

ORIGINAL ARTICLE

The association between the prevalence, treatment and control of hypertension and the risk of mild cognitive impairment in an elderly urban population in China

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It remains unclear whether lowering the blood pressure effectively prevents cognitive impairment. The aim of the current study was to explore the association between the prevalence, treatment and control of hypertension and the risk of mild cognitive impairment (MCI) among elderly Chinese people. This is a cross-sectional study conducted in Beijing, China. A two-stage stratified clustering sampling method was used, and 2065 participants, aged ≥ 60 years, were included in the analysis. The Mini-Mental State Examination was used to assess participants' cognitive function. The prevalence of MCI was higher in hypertensive (16.5%) than in normotensive individuals (13.1%; $P=0.043$). Furthermore, in those hypertensive patients, the prevalence of MCI was lower in those treated (14.9%) than in those not treated (19.9%; $P=0.019$) and lower in those controlled (13.4%) than in those uncontrolled (17.9%; $P=0.042$). The adjusted odds ratio (OR; 95% confidence interval (CI)) of having MCI was 1.59 (1.07–2.35) in those with hypertension compared with those normotensive individuals. The assessment of the hypertensive patients revealed the adjusted OR (95% CI) of having MCI in those with treated hypertension was 0.60 (0.42–0.86) compared with those untreated hypertension, and in those with controlled hypertension was 0.64 (0.43–0.93) compared with those non-controlled hypertension (regardless of treatment). However, among the treated hypertensive patients, there was no difference in the prevalence of MCI between the patients who reached and those who did not reach their treatment goal. We suggest that improved diagnoses and optimal therapeutics are needed to achieve the aim of cognitive decline prevention.

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INTRODUCTION

With the anticipated increase in the elderly population, a higher prevalence of hypertension is emerging. Hypertension affected 66.9% of elderly Chinese people in 2010.¹ As a result, the treatment and control of hypertension are both considered important public health issues in preventing the traditional risk factors for stroke, cardiovascular events and heart failure.²

In recent years, accumulating epidemiologic and mechanistic evidence has shown that hypertension is also an important risk factor for dementia, Alzheimer's disease and mild cognitive impairment (MCI).^{3–7} However, several authors did not observe such a relationship, and most of the negative associations involved the elderly population.^{8,9} One reason for these negative associations is a potential survival bias related to blood pressure reduction.^{10,11} In addition, different participant exclusion criteria, definitions of hypertension and cognitive function measurement tools might account for the conflicting relationship between blood pressure and cognitive function.¹² A recent meta-analysis failed to demonstrate that

antihypertensive treatment is associated with a reduction in cognitive decline.¹³ To the best of our knowledge, it remains unclear whether lowering blood pressure is effective for preventing cognitive impairment.^{14,15}

By 2050, adults over 60 years of age will constitute 29.7% of the total Chinese population.¹⁶ With the increasing aging population, China is facing serious challenges in terms of the medical demand for cognitive disorders and other chronic diseases.¹⁷ Evidence has demonstrated that individuals with MCI are at a higher risk of progressing to dementia, particularly in the elderly population.¹⁸ The prevalence of dementia has been rapidly increasing over the past few decades in China.¹⁹ Therefore, it is urgent to identify the population at a higher risk of MCI. Moreover, an optimal treatment approach must be developed to prevent the expected social and disease burden. The current study aims to examine the association between the prevalence, treatment and control of hypertension and the increased risk of MCI in participants over 60 years of age in an urban area in Beijing, China.

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METHODS

Study design

The sampling method was described in our previous study.²⁰ In brief, we conducted a two-stage stratified clustering sampling method and included all participants who were aged ≥ 60 years old in the Wanshoulu Community. First, we randomly selected 9 of the 94 communities in the Wanshoulu District. Second, we selected all the households (only one elderly resident from each household was recruited) with elderly residents from these 9 communities. Between September 2009 and June 2010, a total of 2162 of the 2510 elderly subjects completed the survey, resulting in a response rate of 86.1%. After excluding 97 adults with incomplete data, a total of 2065 subjects (839 males and 1226 females) were included in the current survey.

The Independent Ethics Committee of the Chinese People's Liberation Army General Hospital (No. EC0411-2001) approved the current study. Signed informed consent was obtained from all of the eligible participants.

Data collection and measurement

Each participant completed a standardized questionnaire through a face-to-face interview. Data were collected on the participants' demographic characteristics, medical histories and lifestyles. Trained observers measured the body height, weight, waist circumference and blood pressure of each participant according to the standardized protocol. While participants were in the standing position, their waist circumference was measured midway between the lower rib margin and the iliac crest. The body height was measured in meters while participants were not wearing shoes. The body weight was measured after participants removed heavy clothing, and 1 kg was deducted for the remaining garments. The body mass index was calculated as weight in kilograms divided by height in meters squared. After an overnight fasting, blood specimens were obtained for the measurements of serum lipids and glucose. Each participant's specimens were sent to the central certified laboratory of the Chinese People's Liberation Army General Hospital in fewer than 30 min.

Definition of MCI

Trained neurologists evaluated each participant's cognitive function with the Mini-Mental State Examination (MMSE), which is a commonly used measurement worldwide.²¹ MCI was defined as an MMSE score < 17 for illiterate subjects, < 20 for subjects with 1–6 years of education and < 24 for subjects with ≥ 7 years of education. These MMSE score cutoff points demonstrated high efficiency in diagnosing MCI among the elderly population in China.^{22,23}

BP measurement and definitions

Before the survey, each participant was asked to avoid drinking alcohol, smoking cigarettes and drinking coffee or tea. Each participant's blood pressure records were obtained from 0700 to 0800 hours. Using standardized mercury sphygmomanometers, we obtained the blood pressure records from the right arm of each participant while he/she was in a sitting position. Both diastolic blood pressure and systolic blood pressure were measured twice with a resting interval between the two measurements. The mean of the two readings was calculated to record each participant's blood pressure value. If the two measurements differed by more than 10 mm Hg, the participant's blood pressure was measured a third time, and the average of the three measurements was calculated as the final measurement. Trained observers calculated the average of the three records as the final measurement.

Hypertension was defined as systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg and/or the self-reported use of antihypertensive medication.²⁴ Among the hypertensive patients in the review, hypertension treatment was defined as the use of prescribed antihypertensive drugs in the previous 2 weeks. Control of hypertension was defined as pharmacological treatment of hypertension associated with an average systolic blood pressure < 140 mm Hg and an average diastolic blood pressure < 90 mm Hg.²⁵

Statistical analysis

The data were double entered using Epidata (3.1). SPSS (SPSS Inc., Chicago, IL, USA) for Windows (19.0) was used for the data analysis. A two-sided $P < 0.05$ was defined as statistical significance.

The baseline characteristics were described using descriptive statistics, and the *t*-test and χ^2 -test were used to assess differences in the continuous and categorical variables, respectively, unless otherwise specified. The relationship between the prevalence, treatment and control of hypertension and the MMSE score (continuous variable) was examined using a multivariable linear regression model. Logistic regression was used to calculate the unadjusted and adjusted odds ratios (ORs) and the 95% confidence intervals (95% CIs) of the prevalence, treatment and control of hypertension, and the prevalence of MCI. The participants who had cerebrovascular diseases or were < 65 years of age were excluded from the sensitivity analysis.

RESULTS

Description of the population

The baseline characteristics of the participants are shown in Table 1. The data for a total of 2065 (839 males and 1226 females) participants were included in the analysis. The mean age of the participants was 71.7 ± 6.6 years, with a range from 60 to 95 years. The male participants were significantly older, were taller and had greater weight, higher waist circumference, lower systolic blood pressure, higher diastolic blood pressure, lower total cholesterol, lower triglycerides, lower high-density lipoprotein-cholesterol, lower low-density lipoprotein-cholesterol and higher MMSE scores than the female participants. The proportions of male participants who were better educated, married, normotensive and currently drinking and smoking were significantly higher than those of the female participants.

Overall, the mean MMSE score was 27.0 ± 3.6 , and the prevalences of MCI and hypertension were 15.4% and 68.2%, respectively. In the hypertensive patient population, the rates of hypertension treatment and control were 67.1% and 29.6%, respectively. A rate of hypertension control of 44.1% was achieved in the population of treated hypertensive patients. The prevalence of MCI showed little difference between males (16.0%) and females (15.1%). The prevalence of hypertension in female participants (70.8%) was significantly higher than that in male participants (64.4%). The analysis of the population of treated hypertensive patients revealed that the hypertension control rate in male participants (48.4%) was significantly higher than that achieved in female participants (41.6%). A higher proportion of females (68.9%) than males (64.3%) was treated as hypertensive patients, whereas more males (31.1%) than females (28.7%) were controlled hypertensive patients; however, the differences were not significant.

The association between hypertension and MMSE scores

Table 2 shows the unadjusted and adjusted association between the prevalence, treatment and control of hypertension and the MMSE score by gender. Overall, the prevalence of hypertension was negatively associated with the MMSE score, whereas the treatment and control of hypertension were associated with the MMSE score (all $P < 0.05$). For the MMSE score (as a continuous variable), after adjusting for age, education level, marital status, physical activity, smoking and drinking status, body mass index, triglycerides, high-density lipoprotein, low-density lipoprotein, diabetes mellitus (yes/no), history of stroke and family history of dementia, the hypertensive patients had a significantly lower MMSE score (by 0.68) than the normotensives. The assessment of the population of hypertensive patients ($n = 1408$) revealed that the treated hypertensive patients had a significantly higher MMSE score (by 0.85) than the untreated hypertensive patients.

Table 1 Characteristics of the elderly population by gender

Characteristics	Male (n = 839)	Female (n = 1226)	P-value	All (n = 2065)
<i>Mean ± s.d.</i>				
Age (years)	72.9 ± 6.9	70.9 ± 6.3	<0.001	71.7 ± 6.6
Height (cm)	167.4 ± 5.8	155.5 ± 5.5	<0.001	160.3 ± 8.1
Weight (kg)	70.1 ± 10.2	60.5 ± 9.4	<0.001	64.4 ± 10.8
BMI (kg m ⁻²)	25.0 ± 3.1	25.0 ± 3.6	0.641	25.0 ± 3.4
WC (cm)	91.2 ± 8.5	86.3 ± 9.0	<0.001	88.3 ± 9.1
SBP (mm Hg)	136.6 ± 17.8	140.6 ± 20.9	<0.001	139.0 ± 19.8
DBP (mm Hg)	78.3 ± 9.7	76.6 ± 10.0	<0.001	77.3 ± 9.9
TC (mmol l ⁻¹)	4.9 ± 0.9	5.5 ± 1.0	<0.001	5.3 ± 1.0
TG (mmol l ⁻¹)	1.5 ± 0.9	1.8 ± 0.9	<0.001	1.7 ± 0.9
HDL-C (mmol l ⁻¹)	1.3 ± 0.4	1.5 ± 0.4	<0.001	1.4 ± 0.4
LDL-C (mmol l ⁻¹)	3.1 ± 0.8	3.4 ± 0.9	<0.001	3.3 ± 0.9
FPG (mmol l ⁻¹)	6.1 ± 1.5	6.1 ± 1.8	0.942	6.1 ± 1.7
MMSE score	27.2 ± 3.5	26.8 ± 3.7	0.013	27.0 ± 3.6
<i>N (%)</i>				
Education (>7 years)	691 (82.4)	797 (65.0)	<0.001	1488 (72.1)
Marital status	774 (92.3)	967 (78.9)	<0.001	1741 (84.3)
Current drinker	322 (38.4)	94 (7.7)	<0.001	416 (20.1)
Current smoker	179 (21.3)	51 (4.2)	<0.001	230 (11.1)
Physical activity (≥1 h per day)	734 (87.5)	1038 (84.7)	0.071	1772 (85.8)
Prevalence of MCI	134 (16.0)	185 (15.1)	0.586	319 (15.4)
Prevalence of hypertension	540 (64.4)	868 (70.8)	0.002	1408 (68.2)
Treated hypertensive patients in the hypertensive patient population	347/540 (64.3)	598/868 (68.9)	0.072	945/1408 (67.1)
Patients with controlled hypertension in the population of hypertensive patients	168/540 (31.1)	249/868 (28.7)	0.333	417/1408 (29.6)
Patients with controlled hypertension in the population of treated hypertensive patients	168/347 (48.4)	249/598 (41.6)	0.043	417/945 (44.1)

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; FPG, fasting plasma glucose; HDL-C, high-density lipoprotein-cholesterol; LDL-C, low-density lipoprotein-cholesterol; MCI, mild cognitive impairment; MMSE, mini-mental state examination; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides; WC, waist circumference.

In the population of hypertensive patients ($n = 1408$), the patients with controlled hypertension had a significantly higher MMSE score (by 0.52) compared with those non-controlled hypertension (regardless of treatment). There was no significant difference in the MMSE score between the hypertensive patients who received treatment for hypertension and achieved or did not achieve the treatment goal. Both male and female participants showed trends that were similar to those obtained in the main analyses.

The association between hypertension and MCI

Table 3 shows the unadjusted and adjusted associations between the prevalence, treatment and control of hypertension and the prevalence of MCI by gender. Overall, the prevalence of MCI was higher in hypertensive (16.5%) than in normotensive (13.1%; $P = 0.043$) patients. Furthermore, in those hypertensive patients, the prevalence of MCI was lower in those treated (14.9%) than in those not treated (19.9%; $P = 0.019$) and lower in those controlled (13.4%) than in those uncontrolled (17.9%; $P = 0.042$). For the prevalence of MCI (as a dichotomous variable), after adjusting for age, education level, marital status, physical activity, smoking and drinking status, body mass index, triglycerides, high-density lipoprotein, low-density lipoprotein, diabetes mellitus (yes/no), history of stroke and family history of dementia, the OR (95% CI) of having MCI was 1.59 (1.07–2.35) in those with hypertension compared with those normotensive individuals. In the hypertensive patients ($n = 1408$), the adjusted OR (95% CI) of having MCI in those with treated hypertension was 0.60 (0.42–0.86) compared with those with untreated hypertension, and in those with controlled hypertension was 0.64 (0.43–0.93) compared with those with non-controlled

hypertension (regardless of treatment). However, the difference between the treated hypertensive patients who achieved and those who did not achieve their treatment goal was not significant. Both male and female participants showed trends that were similar to those obtained in the main analyses, but the differences were not significant in females.

Table 4 shows the unadjusted and adjusted associations between the prevalence, treatment and control of hypertension and the prevalence of MCI by age. Overall, participants in all age groups showed trends that were similar to those of the general population. In the 60–69 age group ($n = 748$), the adjusted OR (95% CI) of having MCI was 1.90 (1.10–3.29) in those with hypertension compared with those normotensive individuals. In the population of hypertensive patients belonging to the 60–69 age group ($n = 424$), the adjusted OR (95% CI) of having MCI in those with treated hypertension was 0.41 (0.23–0.71) compared with those with untreated hypertension, and in those with controlled hypertension was 0.53 (0.29–0.97) compared with those with non-controlled hypertension (regardless of treatment). However, among the treated hypertensive patients, there was no difference in the prevalence of MCI between the patients who reached and those who did not reach their treatment goal. In addition, the differences were not significant between the age groups of 70–79 years and ≥80 years.

Sensitivity analysis

We assessed the relationship between the prevalence, treatment and control of hypertension and the prevalence of MCI in the sensitivity analysis (Appendix Tables 1 and 2). The results did not change after excluding the participants with cerebrovascular diseases ($n = 261$, 12.6%) and the participants aged 60–64 years ($n = 358$, 17.3%).

Table 2 Association between the prevalence, treatment and control of hypertension and the MMSE score by gender

MMSE score	Unadjusted β (95% CI), P	Adjusted ^a β (95% CI), P
<i>Male (n = 839)</i>		
Normotensives (n = 299, reference group)		
Hypertensives (n = 540)	-0.80 (-1.28, -0.31), 0.001	-0.88 (-1.62, -0.14), 0.020
Untreated hypertensives (n = 193, reference group)		
Treated hypertensives (n = 347)	0.62 (-0.03, 1.27), 0.062	0.75 (-0.05, 1.54), 0.067
Uncontrolled hypertensives among hypertensives (n = 372, reference group)		
Controlled hypertensives among hypertensives (n = 168)	0.54 (-0.14, 1.21), 0.120	0.62 (-0.17, 1.41), 0.121
Uncontrolled hypertensives among treated hypertensives (n = 179, reference group)		
Controlled hypertensives among treated hypertensives (n = 168)	0.29 (-0.45, 1.02), 0.445	0.18 (-0.65, 1.00), 0.671
<i>Female (n = 1226)</i>		
Normotensives (n = 358, reference group)		
Hypertensives (n = 868)	-0.63 (-1.08, -0.18), 0.006	-0.48 (-1.10, 0.15), 0.134
Untreated hypertensives (n = 270, reference group)		
Treated hypertensives (n = 598)	1.18 (0.66, 1.69), <0.001	0.91 (0.37, 1.44), 0.001
Uncontrolled hypertensives among hypertensives (n = 619, reference group)		
Controlled hypertensives among hypertensives (n = 249)	1.04 (0.51, 1.57), <0.001	0.50 (-0.03, 1.03), 0.063
Uncontrolled hypertensives among treated hypertensives (n = 349, reference group)		
Controlled hypertensives among treated hypertensives (n = 249)	0.65 (0.10, 1.20), 0.020	0.33 (-0.22, 0.89), 0.239
<i>All (n = 2065)</i>		
Normotensives (n = 657, reference group)		
Hypertensives (n = 1408)	-0.73 (-1.06, -0.40), <0.001	-0.68 (-1.15, -0.21), 0.005
Untreated hypertensives (n = 463, reference group)		
Treated hypertensives (n = 945)	0.94 (0.53, 1.34), <0.001	0.85 (0.40, 1.29), <0.001
Uncontrolled hypertensives among hypertensives (n = 991, reference group)		
Controlled hypertensives among hypertensives (n = 417)	0.85 (0.43, 1.27), <0.001	0.52 (0.08, 0.96), 0.020
Uncontrolled hypertensives among treated hypertensives (n = 528, reference group)		
Controlled hypertensives among treated hypertensives (n = 417)	0.52 (0.09, 0.96), 0.019	0.23 (-0.22, 0.68), 0.321

Abbreviations: CI, confidence interval; MMSE, mini-mental state examination.

^aAdjusted for age, education level, marital status, physical activity, smoking and drinking status, body mass index, triglycerides, high-density lipoprotein, low-density lipoprotein, diabetes mellitus (yes/no), history of stroke and family history of dementia.

DISCUSSION

The present study is a population-based, cross-sectional study with a strict training process and quality assurance programs. After adjusting for confounding variables, we found that the prevalence of hypertension was positively associated with the prevalence of MCI, whereas the treatment of hypertension was negatively related to the prevalence of MCI, particularly in males and the younger elderly population in an urban community in Beijing, China.

Previous studies on the cognitive consequences of hypertension among the elderly population have yielded inconsistent results. Both positive and negative relationships have been reported between hypertension and cognition decline. A cross-sectional study by Paran *et al.*²⁶ reported that increasing blood pressure was related to a reduced risk of cognitive impairment in an elderly population aged 70–85 years. Guo *et al.* also found that lower blood pressure was associated with poor cognitive performance in participants aged 75–101 years. It should be noted that the participants in the reports mentioned above was older than the participants in the present study. The possible biological mechanism linking blood pressure and cognitive decline has been explored by Skoog,²⁷ who found that age-related changes in the brain might contribute to low blood pressure in very old people. In the present study, we did not find significant differences between hypertension and MCI in the 70–79 and ≥ 80 age groups. However, for the 10.6% of the very elderly (≥ 80

years) in the present study, we could not make an affirmative conclusion because of the limited sample size.

Nonetheless, the findings of the current study are in accordance with previous authors who have reported a positive relationship between hypertension and cognitive decline. Budge *et al.*²⁸ reported that blood pressure was negatively related to the MMSE score in an elderly community. A cohort study of 13 476 African-American and white participants indicated that midlife hypertension was associated with more cognitive decline over the 20-year study period.²⁹ Okusaga *et al.*⁴ reported that elevated blood pressure might be a risk factor for cognitive decline in a population-based cohort design. For the prevalence of MCI, both male and female participants showed trends that were similar to those of the general population, but the differences were not significant in females. To the best of our knowledge, no previous studies have separately studied men and women. Further prospective cohort studies with larger samples should be conducted to explore possible explanation for potential gender differences.

Whether lowering blood pressure aids in preventing dementia or cognitive decline in hypertensive patients is unclear.³⁰ There have been reports that antihypertensive therapy has a protective effect on cognitive impairment, but other authors report an adverse result. In a meta-analysis, Chang-Quan *et al.*¹³ evaluated the association between antihypertensive medication use and the risk of cognitive decline but showed that antihypertensive treatment did not decrease the risk of cognitive decline. The conclusion of Chang-Quan *et al.* should be

Table 3 Association between the prevalence, treatment and control of hypertension and the prevalence of MCI by gender

Prevalence of MCI	N (%)	Unadjusted OR (95% CI), P	Adjusted ^a OR (95% CI), P
<i>Male</i>			
Normotensives (reference group)	36/299 (12.0)		
Hypertensives	98/540 (18.1)	1.62 (1.07–2.44), 0.022	2.20 (1.21–4.01), 0.010
Untreated hypertensives (reference group)	43/193 (22.3)		
Treated hypertensives	55/347 (15.9)	0.66 (0.42–1.03), 0.064	0.47 (0.27–0.82), 0.009
Uncontrolled hypertensives among hypertensives (reference group)	76/372 (20.4)		
Controlled hypertensives among hypertensives	22/168 (13.1)	0.59 (0.35–0.98), 0.042	0.47 (0.25–0.88), 0.019
Uncontrolled hypertensives among treated hypertensives (reference group)	33/179 (18.4)		
Controlled hypertensives among treated hypertensives	22/168 (13.1)	0.67 (0.37–1.20), 0.175	0.64 (0.31–1.32), 0.224
<i>Female</i>			
Normotensives (reference group)	50/358 (14.0)		
Hypertensives	135/868 (15.6)	1.14 (0.80–1.61), 0.481	1.41 (0.91–2.19), 0.122
Untreated hypertensives (reference group)	49/270 (18.1)		
Treated hypertensives	86/598 (14.4)	0.76 (0.52–1.11), 0.157	0.68 (0.42–1.09), 0.108
Uncontrolled hypertensives among hypertensives (reference group)	101/619 (16.3)		
Controlled hypertensives among hypertensives	34/249 (13.7)	0.81 (0.53–1.23), 0.328	0.73 (0.45–1.19), 0.206
Uncontrolled hypertensives among treated hypertensives (reference group)	52/349 (16.3)		
Controlled hypertensives among treated hypertensives	34/249 (13.7)	0.90 (0.57–1.44), 0.669	0.75 (0.43–1.29), 0.298
<i>All</i>			
Normotensives (reference group)	86/657 (13.1)		
Hypertensives	233/1408 (16.5)	1.32 (1.01–1.72), 0.043	1.59 (1.07–2.35), 0.022
Untreated hypertensives (reference group)	92/463 (19.9)		
Treated hypertensives	141/945 (14.9)	0.71 (0.53–0.95), 0.019	0.60 (0.42–0.86), 0.005
Uncontrolled hypertensives among hypertensives (reference group)	177/991 (17.9)		
Controlled hypertensives among hypertensives	56/417 (13.4)	0.71 (0.52–0.99), 0.042	0.64 (0.43–0.93), 0.020
Uncontrolled hypertensives among treated hypertensives (reference group)	85/528 (16.1)		
Controlled hypertensives among treated hypertensives	56/417 (13.4)	0.81 (0.56–1.16), 0.253	0.75 (0.49–1.16), 0.194

Abbreviations: CI, confidence interval; MCI, mild cognitive impairment; OR, odds ratio.

^aAdjusted for age, education level, marital status, physical activity, smoking and drinking status, body mass index, triglycerides, high-density lipoprotein, low-density lipoprotein, diabetes mellitus (yes/no), history of stroke and family history of dementia.

further improved because the data from randomized controlled trials and observational studies were pooled together. The findings of the current study were in line with some randomized controlled trials. Tzourio *et al.*³¹ confirmed the association between active treatment and the reduced risk of both dementia and cognitive decline, and the treatment group showed a 19% reduction of the risk of cognitive decline. Forette *et al.*³² reported that antihypertensive treatment was related to a 50% reduction in the incidence of dementia in an elderly population. A 4-year follow-up study by Tzourio *et al.*³³ reported that untreated hypertensive participants displayed significantly worse cognitive performance on the MMSE than did normotensive and treated hypertensive participants. Spinelli *et al.*⁶ used various cognitive assessments scores, including MMSE scores, and reported that poorer blood pressure control was associated with impaired cognition among treated hypertensive subjects.

It is worth noting that the two ORs (ORs for the prevalence of MCI in treated hypertensive patients compared with all untreated hypertensive patients and in patients with controlled hypertensive compared with those with non-controlled hypertension regardless of treatment) obtained throughout the main analyses were similar. In addition, the differences in the MMSE score and the prevalence of MCI were not significant between treated hypertensive patients who reached and those who did not reach their treatment goal in the present study. The results suggest that treatment for hypertension by itself appears to exert a protective effect against MCI, but the results show that the

aims of controlled and uncontrolled hypertension have almost no impact on the prevalence of MCI. Admittedly, the present study was limited by its small sample size; thus, a larger sample size is required to detect the association between hypertension control and the prevalence of MCI among treated hypertensive patients in future research.

Furthermore, numerous complex factors may be involved in the evaluation of higher blood pressure and poorer cognitive performance. Long-term hypertension might be associated with brain white matter diseases, resulting in cognitive impairment.^{34,35} In addition, brain tissue loss might occur as a result of stroke, which is associated with cognitive impairment. As the most important risk factor for stroke, hypertension substantially increases the risk of cognitive impairment.³⁶ Kobayashi *et al.*³⁷ found that diastolic blood pressure is an independent risk factor affecting the extent of decreased regional cerebral blood flow and is considered an indicator of cognitive impairment.³⁸ In general, hypertension does not exist alone; it is always accompanied by other risk factors, such as metabolic risks^{39,40} or stroke-related factors.^{41,42} Future research should focus on the interaction of multiple risk factors with a longer follow-up period.

Admittedly, this study has some limitations. First, cross-sectional studies are limited in determining the direction of an association, as both the exposure and the outcome are simultaneously assessed. Second, the information (lifestyles and disease histories) about each participant was self-reported, which might result in recall bias. To

Table 4 Association between the prevalence, treatment and control of hypertension and the prevalence of MCI by age

Prevalence of MCI	N (%)	Unadjusted OR (95% CI), P	Adjusted ^a OR (95% CI), P
<i>60–69 years</i>			
Normotensives (reference group)	32/324 (9.9)		
Hypertensives	52/424 (12.3)	1.28 (0.80–2.03), 0.306	1.90 (1.10–3.29), 0.022
Untreated hypertensives (reference group)	23/142 (16.2)		
Treated hypertensives	29/282 (10.3)	0.59 (0.33–1.07), 0.082	0.41 (0.23–0.71), 0.002
Uncontrolled hypertensives among hypertensives (reference group)	38/280 (13.6)		
Controlled hypertensives among hypertensives	14/144 (9.7)	0.69 (0.36–1.31), 0.255	0.53 (0.29–0.97), 0.039
Uncontrolled hypertensives among treated hypertensives (reference group)	15/138 (10.9)		
Controlled hypertensives among treated hypertensives	14/144 (9.7)	0.88 (0.41–1.91), 0.751	0.72 (0.34–1.51), 0.388
<i>70–79 years</i>			
Normotensives (reference group)	40/278 (14.4)		
Hypertensives	135/821 (16.4)	1.17 (0.80–1.72), 0.419	1.22 (0.77–1.94), 0.390
Untreated hypertensives (reference group)	47/263 (17.9)		
Treated hypertensives	88/558 (15.8)	0.86 (0.58–1.27), 0.449	0.80 (0.54–1.19), 0.277
Uncontrolled hypertensives among hypertensives (reference group)	103/594 (17.3)		
Controlled hypertensives among hypertensives	32/227 (14.1)	0.78 (0.51–1.20), 0.263	0.77 (0.51–1.15), 0.201
Uncontrolled hypertensives among treated hypertensives (reference group)	56/331 (16.9)		
Controlled hypertensives among treated hypertensives	32/227 (14.1)	0.81 (0.50–1.29), 0.370	0.78 (0.50–1.22), 0.278
<i>≥ 80 years</i>			
Normotensives (reference group)	14/55 (25.5)		
Hypertensives	46/163 (28.2)	1.15 (0.57–2.31), 0.691	2.44 (0.60–9.94), 0.213
Untreated hypertensives (reference group)	22/58 (37.9)		
Treated hypertensives	24/105 (22.9)	0.49 (0.24–0.98), 0.042	0.56 (0.15–2.11), 0.391
Uncontrolled hypertensives among hypertensives (reference group)	36/117 (30.8)		
Controlled hypertensives among hypertensives	10/46 (21.7)	0.63 (0.28–1.40), 0.251	0.50 (0.17–1.52), 0.225
Uncontrolled hypertensives among treated hypertensives (reference group)	14/59 (23.7)		
Controlled hypertensives among treated hypertensives	10/46 (21.7)	0.89 (0.36–2.25), 0.810	0.47 (0.13–1.75), 0.259

Abbreviations: CI, confidence interval; MCI, mild cognitive impairment; OR, odds ratio.

^aAdjusted for age, education level, marital status, physical activity, smoking and drinking status, body mass index, triglycerides, high-density lipoprotein, low-density lipoprotein, diabetes mellitus (yes/no), history of stroke and family history of dementia.

avoid these issues, we asked all the participants to bring their certificate of disease diagnosis to the interview, if possible. Third, detailed information on the participants' diets and types of antihypertensive drugs used was not collected; such factors might be important covariates in the analysis of the study. Fourth, the association between hypertension and cognitive function is multifactorial, and the elderly population often has many risk factors, such as atherosclerosis, cardiovascular disease and diabetes mellitus. Although we have adjusted the potential confounding variables in the analysis, other undetected covariates might affect the results of the current study. Fifth, hypertensive patients who exhibit mild cognitive impairment may experience difficulty in going to a clinic/hospital and/or taking antihypertensive medication. This possible issue may have had a critical influence on the cross-sectional relationship of interest. Sixth, misclassification bias may exist in the present study. Some of the treated hypertensive patients may have not taken antihypertensive medication in the morning of the day of the study because the study participants were asked to undergo this examination without having eaten breakfast that day. This may have led to the misclassification of some of the patients with controlled hypertension as patients with uncontrolled hypertension due to an increase in blood pressure on the day of study. Finally, the Wanshoulu Community is a metropolitan area that is representative of the geographic and economic characteristics of Beijing, but the results are likely difficult to generalize to other areas in China. Further prospective studies with larger sample sizes are

required to examine the association between the prevalence, awareness and treatment of hypertension and cognitive performance in the elderly population in China.

CONCLUSIONS

In conclusion, the present study showed a positive relationship between the prevalence of hypertension, untreated hypertension and an increased risk of cognitive impairment, particularly in males and the younger elderly population in an urban community of Beijing. The question of whether treatment for hypertension reached or did not reach the treatment goal to have an impact on the prevalence of MCI is an important topic to be addressed with a larger sample size in future research. Our findings suggest that improved diagnoses and optimal therapeutics are needed to achieve the target of cognitive decline prevention in the elderly population.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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APPENDIX TABLE 1 Association between the prevalence, treatment and control of hypertension and the prevalence of MCI in participants without cerebrovascular disease by gender (*n* = 1804)

<i>Prevalence of MCI</i>	<i>N (%)</i>	<i>Unadjusted OR (95% CI), P</i>	<i>Adjusted^a OR (95% CI), P</i>
<i>Male</i>			
Normotensives (reference group)	32/275 (11.6)		
Hypertensives	74/447 (16.6)	1.51 (0.97–2.35), 0.071	2.22 (1.15–4.29), 0.017
Untreated hypertensives (reference group)	35/174 (20.1)		
Treated hypertensives	39/273 (14.3)	0.66 (0.40–1.09), 0.107	0.60 (0.31–1.14), 0.118
Uncontrolled hypertensives among hypertensives (reference group)	60/320 (18.8)		
Controlled hypertensives among hypertensives	14/127 (11.0)	0.54 (0.29–1.00), 0.050	0.57 (0.27–1.19), 0.134
Uncontrolled hypertensives among treated hypertensives (reference group)	25/146 (17.1)		
Controlled hypertensives among treated hypertensives	14/127 (11.0)	0.60 (0.30–1.21), 0.154	0.68 (0.30–1.58), 0.375
<i>Female</i>			
Normotensives (reference group)	43/331 (13.0)		
Hypertensives	115/751 (15.3)	1.21 (0.83–1.77), 0.319	1.30 (0.73–2.33), 0.371
Untreated hypertensives (reference group)	43/241 (17.8)		
Treated hypertensives	72/510 (14.1)	0.76 (0.50–1.14), 0.187	0.72 (0.43–1.21), 0.220
Uncontrolled hypertensives among hypertensives (reference group)	86/538 (16.0)		
Controlled hypertensives among hypertensives	29/213 (13.6)	0.83 (0.53–1.31), 0.417	0.85 (0.50–1.44), 0.534
Uncontrolled hypertensives among treated hypertensives (reference group)	43/297 (14.5)		
Controlled hypertensives among treated hypertensives	29/213 (13.6)	0.93 (0.56–1.55), 0.783	0.88 (0.48–1.61), 0.681
<i>All</i>			
Normotensives (reference group)	75/606 (12.4)		
Hypertensives	189/1198 (15.8)	1.33 (1.00–1.77), 0.054	1.61 (1.05–2.48), 0.029
Untreated hypertensives (reference group)	78/415 (18.8)		
Treated hypertensives	111/783 (14.2)	0.71 (0.52–0.98), 0.037	0.67 (0.45–0.99), 0.045
Uncontrolled hypertensives among hypertensives (reference group)	146/858 (17.0)		
Controlled hypertensives among hypertensives	43/340 (12.6)	0.71 (0.49–1.02), 0.062	0.72 (0.47–1.10), 0.130
Uncontrolled hypertensives among treated hypertensives (reference group)	68/443 (15.3)		
Controlled hypertensives among treated hypertensives	43/340 (12.6)	0.80 (0.53–1.20), 0.283	0.81 (0.50–1.31), 0.390

Abbreviations: CI, confidence interval; MCI, mild cognitive impairment; OR, odds ratio.

^aAdjusted for age, education level, marital status, physical activity, smoking and drinking status, body mass index, triglycerides, high-density lipoprotein, low-density lipoprotein, diabetes mellitus (yes/no), history of stroke and family history of dementia.

APPENDIX TABLE 2 Association between the prevalence, treatment and control of hypertension and the prevalence of MCI in participants aged at least 65 years by gender (n = 1707)

Prevalence of MCI	N (%)	Unadjusted OR (95% CI), P	Adjusted ^a OR (95% CI), P
<i>Male</i>			
Normotensives (reference group)	32/238 (13.4)		
Hypertensives	91/479 (19.0)	1.51 (0.98–2.34), 0.065	2.05 (1.07–3.90), 0.030
Untreated hypertensives (reference group)	39/164 (23.8)		
Treated hypertensives	52/315 (16.5)	0.63 (0.40–1.01), 0.055	0.48 (0.26–0.87), 0.016
Uncontrolled hypertensives among hypertensives (reference group)	71/331 (21.5)		
Controlled hypertensives among hypertensives	20/148 (13.5)	0.57 (0.33–0.98), 0.043	0.44 (0.22–0.85), 0.014
Uncontrolled hypertensives among treated hypertensives (reference group)	32/167 (19.2)		
Controlled hypertensives among treated hypertensives	20/148 (13.5)	0.66 (0.36–1.21), 0.180	0.56 (0.26–1.19), 0.130
<i>Female</i>			
Normotensives (reference group)	37/257 (14.4)		
Hypertensives	117/733 (16.0)	1.13 (0.76–1.69), 0.552	1.49 (0.81–2.73), 0.196
Untreated hypertensives (reference group)	44/229 (19.2)		
Treated hypertensives	73/504 (14.5)	0.71 (0.47–1.08), 0.106	0.61 (0.36–1.01), 0.053
Uncontrolled hypertensives among hypertensives (reference group)	90/536 (16.8)		
Controlled hypertensives among hypertensives	27/179 (13.7)	0.79 (0.49–1.25), 0.313	0.61 (0.35–1.07), 0.085
Uncontrolled hypertensives among treated hypertensives (reference group)	46/307 (15.0)		
Controlled hypertensives among treated hypertensives	27/179 (13.7)	0.90 (0.54–1.51), 0.691	0.69 (0.37–1.27), 0.230
<i>All</i>			
Normotensives (reference group)	69/495 (13.9)		
Hypertensives	208/1212 (17.2)	1.28 (0.95–1.72), 0.102	1.69 (1.09–2.61), 0.018
Untreated hypertensives (reference group)	83/393 (21.1)		
Treated hypertensives	125/819 (15.3)	0.67 (0.49–0.92), 0.012	0.56 (0.39–0.83), 0.003
Uncontrolled hypertensives among hypertensives (reference group)	161/867 (18.6)		
Controlled hypertensives among hypertensives	47/345 (13.6)	0.69 (0.49–0.98), 0.040	0.55 (0.36–0.84), 0.005
Uncontrolled hypertensives among treated hypertensives (reference group)	78/474 (16.5)		
Controlled hypertensives among treated hypertensives	47/345 (13.6)	0.80 (0.54–1.19), 0.266	0.66 (0.42–1.05), 0.082

Abbreviations: CI, confidence interval; MCI, mild cognitive impairment; OR, odds ratio.

^aAdjusted for age, education level, marital status, physical activity, smoking and drinking status, body mass index, triglycerides, high-density lipoprotein, low-density lipoprotein, diabetes mellitus (yes/no), history of stroke and family history of dementia.