, only 13.9% (11.7% of men and 15.4% of women) had optimal BP levels. 55.7% (95% confidence interval (CI): 55.3–56.1%) of the participants had hypertension. A total 52.8% (52.3–53.3%) of patients with hypertension were aware of their diagnosis and 43.3% (42.8–43.8%) were taking antihypertensive medications. Only 8.6% (8.3–8.9%) of patients with hypertension had their BP under control, and 19.8% (19.2–20.4%) of those who were treated had their BP under control. The standardized rates of hypertension prevalence, awareness, treatment, control, and control under treatment were 49.4% (49.0–49.8%), 45.4% (44.9–45.9%), 35.7% (35.2%–36.2), 7.3% (7.0–7.6%), and 20.8% (20.2–21.4%), respectively.

# Conclusion

Hypertension is highly prevalent in northern China, with inadequate awareness, treatment, and control of hypertension. Even if patients with hypertension are under treatment, hypertension can remain inadequately controlled.

## Introduction

Hypertension is a leading health risk[1,2]. The Global Burden of Disease study 2017 indicated that high systolic blood pressure (SBP) accounted for 10.4 million deaths and was responsible for the largest number of all-cause deaths, resulting in a loss of 218 million disability-adjusted life-years[3]. Hypertension contributes to 51% of stroke deaths and 45% of ischemic heart disease deaths worldwide[4] and causes more than 7 million premature deaths each year[5]. Studies have shown that the global prevalence of hypertension has risen continuously in recent decades, especially in low-income and middle-income countries[6,7]. It is estimated that 26.4% (972 million) of adults had hypertension in 2000, and the number in 2025 is predicted to increase by about 60%, to a total of 1.56 billion globally [8]. The number of Chinese adult patients with hypertension increased from 153 million in 2000 to more than 270 million in 2012[9]. A national study during 2014–2017 showed that 44.7% of Chinese adults aged 35–75 years had hypertension[10]. However, the level of hypertension management remains suboptimal in China, with fewer than half of patients with hypertension in China receiving treatment and fewer than one-fifth with controlled blood pressure (BP)[11–14].

Studies have shown that the prevalence of hypertension in southern China is lower than that in the northern part of the country[13,15]. Because Inner Mongolia lies across a large part of northern China, it is somewhat representative of this region, where people have a high-fat, high-salt diet and heavy alcohol consumption[16]. However, previous studies have covered a limited area and have included a small sample size, and most studies have not linked BP with demographic characteristics and clinical variables of different populations. The disease burden of hypertension in northern China remains unclear and identifying adverse factors involved in hypertension is urgent. Thus, obtaining reliable information about the prevalence, awareness, treatment, and control of hypertension is critical for further prevention and control of this disease and diseases secondary to hypertension.

Accordingly, in this study, we aimed to provide updated and reliable data on the hypertension prevalence, awareness, treatment, and control of the total population and subpopulations in northern China.

## Materials And Methods

### Study population

Taking into account the geographical environment, distribution of the urban and rural population, and distribution of ethnic minority nationalities, we conducted a multi-stage stratified cluster sampling to survey 70,380 participants aged 35-75 years residing in Inner Mongolia for the Early Screening and Comprehensive Intervention Project for High Risk Groups of Cardiovascular Diseases in Inner Mongolia. This project was approved by the ethics

committee of Fuwai Hospital Chinese Academy of Medical Sciences (approval number: 2014-574), and all participants gave their written informed consent.

### Measurement

We collected participant information regarding sociodemographic characteristics, health behaviors, and medical history using questionnaires and took physical measurements in a physical examination. Using these data, we assessed the rates of hypertension prevalence, awareness, treatment, control, and control under treatment.

We used a self-designed questionnaire and trained medical personnel conducted face-to-face interviews. The questionnaire mainly included demographic characteristics, history of disease (hypertension, stroke, myocardial infarction (MI), cardiovascular disease (CVD), coronary heart disease (CHD)), and CVD risk factors (diabetes, obesity, smoking status, drinking status). Information on height, weight, BP, and blood glucose was obtained in physical or laboratory examinations.

For each participant, two BP measurements were taken using an electronic BP monitor (Omron HEM-7430; Omron Corporation, Kyoto, Japan) and a standard protocol. Two consecutive BP measurements were taken and the mean BP value of the two readings was used.

### Definition

Hypertension was defined as an average SBP ≥140 mmHg, or average diastolic blood pressure (DBP) ≥90 mmHg, and/or self-reported use of antihypertensive medications in the previous 2 weeks. Awareness was defined as a self-reported hypertension history or self-reported use of antihypertensive drugs among patients with hypertension. Treatment of hypertension was defined as use of antihypertensive medication among participants with hypertension. Control of hypertension was defined as an average SBP <140 mmHg and an average DBP <90 mmHg among patients with hypertension. Control under treatment was defined as an average SBP <140 mmHg and average DBP <90 mmHg after using antihypertensive medication among patients with hypertension. According to the 2018 Revision of Chinese Guidelines for Hypertension Prevention and Control, optimal BP is defined as an average SBP <120 mmHg and DBP <80 mmHg. High–normal, stage 1, stage 2, and stage 3 are defined as average SBP 120-139 mmHg and/or DBP 80-89 mmHg, SBP 140-159 mmHg and/or DBP 90-99 mmHg, SBP 160-179 mmHg and/or DBP 100-109 mmHg, and SBP ≥180 mmHg and/or DBP ≥110 mmHg, respectively. If SBP and DBP had different grades, the higher grade was chosen.

Body mass index (BMI) was defined as weight in kilograms (kg) divided by height in meters squared ($m^2$). Obesity was defined as a BMI of at least 28 $kg/m^2$, according to recommendations of the Working Group on Obesity in China. Diabetes was defined as use of hypoglycemic medication or a measured fasting blood glucose level ≥7.0 mmol/L or non-fasting blood glucose level ≥11.1 mmol/L. Drinking referred to drinking alcohol at least 1 time/month in the previous 1 year. Current smoking was defined as smoking at least 1 cigarette every day.

### Statistical analysis

Statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). We calculated age- and sex-standardized rates of hypertension prevalence, awareness, treatment, control, and control under treatment based on data of the sixth national census of China 2010. Continuous variables were expressed as mean and standard deviation (SD), and categorical variables were expressed as percentage. Differences in proportions were compared using the chi-square test. A two-sided $P$ value <0.05 was considered statistically significant.

## Results

### Demographic characteristics

A total of 70,380 participants aged 35–75 years were included in the study. Table 1 shows that the mean age of the study population was 54.4 years, and 58.0% were women. Most participants were of Han (89.8%) ethnicity and married (91.2%). A total of 69.2% participants were from rural areas. The prevalence of diabetes was 19.5% and the mean BMI was 25.8 $kg/m^2$.

Table 1. Demographic characteristics of the study population

| Characteristics | All subjects | Men | Women |
|---|---|---|---|
| **Total, n (%)** | 70380 (100.0) | 29539 (42.0) | 40841 (58.0) |
| **Age (years), Mean±SD** | 54.4±9.4 | 55.0±9.6) | 54.0±9.2 |
| **BMI(kg/m$^2$) , Mean±SD** | 25.8±3.6 | 25.7±3.5) | 25.9±3.6 |
| **Ethnicity, n (%)** | | | |
| Han | 63172 (89.8) | 26572 (90.0) | 36600 (89.6) |
| Mongolian | 6086 (8.6) | 2513 (8.5) | 3573 (8.7) |
| Others | 1122 (1.6) | 454 (1.5) | 668 (1.7) |
| **Married, n (%)** | 64203 (91.2) | 27534 (93.2) | 36669 (89.8) |
| **Rural, n (%)** | 48695 (69.2) | 20659 (69.9) | 28036 (68.7) |
| **History of diseases, n (%)** | | | |
| Stroke | 2315 (3.3) | 1124 (3.8) | 1191 (2.9) |
| MI | 755 (1.1) | 387 (1.3) | 368 (0.9) |
| CVD | 3436 (4.9) | 1735 (5.9) | 1701 (4.2) |
| CHD | 1218 (1.7) | 666 (2.3) | 552 (1.4) |
| **Diabetes, n (%)** | 13707 (19.5) | 6137 (20.8) | 7570 (18.5) |
| **Obesity, n (%)** | 17498 (24.9) | 7229 (24.5) | 10269 (25.1) |
| **Current smoker, n (%)** | 17624 (25.0) | 14619 (49.5) | 3005 (7.4) |
| **Drinking, n (%)** | 19089 (27.1) | 15613 (52.9) | 3476 (8.5) |

SD, standard deviation; BMI, body mass index; MI, myocardial infarction; CVD, cardiovascular disease; CHD, coronary heart disease.

## BP levels

Table 2 shows mean BP levels according to different sex and age groups. The mean SBP and DBP was 140.5±20.9 mmHg and 84.8±11.6 mmHg, respectively. Overall, men had slightly higher SBP and DBP levels than women. The mean SBP increased gradually with age, but mean DBP decreased in higher age groups. Compared with the no hypertensive participants, the SBP was 38.4 and 31.0 higher of the untreated hypertension participants and the treated hypertension participants, respectively, and the DBP was 18.3 and 13.7 higher, respectively. In contrast, the mean SBP and DBP among treated patients with hypertension was 7.4 mmHg and 4.6 mmHg, respectively, lower than the values among untreated patients with hypertension. The difference in SBP and DBP between treated and untreated patients was statistically significant ($P$<0.05).

The percentage distribution of BP levels among study participants is shown in the Figure 1. Overall, only 13.9% of the study population (11.7% of men and 15.4% of women) had optimal BP whereas nearly two-fifths (38.6%) had high normal BP. The prevalence of stage 1, 2, and 3 hypertension was 30.6%, 10.7%, and 6.3% in men (29.1%, 12.2%, and 6.1% in women), respectively. With increasing age, the percentage of optimal and high-normal BP decreased whereas the proportion of stage 1, stage 2, and stage 3 hypertension increased.

Table 2. Systolic and diastolic blood pressure among study participants by sex and age

| Age (years) | Total | | No hypertension | | Treated | | Untreated | |
|---|---|---|---|---|---|---|---|---|
| | SBP (mmHg) | DBP (mmHg) | SBP (mmHg) | DBP (mmHg) | SBP (mmHg) | DBP (mmHg) | SBP (mmHg) | DBP (mmHg) |
| **Men** | 140.7±19.9 | 86.7±11.4 | 124.6±9.1 | 78.5±6.8 | 152.9±19.7 | 92.3±11.7 | 161.2±17.2 | 97.7±11.0 |
| 35- | 133.3±17.0 | 85.7±11.6 | 123.0±8.8 | 78.7±6.7 | 148.9±18.6 | 96.9±11.7 | 156.2±14.5 | 101.4±9.7 |
| 45- | 138.8±19.2 | 88.1±11.5 | 124.3±8.9 | 79.5±6.5 | 151.2±19.4 | 95.9±11.4 | 160.6±17.2 | 101.0±10.7 |
| 55- | 143.1±20.1 | 87.0±11.1 | 125.3±9.2 | 78.3±6.6 | 153.4±19.8 | 92.1±11.2 | 161.9±17.6 | 96.4±10.3 |
| 65-75 | 146.2±20.6 | 84.4±11.1 | 126.2±9.3 | 76.1±7.3 | 154.9±20.0 | 87.7±11.2 | 164.1±17.5 | 92.3±11.0 |
| **Women** | 140.4±21.5 | 83.4±11.5 | 123.2±9.9 | 76.0±7.4 | 155.8±20.5 | 89.6±11.5 | 162.8±17.3 | 93.3±10.6 |
| 35- | 127.9±17.7 | 80.4±11.5 | 119.8±10.0 | 75.5±7.5 | 151.9±19.0 | 95.3±11.6 | 158.6±15.4 | 97.7±9.7 |
| 45- | 137.8±20.4 | 84.0±11.6 | 123.2±9.7 | 76.6±7.3 | 153.7±20.4 | 92.4±11.3 | 162.1±17.0 | 96.2±10.1 |
| 55- | 145.1±20.9 | 84.3±11.1 | 125.7±9.4 | 76.1±7.2 | 155.9±20.4 | 89.0±11.0 | 163.3±17.6 | 92.2±10.2 |
| 65-75 | 151.4±21.3 | 83.2±11.3 | 126.9±9.3 | 74.3±7.7 | 159.1±20.8 | 86.0±11.5 | 164.8±17.6 | 88.6±10.7 |
| **Total** | 140.5±20.9 | 84.8±11.6 | 123.7±9.6 | 77.0±7.3 | 154.7±20.3 | 90.7±11.7 | 162.1±17.3 | 95.3±11.0 |
| 35- | 130.1±17.6 | 82.6±11.8 | 121.0±9.7 | 76.6±7.4 | 150.5±18.8 | 96.1±11.6 | 157.3±14.9 | 99.8±9.9 |
| 45- | 138.2±20.0 | 85.6±11.7 | 123.6±9.4 | 77.7±7.2 | 152.7±20.0 | 93.8±11.5 | 161.4±17.1 | 98.4±10.6 |
| 55- | 144.3±20.6 | 85.5±11.2 | 125.6±9.3 | 77.1±7.1 | 154.9±20.2 | 90.2±11.2 | 162.7±17.6 | 94.0±10.4 |
| 65-75 | 148.9±21.1 | 83.8±11.2 | 126.5±9.3 | 75.3±7.5 | 157.4±20.6 | 86.7±11.4 | 164.5±17.6 | 90.3±11.0 |

SBP, systolic blood pressure; DBP, diastolic blood pressure.

### Prevalence, awareness, treatment, control, and control under treatment of hypertension

Table 3( see Additional file 1) shows that the crude prevalence of hypertension was 55.7% (55.3%–56.1%), and the age- and sex-standardized rate was 49.4% (49.0%–49.8%). A total 52.8% (52.3%–53.3%) of patients with hypertension were aware of their diagnosis. Among participants with hypertension, 43.3% (42.8%–43.8%) of patients were taking medications to lower BP, and only 8.6% (8.3%–8.9%) had their BP controlled to less than 140/90 mmHg. Additionally, only 19.8% (19.2%-20.4%) of treated participants with hypertension had mean SBP <140 mmHg and DBP <90 mmHg. The age- and sex-standardized rates of hypertension awareness, treatment, control, and control under treatment were 45.4% (44.9%–45.9%), 35.7% (35.2%–36.2%), 7.3% (7.0%–7.6%), and 20.8% ( 20.2%–21.4%), respectively.

There was a higher prevalence of hypertension among participants who were male, of Han ethnicity, older, unmarried, uninsured, living in a rural area, and those who had lower education or income levels. Patients with a history of diseases (stroke, MI, CVD, CHD) and CVD risk factors (diabetes, obesity, drinking) had higher prevalence of hypertension.

The prevalence, awareness, and treatment of hypertension increased with age (trend chi-square tests: $P<0.001$). In contrast, control under treatment for hypertension decreased with age (trend chi-square tests: $P<0.001$). The prevalence of hypertension was significantly greater among men than among women (57.4% vs 54.5%, $P<0.001$). Compared with men (49.7%), women (55.2%) were more aware of their hypertension status and were more likely to take medication (46.1% vs 39.6%) and achieve control under treatment (8.8% vs 8.2%). However, women (19.2%) had lower control rates under treatment for hypertension than men (20.8%) (Table 3, see Additional file 1).

Hypertension was categorized as unaware of disease, aware but not treated, treated but not controlled, or controlled (Figure 2). Most patients with hypertension were unaware of their, aware but untreated, and treated but not controlled. The control rates of hypertension among patients with hypertension were very low among all age groups.

## Discussion

To the best of our knowledge, this study presents the latest reliable information about the epidemiological situation of hypertension in Inner Mongolia, the largest province in northern China. In the first and largest population survey in Inner Mongolia, we precisely estimated the level of BP, the current situation of hypertension, and the disease burden of hypertension in Inner Mongolia. The results of this study clarify the rates of prevalence, awareness, treatment, control, and control under treatment of hypertension among the total study population and subpopulations.

In this study, we found that 55.7% of study participants aged 35–75 years in northern China's Inner Mongolia had hypertension. Hypertension affects over half of the population in this region, which corresponds to 14.1 million (8.7 million in urban and 5.4 million in rural areas) people with hypertension in Inner Mongolia. Among participants with hypertension, 52.8% were aware of their diagnosis, 43.3% received treatment, 8.6% had successfully controlled BP, and 19.8% patients had adequately controlled BP after using antihypertensive medication. The age- and sex-standardized rates of hypertension prevalence (49.4% vs. 37.2%), awareness (49.4% vs. 36.0%), treatment (35.7% vs. 22.9%), and control (7.3% vs. 5.7%) were higher than those in a 2017 report from national report[10]. Higher prevalence and lower control rates of hypertension have also been reported in Inner Mongolia and northern China in other previous studies[11,17–20]. Notably, among young people (age 35–44 years), the prevalence of hypertension was 32.6% in this study, which was higher than national levels (22%) in China[10].

Hypertension is a serious public health challenge in Inner Mongolia, with high prevalence and low control. The mean BP level (SBP 140.5 mmHg /DBP 84.8 mmHg) in this study was higher than that reported in a study in Henan Province among people aged 15–74 years in 2012 (SBP 124.0 mmHg /DBP 78.3 mmHg)[21]. This study conducted from 2015 to 2017 provided the updated current status of hypertension in northern China, with a prevalence of 54.5% among women and 57.4% among men. The prevalence of hypertension in the present study was higher than that reported in most other parts of China[13,14,22] and higher than the rates in many other countries[20, 23–26]. Lu et al. also reported a prevalence of 43.3% among women and 46.9% among men in a representative Chinese population aged 35–75 years, during 2014-2017[10]. We noted that there were large gaps in hypertension awareness, treatment, and control of this study as compared with many other countries. A study of 12 high-income countries, conducted between 1976 and 2017 and published in 2019[27], which included data from more than 500,000 participants aged 45–79 years showed varied results with respect to hypertension prevalence (33% in Australia, 59% in Finland), awareness (46% in Ireland, 87% in Germany), treatment (39% in Ireland, 84% in Canada), and control (17% in Ireland, 69% in Canada). Another study published in 2019[28] conducted in 44 low- and middle-income countries showed that Costa Rica's control rate of hypertension was 45%, Brazil's was 28%, and the rate in Belize was 11.3%, the lowest in that study. In Korea[29], a 2019 report revealed that the prevalence, awareness, treatment, and control of hypertension in adults aged 30 years or older was 30.5%, 67.3%, 63.6%, and 46.2%, respectively. However, in our study in Inner Mongolia, the control rate of hypertension was only 8.6%. Even among patients with hypertension who were under antihypertensive treatment, SBP and DBP values were only 7.4 mmHg and 6.6 mmHg, respectively, which were lower than those among patients with hypertension who were not under antihypertensive treatment. The rate of control under treatment for hypertension was only was 19.8%. More effective measures to treat and manage hypertension need to be explored in China, especially in Inner Mongolia.

## Conclusion

In conclusion, the results of our study suggested that hypertension in northern China's Inner Mongolia Autonomous Region is a serious problem, especially lack of control. Most participants with hypertension were uncontrolled, especially young males. Even treated patients with hypertension had still not achieved adequate levels of control. Therefore, action is needed to prevent and control hypertension, to further reduce the disease burden caused by high–normal BP and hypertension in northern China, especially Inner Mongolia.

## Abbreviations

SBP: Systolic blood pressure; BP: Blood pressure; MI: Myocardial infarction; CVD: Cardiovascular disease; CHD: Coronary heart disease; DBP: Diastolic blood pressure; BMI: Body mass index; SD: Standard deviation

## Supplementary Information

Additional file 1: Table 3. Prevalence, awareness, treatment, control and control under treatment of hypertension among different groups.

## Declarations

### Ethics approval and consent to participate

This project was approved by the ethics committee of Fuwai Hospital Chinese Academy of Medical Sciences (approval number: 2014-574). All participants gave their written informed consent.

### Consent for publication

Written informed consent for publication was obtained from all participants.

### Availability of data and materials

The data that support the findings of this study are available from Early Screening and Comprehensive Intervention Project for High Risk Groups of Cardiovascular Diseases of National Center for Cardiovascular
Diseases, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available.

Data are however available from the authors upon reasonable request and with permission of National Center for Cardiovascular Diseases.

### Conflicting Interests

The Authors declare that there is no conflict of interest.

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### Authors' contributions

YX and XX contributed the central idea. XX wrote the initial draft of the paper. XY, XX, HZ and LN
analysed the data. The remaining authors contributed to refining the ideas, carrying out additional analyses and finalizing this paper.All authors gave final approval, and agreed to be accountable for all aspects of work ensuring integrity and accuracy (YX, XX, ZT, LQ, HB, HZ, LZ, LN, TY, KH, GH, WW, XZ).

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## Figures

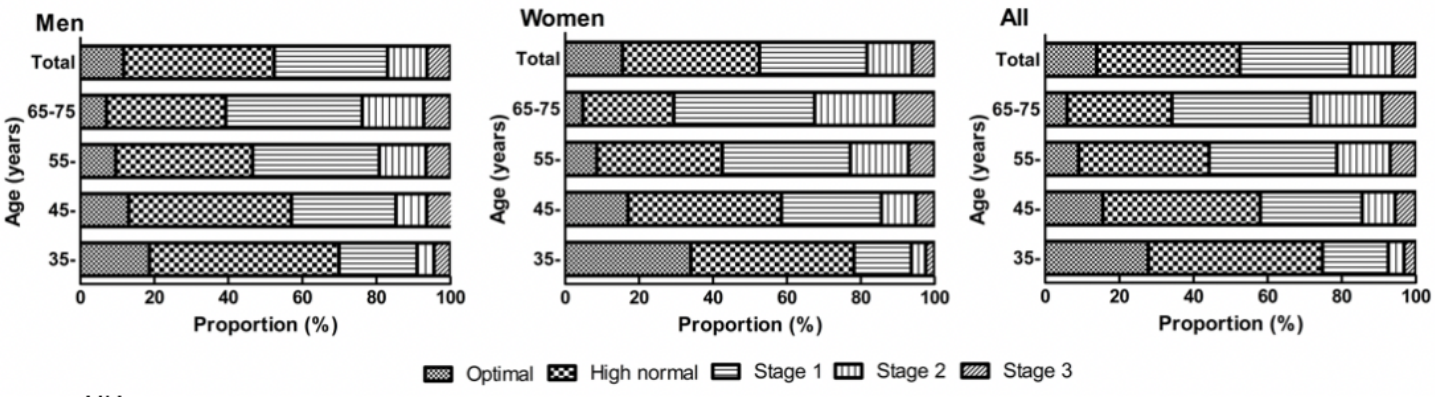


Figure 1

Percentage distribution of blood pressure (BP) levels among study participants

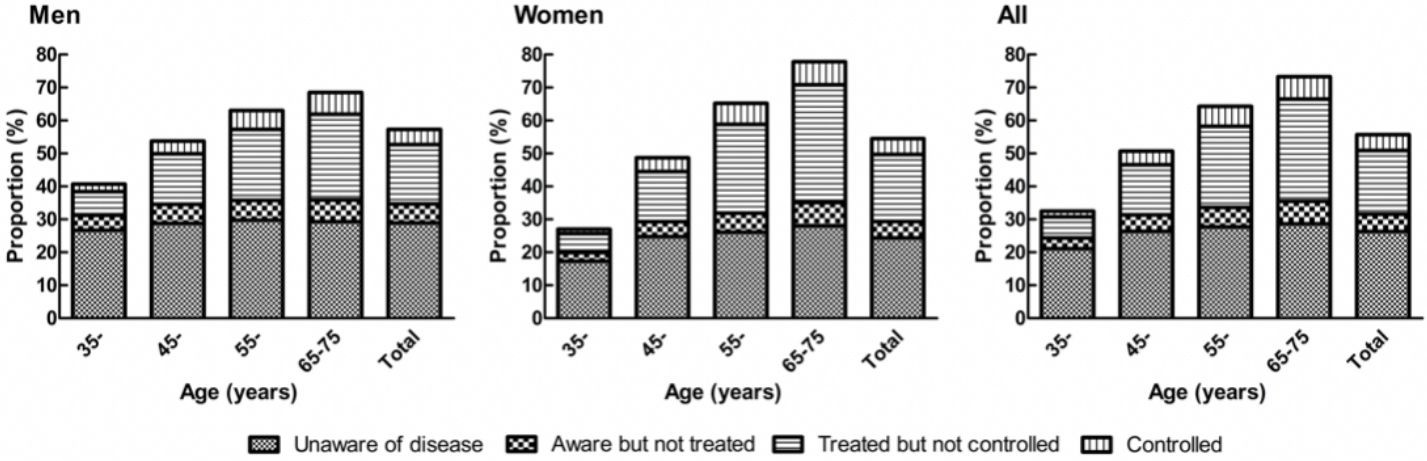


Figure 2

Awareness and control of hypertension among groups by age and sex

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Additionalfile1.xls