# Differential Control of Systolic and Diastolic Blood Pressure: Factors Associated With Lack of Blood Pressure Control in Rural Community of Liaoning Province, China

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(Received August 29, 2006; Accepted November 10, 2006)

**The purpose of the study was to determine whether poor hypertension control is due to lack of systolic blood pressure control, diastolic blood pressure control or both. We analyzed data from 10854 Chinese patients (age ≥ 35 years old) with hypertension from 60 villages of Fuxin County between 2004 and 2005 in Liaoning province of China. We screened for hypertension with a systolic blood pressure of ≥ 140 mmHg or a diastolic blood pressure of ≥ 90 mmHg, or those who were taking antihypertensive therapy at the time of the examination. Blood pressure control was defined as systolic goal (systolic < 140 mmHg), diastolic goal (diastolic < 90 mmHg), or both (systolic < 140 mmHg and diastolic < 90 mmHg). Statistical analysis was performed using the software of Statistical Program for Social Sciences (SPSS) version 11.5, and a value of $P < 0.05$ was considered to indicate statistical significance. Of 10854 hypertensive patients (mean age 56.2 years, 50.2% women), 14.7% were controlled to systolic goal, 33.9% were controlled to diastolic goal, and 1.0% were controlled to both. Among 2450 subjects who were undergoing antihypertensive therapy (22.6% of all hypertensive patients), 6.5% were controlled to systolic goal, 22.1% were controlled to diastolic goal, and 4.3% were controlled to both. Thus, poor systolic blood pressure control was overwhelmingly responsible for poor rates of overall control to goal. Covariates associated with lack of systolic control in treated patients included older age (compared with patients aged 35 to 44 years, Odds Ratio (OR) for age 55 to 64 years, 1.814, 95% CI 1.087–3.028; OR for age ≥ 65 years, 2.753, 95% CI 1.558–4.863) and prevalent CVD (cardiovascular disease) (OR 0.666, 95% CI 0.464–0.956). The same covariates were associated with the lack of both control(systolic < 140 mmHg and diastolic < 90 mmHg). In this rural community-based sample of middle-aged and older subjects, overall rates of antihypertensive therapy and hypertension control were lower than those in the National Health and Nutrition Examination Survey conducted in 2002. Poor blood pressure control was overwhelmingly due to lack of systolic control, even among the treated subjects. Therefore, greater emphasis should be placed by clinicians and policymakers on the achievement of systolic goal levels in all hypertensive patients, especially in the elderly.**

**Key words**——hypertension detection and control, blood pressure, epidemiology, antihypertensive

## INTRODUCTION

Hypertension is a risk factor for the development of stroke, congestive heart failure, coronary heart disease, peripheral vascular disease, and renal failure.[1)] More than 1.6 billion Chinese are currently suffering from hypertension, a major risk factor for the development of cardiovascular disease (CVD) and end-organ damage.[2)] However, data from a Chinese National Health and Nutrition Survey indicates that among hypertensive subjects, 30.2% are aware of having hypertension, 24.7% are receiving treatment, and 6.1% are controlled to goal blood pressure levels of systolic blood pressure (SBP) <140 mmHg and diastolic blood pressure (DBP) <90 mmHg.[3,4)] Even in U.S.A., the rate of hypertension control only reached 27.4% in the Third National Health and Nutrition Examination Survey (NHANES III, phase 2, performed from 1991 to 1994).[5,6)] It is important to understand the barriers to the control of hypertension in a commu-

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nity. Previous study did not obtain strong evidence showing whether poor rates of hypertension control are due to lack of SBP or DBP control, or both. As far as our own knowledge is concerned, only a Framingham Heart Study focused on this problem in western people. No similar research was done in Asian people, especially in rural communities of China. The purpose of our study was to determine rates of antihypertensive treatment among subjects with hypertension in a community-based sample, to determine rates of blood pressure control to SBP goal, DBP goal and both and to identify covariates associated with lack of blood pressure control among treated subjects.

## MATERIALS AND METHODS

**Subjects** —— This investigation was based on a large-scale epidemiological study in China with a cross-sectional survey that adopted a multi-stage, stratified clustering sampling scheme in Fuxin county of Liaoning province. Of 29970 subjects over 35 years of age examined between 2004 and 2005, we included only those with hypertension, defined as a SBP of ≥140 mmHg or a DBP of ≥90 mmHg, or those who were receiving antihypertensive therapy at the time of the examination.[7)]

**Associated Factors** —— There were 10854 subjects with hypertension. A questionnaire was developed to assess the associated factors which included body mass index (BMI), smoking, drinking, diabetes, lipid disorder, prevalent CVD, and family history. The weight and height of subjects were measured while they were wearing light clothes and no shoes. BMI was calculated as weight (kg)/height$^2$ (m$^2$). Information on smoking and drinking were based on a self-report. Diabetes and lipid disorders were defined as a history of physician-diagnosed report. Prevalent CVD was defined as a history of angina, coronary insufficiency, myocardial infarction and stroke. Family history was defined as the history of hypertension of one of their parents.

**Blood Pressure Measurement** —— At each examination, blood pressure was measured twice in the left arm by an examining physician using an electric sphygmomanometer after the subject had been at rest in a sitting position for ≥1 minutes. The mean value of the 2 separate systolic and 2 separate diastolic blood pressure measurements was used to derive the reported blood pressure for that examination.

**Hypertension Control** —— SBP control was defined as a SBP of <140 mmHg at the time of the physical examination. DBP control was defined as a DBP of <90 mmHg. Overall blood pressure control was defined as an SBP of <140 mmHg and a DBP of <90 mmHg.

**Statistical Analysis** —— All analyses were performed with SPSS statistical software version 11.5. A 2-tailed probability value of <0.05 was considered to be statistically significant. We first determined the rates of antihypertensive treatment and control among all 10854 subjects with hypertension. The proportion of subjects controlled to SBP goal, DBP goal, and both were calculated separately. With logistic regression analysis, the Odds Ratio (OR) and 95% CI for antihypertensive treatment were determined for subjects according to age group, sex, prevalent CVD, current smoking, drinking, diabetes, lipid disorders, family history and categorized BMI. Stepwise logistic regression was used to select covariates significantly associated with treatment after forcing the age group into the model, because the age was the most significant covariate associated with antihypertensive treatment.

We then determined rates of control to SBP goal, DBP goal, and both among the 2450 treated hypertensive patients. Multivariate stepwise logistic regression was performed to determine the covariates associated with lack of SBP control and with lack of DBP control in this subgroup. Because very few subjects ($n$ = 55) were controlled to SBP goal but not DBP goal, the models for lack of control to SBP goal and lack of overall control were nearly identical. Therefore, we have presented only the models for lack of control to SBP goal and DBP goal.

## RESULTS

### Study Sample

As stated, there were 10854 hypertensive subjects in the study sample. The mean age was 56.2 years, and 50.2% were women. Characteristics of the study sample are shown in Table 1.

### All Hypertensive Subjects

Among the 10854 subjects with hypertension, 2450 (22.6%) were receiving antihypertensive therapy, which is slightly lower than the treatment

**Table 1.** Baseline Characteristics of All 10854 Hypertensive Subjects and the Subset of 2450 Treated Hypertensive Subjects Examined Between 2004–2005 in Rural Community of Liaoning Province, China

| Characteristic | All Subjects, *n* (%) | | Treated Subjects, *n* (%) | |
|---|---|---|---|---|
| | Men (*n* = 5407) | Women (*n* = 5447) | Men (*n* = 1015) | Women (*n* = 1435) |
| Age, y | | | | |
| 35–44 | 1136 (21.0) | 1037 (19.0) | 129 (12.7) | 167 (11.6) |
| 45–54 | 1508 (27.9) | 1555 (28.5) | 245 (24.1) | 349 (24.3) |
| 55–64 | 1401 (25.9) | 1432 (26.1) | 308 (30.3) | 489 (34.1) |
| ≥65 | 1362 (25.2) | 1423 (26.1) | 333 (31.8) | 430 (30.0) |
| Prevalent CVD | 592 (10.9) | 665 (12.2) | 360 (35.5) | 401 (27.9) |
| Current Smoker | 3612 (66.8) | 1198 (22.0) | 622 (61.3) | 325 (22.6) |
| Drinking | 3034 (56.1) | 408 (7.5) | 484 (47.7) | 76 (5.3) |
| Family History | 1278 (23.6) | 1235 (22.7) | 355 (35.0) | 537 (37.4) |
| Diabetes | 38 (0.7) | 50 (0.9) | 23 (2.3) | 22 (1.5) |
| Lipid Disorder | 418 (7.7) | 408 (7.5) | 240 (23.6) | 622 (61.3) |
| BMI, kg/m$^2$ | | | | |
| < 25 | 4199 (77.7) | 3671 (67.4) | 729 (71.8) | 844 (58.8) |
| 25–30 | 1102 (20.4) | 1571 (28.8) | 251 (24.7) | 511 (35.6) |
| ≥30 | 106 (2.0) | 205 (3.8) | 35 (3.4) | 80 (5.6) |

CVD indicates cardiovascular disease; BMI indicates body mass index.

**Table 2.** Control to SBP Goal, DBP Goal, or Both by Gender Among All 10854 Subjects and 2450 Treated Subjects With Hypertension

| Subjects | SBP Goal (*n*, %) | DBP Goal (*n*, %) | SBP and DBP Goal (*n*, %) |
|---|---|---|---|
| All Subjects | | | |
| Men (*n* = 5407) | 840, 15.5 | 1770, 32.7 | 43, 0.8 |
| Women (*n* = 5447) | 756, 13.9 | 1960, 35.0 | 62, 1.1 |
| Total (*n* = 10854) | 1596, 14.7 | 3676, 33.9 | 105, 1.0 |
| Treated Subjects | | | |
| Men (*n* = 1015) | 72, 7.1 | 207, 20.4 | 43, 4.2 |
| Women (*n* = 1435) | 88, 6.1 | 335, 23.3 | 62, 4.3 |
| Total (*n* = 2450) | 160, 6.5 | 542, 22.1 | 105, 4.3 |

prevalence of 24.7% observed in the concurrent National Health and Nutrition Examination Survey conducted in 2002 in China. The blood pressure distribution of all hypertensive subjects is shown in Table 2. In this group, 14.7% were controlled to SBP goal (<140 mmHg), 33.9% were controlled to DBP goal (<90 mmHg), and 1.0% were controlled to both. The percentage of 1.0% controlled to overall goal that we observed is far lower than the percentage of 6.1% observed in the concurrent National Health and Nutrition Examination Survey sample. In the multivariate model, covariates that were associated with antihypertensive treatment included gender, older age, prevalent CVD, lipid disorder, overweight and obesity. Compared to men, women had an OR of 1.421 (95%CI 1.260 to 1.604) for treatment. Subjects aged 45 to 54 years had an OR of 1.443 (95%CI 1.225 to 1.701) for treatment, subjects aged 55 to 64 years had an OR of 2.454 (95%CI 2.087 to 2.886) and subjects aged ≥65 years had an OR of 2.489 (95%CI 2.104 to 2.945) compared with subjects 35 to 44 years of age. Subjects with prevalent CVD had an OR for treatment of 4.923 (4.296 to 5.643) compared with those without a history of CVD. Subjects with a history of lipid disorder had an OR of 4.171 (95%CI 3.531 to 4.929). Subjects with a BMI of 25 to 30 kg/m$^2$ had an OR of 1.521 (1.356 to 1.706), whereas those with a BMI of ≥30 kg/m$^2$ had an OR of 1.962 (1.500 to 2.566) compared with those with a BMI of <25 kg/m$^2$.

## Control Among Treated Hypertensive Subjects

Table 2 also shows the distribution of SBP and DBP among the 2450 treated hypertensive subjects. In this group, 6.5% were controlled to SBP goal,

22.1% were controlled to DBP goal, and 4.3% were controlled to both. Thus, poor systolic control was overwhelmingly responsible for poor rates of overall control to goal.

### Covariates Associated With Lack of Hypertension Control

We first examined the univariate relationships for gender and age with hypertension control. There were no significant statistical differences in rates of control to goal SBP and DBP levels among treated subjects with hypertension (data shown in Table 2). Age was associated with rates of control to goal SBP and DBP levels among treated subjects with hypertension. Similar results were observed among all hypertensive subjects. As shown in Fig. 1 and Fig. 2, older subjects had lower rates of SBP control and overall control but higher rates of DBP control. These age trends were observed in both men and women (data not shown). With multivariate stepwise logistic regression, the covariates that were associated with lack of SBP control were older age and prevalent CVD. Covariates associated with lack of DBP control are also shown in Table 3. Increasing age was significantly associated with lack of SBP control. Surprisingly, prevalent CVD had an adverse association with lack of SBP control in contrast with increasing age.

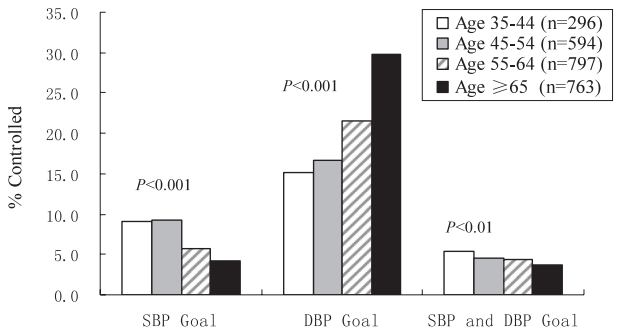


**Fig. 1.** Age-stratified Rates of Control to SBP Goal, DBP Goal, or Both Among 2450 Treated Subjects with Hypertension

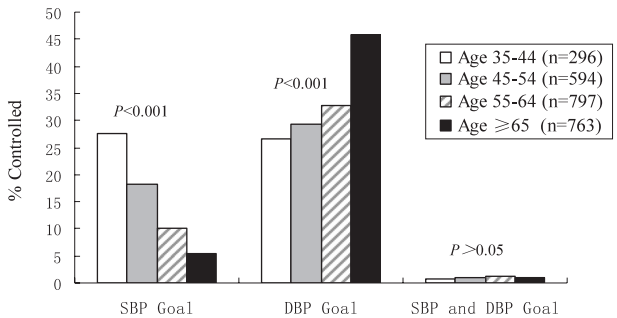


**Fig. 2.** Age-stratified Rates of Control to SBP Goal, DBP Goal, or Both Among all 10854 Hypertensive Subjects

## DISCUSSION

Data from the Third National Health and Nutrition Examination Survey (NHANES III, phase 2, performed in 1991 to 1994) in the United States indicates that only 53.6% of hypertensive patients were treated and only 27.4% were controlled to goal levels of systolic <140 mmHg and diastolic <90 mmHg.[6] Among our patients with hypertension, 22.6% were receiving treatment, and 1.0% were controlled to goal levels of <140/<90 mmHg. Blood pressure control was poor even among treated patients, at 4.3%. Rates of hypertension treatment and control that we observed in our community-based sample were far lower than those observed in NHANES III. There are several reasons. Rural patients in China rarely have the chance to go to a hospital to see a doctor and the doctor in a village do not have enough knowledge to treat the hypertensive patients, in contrast to patients in U.S.A. On the

**Table 3.** Covariates Associated With Lack of Control to SBP Goal (SBP <140 mmHg) or DBP Goal (DBP <90 mmHg) Among 2450 Treated Hypertensive Subjects

| Covariate | OR for Lack of Control to Goal Level (95% CI) | | | |
|---|---|---|---|---|
| | SBP < 140 mmHg | *P* | DBP < 90 mmHg | *P* |
| Age, y | | | | |
| 35–44 | 1.000 (reference) | | 1.000 (reference) | |
| 45–54 | 1.059 (0.648–1.731) | 0.820 | 0.964 (0.654–1.420) | 0.854 |
| 55–64 | 1.814 (1.087–3.028) | 0.023 | 0.716 (0.496–1.034) | 0.074 |
| ≥ 65 | 2.753 (1.558–4.863) | < 0.001 | 0.494 (0.341–0.716) | < 0.001 |
| Prevalent CVD | 0.666 (0.464–0.956) | 0.027 | * | |
| Lipid Disorder | * | | 1.316 (1.014–1.707) | 0.039 |

*: Not entered in model; CVD indicates cardiovascular disease.

other hand, our patients used mainly traditional antihypertensive medicine, whereas patients in U.S.A. take new antihypertensive medicine. Even though our finding coincides with the Framingham Heart Study,[9, 10] both revealed that the lack of SBP control was responsible for poor rates of blood pressure control.

Our findings extend the observations of low rates of hypertension treatment and control in China.[3, 4] Based on this survey, we attained first-hand data about the rates of treatment and control in a rural community of China and highlighted the factors associated with the lack of control. The factors associated with antihypertensive treatment included gender, age, prevalent CVD, lipid disorders, and obesity. Older age was associated with lack of SBP control, that is to say, older age was a significant risk factor with lack of SBP control. Increasing age was the most significant characteristic associated with lack of SBP control among treated subjects. In our study community, only the subjects who had a previous attack of CVD were undergoing antihypertensive therapy, so, prevalent CVD became a protective factor of lack of SBP control, in contrast to other results.[9, 10] Therefore, if improvement is to be seen in blood pressure control among treated patients, our data suggests that greater clinical and public health efforts should be directed at achieving goal SBP levels in all hypertensive patients, especially in the elderly. In addition, emphasis should be actively placed on treatment for hypertension.

Historically, elevated DBP was thought to confer a greater risk for cardiovascular events than elevated SBP, which was thought to be a part of the normal aging process.[11] In addition, earlier clinical blood pressure trials used DBP to define hypertension. Thus, in the past,[11] lowering of DBP was considered evidence of the lowering of overall blood pressure. However, epidemiological and actuarial data suggests that elevated SBP is far more common than elevated DBP and that elevated SBP is at least as strong a risk factor as elevated DBP for the development of cardiovascular disease.[12, 13] Clinical trial data have also now demonstrated impressive reductions in cardiovascular events with the treatment of systolic hypertension in older patients.[14–16] Therefore, World Health Organization/International Society of Hypertension guidelines advocated the importance of control of both SBP and DBP since 1999.[6]

In recent years, clinicians have appeared to be positive to equally treat and control patients for hypertension with a SBP goal and a DBP goal; but the SBP control for patients with hypertension is to strengthen. The historical preoccupation with DBP may have created the misperception that the treatment of hypertension requires only control of the diastolic component. Consequently, older patients with an elevated SBP and a normal DBP may be under treated because they may be perceived to be "controlled".[5, 17] Data from a large-scale epidemiological survey indicates that SBP is mainly related to the CVD events.[18–20] Thus, more efforts at preferential control of SBP should lead to reduction of these.

There are some limitations in our study. Our study sample was composed of individual aged ≥35 years old in rural communities; SBP tends to rise with advancing age, whereas DBP rises until the sixth decade, after which it tends to fall. Therefore, the rates of control to the SBP/DBP goal were perhaps lower/higher than those of hypertensive subjects even older in age. However, the vast majority of hypertensive individuals are middle-aged or older, so the findings of our study likely pertain to most of the hypertensive populations. In addition, our findings are based on 2 blood pressure readings obtained at a single examination. It is therefore possible that some subjects were misclassified with regard to hypertension status or control.

In conclusion, our study was a large-sample investigation in a rural community; the rates of treatment and control for patients with hypertension were 22.6% and 1.0%, which are very low. Poor control was overwhelmingly due to lack of SBP control, even among treated subjects. Therefore, clinicians and policymakers should place greater emphasis on achieving goal SBP levels in all hypertensive patients, especially in elderly. Furthermore, health promotion and health care should also actively progress in rural communities.

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