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Impacts of undetected and inadequately treated hypertension on incident stroke in China

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ABSTRACT

Objectives China carries the greatest burden of stroke given its largest volume of people with hypertension. This study assessed the impacts of suboptimal controls of hypertension on incident stroke and projected the number of patients with stroke saved after the control of blood pressure improved in population.

Setting Anhui, China.

Participants We examined data from the Anhui cohort of 2001–2011, consisting of 3336 participants aged ≥60 years who were randomly recruited from the urban and rural Anhui. 2852 participants (89.2%) had hypertensive status measured and no stroke at baseline, and were followed up until 2011 in three surveys using a standard method of interview.

Results At baseline, 1646 participants (57.7%) were identified to have hypertension, among whom 912 (55.4%) were previously undetected, 115 (7.0%) detected but not treated, 452 (27.5%) treated but not controlled and only 127 (7.7%) controlled. During the 10-year follow-up, 211 incident stroke cases (12.8/1000 person-years) occurred. Compared with normotensive individuals at baseline, multivariate adjusted HR for having stroke increased in those with undetected hypertension by 1.63 (95%CI 1.15 to 2.32), untreated by 2.21 (1.26–3.85) and uncontrolled hypertension by 3.34 (2.28–4.88), but did not differ from those with controlled hypertension (1.34; 0.60–2.99). Based on a two-fold increase in the detection and management of current levels of hypertension and algorithms on the current situation in China, approximately 250 000 incident stroke cases could be prevented annually.

Conclusions In China, hypertension is frequently undetected or inadequately treated. With appropriate management of hypertension, a substantial number of people could be saved form stroke.

Strengths and limitations of this study

- This study included a wide range of well-characterised participants, covering high levels of absolute poverty in earlier age, with increasing levels of cardiovascular disease in middle or older age.
- The response rates were high at baseline and follow-up (89%).
- These individuals have experienced a widening gap in income level, particularly between living in rural versus urban areas.
- This study included self-reported physician-diagnosed stroke, which could lead to misclassification. Although the misclassification could be small, it might differ between socioeconomic groups. However, it would have biased the results towards null.
- Information on stroke subtype including ischaemic, intracranial haemorrhage and subarachnoid haemorrhage was not recorded.
- Approximately 10% of participants in the cohort were lost to follow-up while their basic characteristics did not differ from followed up participants.
- Our data of the correlates of hypertensive status were cross-sectional, limiting inference on a causal direction.
- Although the study region had levels of hypertension, stroke risk and economic development comparable to those in other provinces of China, caution should be exercised in generalising our findings to China's 1.3 billion inhabitants.

INTRODUCTION

The WHO estimates that 80% of the world's stroke sufferers would be located in China and India by the year 2050.[1] Being the most populous nation in the world, China has a greater prevalence of stroke than any other single country, with incidence of stroke in China varying from 136 per 100 000 in southern to 486 per 100 000 in northeast.[2]

Similar to other developing countries, China is experiencing rapid economic growth with an increase in life expectancy. As the population ages,[3] the prevalence of chronic diseases has been rising including stroke, hypertension,[4] type 2 diabetes mellitus,[5 6] coronary heart disease (CHD)[7] and atrial fibrillation.[8] The rate of smoking has also increased substantially in Chinese men, among whom, up to two-thirds are current smokers.[9] Meanwhile, there has been an increasing trend for Chinese people adopting Western lifestyles,[6 10] which often lead to higher intake of

energy-dense high-fat foods, accompanying with elevated risks of rising blood pressure (BP), cholesterol levels and CHD events.[11]

Hypertension is the major risk factor for stroke with China having the single largest number of people with this condition in the world. Around half of older Chinese people suffer from hypertension but many are unaware, not diagnosed or poorly controlled.[4] Previous studies reported the relationship between poor BP control and coexistence of chronic conditions including diabetes, CHD and cerebrovascular diseases.[12] However, it remains unclear how, and the extent to which, undetected or poorly controlled hypertension relate to stroke risk and which factors associate with BP control among the Chinese population. Identification of these underlying risk factors may provide insights into the natural history of the aetiology of stroke and help future healthcare planning on prevention and treatment of stroke in the world's largest population.

In the present study, we examined longitudinal data from the Anhui cohort study.[13] This 10-year follow-up study of older Chinese adults (≥60 years) set out to determine the impact of socioenvironmental and lifestyle factors on physical and psychological health outcomes including cardiovascular disease (CVD) and dementia. We aimed to assess: (1) the associations of sociodemographic and health status with awareness and management of hypertension, and (2) the impact of detection and treatment outcomes of hypertension on incident stroke.

METHODS

Study population

We randomly recruited 1810 people >65 years old who had lived >5 years in Yiming subdistrict of Hefei city in 2001, and 1709 >60 years old from all 16 villages in Tangdian district of Yingshang county in 2003. In total, 3336 adults agreed to participate in the present study (response rate of 94.8%), of whom 1736 were living in urban and 1600 in rural area. Participants were interviewed by a trained survey team from Anhui Medical University. Permission for interview and written informed consent were obtained from each participant. In about 5% of participants who could not provide informed consent, their nearest relative or carer were approached to provide assent to participation.[14] The present study was approved by the Ethics Committee of University College London, and School of Health and Well-being at University of Wolverhampton, UK and the Research Ethics Committee of Anhui Medical University and the local governments in China.

Vital status of participants were monitored until December 2011 in four waves. At each survey wave, we conducted home visits to obtain information about participants' survival status through multiple sources including resident committees, family members, neighbours and friends. For the urban cohort, we also reviewed electronic registration databases from the local Centre for Disease Control and Police Registration centralised in Hefei city to identify mortality and causes of deaths. For those who had deceased, a standard Verbal Autopsy questionnaire[15] was used to interview the next of kin responsible for the deceased to ascertain causes of death.

Baseline examination (wave 1)

Socioeconomic and lifestyle factors and general health status

The main interview contents were derived from the Medical Research Council: Ageing in Liverpool Project - Health Aspects (MRC-ALPHA) study[16] and the Scottish Multinational MONItoring of trends and determinants in Cardiovascular disease (MONICA) surveys.[17] These contents consisted of information on general health and risk factors including sociodemographic information (educational level, main occupation status, annual income satisfaction, current smoking and alcohol intake), social support and relationships, psychosocial aspects, self-assessed physical health, adverse life events occurring in the past 2 years, personal hobbies and activities of daily living. Medical history was elicited including awareness, treatment and physician's diagnosis of chronic conditions including hypertension, stroke, hypercholesterolaemia, diabetes mellitus and heart disease. Depression and dementia were diagnosed using the Geriatric Mental State (GMS) questionnaire data,[18] which were analysed by the Automated Geriatric Examination for Computer Assisted Taxonomy (AGECAT). The GMS-AGECAT has been used widely[19] and validated for use among older Chinese in Singapore, Hong Kong, Taiwan and mainland China.[18]

BP and anthropometric measurements

Systolic BP (SBP) and diastolic BP (DBP) was recorded in mm Hg by sphygmomanometer at the first and fifth Korotkoff sounds. Resting BP was measured three times at 1 min intervals. The cuff size was selected according to the size of participant's mid-upper arm circumference. Weight (kg), height (cm) and waist circumference (cm) in light clothes were measured using standard methods[20] to assess overweight and obesity based body mass index (BMI), 25–29.9 and ≥30 kg/m^2 and central fat distributions based on waist circumference action levels 1 and 2: 94 and 102 cm for men, 80 and 88 cm for women.[21]

Definition of hypertension status

Hypertension was defined as SBP ≥140 or DBP ≥90 mm Hg or being treated with antihypertensive agents. Hypertension status was classified into five categories of (1) 'no hypertension': patients with SBP <140 and DBP <90 mm Hg who were not being treated; (2) 'undetected hypertension': patients with SBP ≥140 or DBP ≥90 mm Hg who were unaware of the status; (3) 'untreated hypertension': patients with diagnosed hypertension who have not been treated, (4) 'uncontrolled hypertension': patients on antihypertensive regime whose BP levels remained suboptimal (SBP ≥140 or DBP ≥90 mm Hg, and (5) 'controlled hypertension': patients with adequately controlled BP (SBP <140 and DBP <90 mm Hg) on antihypertensive treatment regimen.

Cohort follow-up surveys

In 2002 for the urban sample and in 2004 for the rural sample, we invited all surviving cohort members for re-interview. Using the same protocol as those at baseline, we successfully interviewed a total of 2608 participants (wave 2), with a response rate of 78.2%. From 2007 to 2009, we conducted wave 3 survey and reinterviewed 1757 participants (67.4%), and in 2011–2012, based on those 1757 participants at wave 3, we reinterviewed 944 participants (56.6%). During the follow-up of cohort, we identified 671 deaths.

Statistical analysis

In the whole cohort there were 3195 non-stroke participants at baseline, among whom 2852 participants (89.3%) were followed up at waves 2, 3 and/or wave 4 by interviews or until the subject was deceased. We analysed the data of 2852 participants using SPSS V.22.0 (SPSS, Chicago, Illinois, USA). Distributions of risk factors among individuals with different status of hypertension at baseline were assessed by the χ^2 test for categorical variables and one-way analysis of variance for continuous variables. We used binomial logistic regression models to examine the correlates of undetected, untreated and uncontrolled hypertension from those basic characteristics of participants, including sociodemography.

In the follow-up data analysis, we computed person-years (per 1000) at risk of stroke to the end of follow-up, date of death or date of loss to follow-up. Multivariate Cox regression with covariate adjustments was used to calculate HR and 95% CI of incidence of stroke among patients with different hypertension status compared with those without hypertension (referent group). In the Cox regression models, censoring time for each participant was his/her date of the end of follow-up, date of death or date of loss to follow-up. Covariates included age, sex, BMI, smoking status, alcohol drinking, marital status, living alone, geographic locations, educational level, occupational class, income, hypercholesterolaemia, diabetes, angina, depression, and dementia. In the regression models' adjustment analysis, we treated missingness in variables as a special group for analysis.

We projected the number of incident stroke cases in China that could be prevented annually if the levels of undetected, untreated and uncontrolled hypertension were reduced (either through primary prevention or adequate BP control). This calculation was based on our findings of the relative risk of stroke from hypertension, the national representative data of prevalence of hypertension, the stroke incidence in general adult population aged ≥20 years[22 23] and the national census population of 2010.[24]

RESULTS

Baseline characteristics

The online supplement 1 shows baseline demographic characteristics, socioeconomic status indicators, social network support and psychosocial features of 2852 participants (1375 men aged (mean ±SD) 71.9±6.6 years and 1477 women aged 71.6±7.1 years). A total of 1646 out of 2852 participants had hypertension, among which, 912 (55.4%) were previously undetected. Over a third of subjects (35.2%, (579/1646)) were treated for physician-diagnosed hypertension, yet there were only 127 subjects (7.8%) whose hypertension was adequately controlled. The remaining demographic and socioeconomic characteristics, social network support and health status are also shown in the online supplement 1.

Correlation between hypertension status and risk factors

Compared with women (adjusted OR and 95% CI), men were more likely to have undetected hypertension by 1.6-fold (1.2–2.1), untreated hypertension by 1.9-fold (1.1–3.3) or uncontrolled hypertension 2.0-fold (1.4–3.0). There were no significant sex differences for controlled hypertension. Compared with individuals with waist circumference below action level 1, those with waist circumference above action level 2 were more likely to have undetected hypertension by 1.9-fold (1.5–2.5), untreated hypertension by 1.9-fold (1.1–3.2), uncontrolled hypertension 3.8-fold (2.7–5.2) or controlled hypertension 2.2 (1.3–3.8) (table 1, full included numbers are shown in the online supplement 1). Undetected hypertension were more likely to occur in people living in rural areas than those living in urban areas by 1.9-fold (1.4–2.6) and in individuals with subcase of dementia (ie, subclinical dementia) (individuals who did not reach diagnostic stage, but had symptoms of dementia) than those without dementia by 1.4 (1.1–1.9). Individuals with untreated hypertension were more likely to not have daily contact with children/relatives by 5-fold (2.1–11.7) and more likely to have heart disease by 1.9-fold (1.2–3.1). Those with heart disease was more commonly associated with uncontrolled hypertension (OR 2.1; 95% CI 1.6 to 2.9) as well as controlled hypertension (OR 2.7; 95% CI 1.6 to 4.7). Current smokers were less likely to associate with undetected hypertension (OR 0.8; 95% CI 0.6 to 1.0), uncontrolled hypertension (OR 0.7; 95% CI 0.5 to 1.0) or controlled hypertension (OR 0.5; 95% CI 0.2 to 1.0), while ex-smokers were less likely to associate with undetected hypertension (OR 0.6; 95% CI 0.4 to 0.9) or uncontrolled hypertension (OR 0.5; 95% CI 0.3 to 0.9).

Impact of detection and treatment of hypertension on incident stroke

There were 211 incident stroke cases over a 10-year follow-up period (109 cases from the interview surveys and 102 from death records) (table 2). Compared with normotensive individuals, the HR for having stroke increased in those with undetected hypertension by 1.6-fold (1.2–2.3), untreated hypertension by 2.2-fold (1.3–3.9), uncontrolled hypertension by 3.3-fold (2.3–4.9), but did not differ from those with controlled hypertension after adjusting for other socio-demographic factors and waist circumference covariates. In all those with undetected,

Table 1 Factors associated with older adults with undetected, untreated and uncontrolled hypertension—the Anhui cohort study, China

	Hypertension											
	Undetected			Untreated			Uncontrolled			Controlled		
	OR*	95% CI	p Value†	OR*	95% CI	p Value†	OR*	95% CI	p Value†	OR*	95% CI	p Value†
Sociodemographic status indicators												
Age (years)												
60–64	0.91	0.67 to 1.24	0.54	0.85	0.44 to 1.66	0.63	1.40	0.86 to 2.28	0.18	0.25	0.03 to 2.01	0.19
65–69 (referent)	1	–	–	1	–	–	1	–	–	1	–	–
70–74	0.99	0.77 to 1.27	0.95	1.03	0.65 to 1.65	0.89	1.18	0.87 to 1.61	0.29	1.05	0.64 to 1.71	0.86
75–79	1.27	0.96 to 1.67	0.09	0.71	0.39 to 1.28	0.26	1.20	0.84 to 1.72	0.33	0.83	0.45 to 1.54	0.55
≥80	1.22	0.90 to 1.66	0.21	1.50	0.84 to 2.66	0.17	0.87	0.54 to 1.39	0.55	0.94	0.43 to 2.07	0.88
Sex												
Women (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Men	1.58	1.19 to 2.10	<0.01	1.88	1.07 to 3.32	0.03	2.04	1.40 to 2.99	<0.01	1.46	0.78 to 2.73	0.24
Urban/rurality												
Urban	1	–	–	1	–	–	1	–	–	1	–	–
Rural	1.87	1.37 to 2.56	<0.01	1.44	0.76 to 2.73	0.27	0.76	0.49 to 1.18	0.21	0.46	0.18 to 1.13	0.09
Educational level												
Higher than secondary school (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Secondary school	0.91	0.64 to 1.30	0.61	1.03	0.57 to 1.85	0.93	0.99	0.70 to 1.40	0.95	0.78	0.46 to 1.34	0.37
Primary school	1.01	0.71 to 1.44	0.95	0.56	0.27 to 1.16	0.12	0.70	0.47 to 1.04	0.08	0.55	0.29 to 1.07	0.08
Illiterate	1.12	0.79 to 1.58	0.53	1.00	0.52 to 1.92	0.99	0.55	0.36 to 0.84	0.01	0.41	0.20 to 0.85	0.02
Social network and psychosocial factors												
Marriage												
Married (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Never married / Divorced	0.82	0.47 to 1.41	0.46	0.47	0.14 to 1.52	0.21	1.09	0.47 to 2.56	0.84	3.01	0.74 to 12.22	0.12
Widow	0.87	0.58 to 1.32	0.52	0.72	0.34 to 1.52	0.39	0.88	0.50 to 1.56	0.67	1.20	0.49 to 2.95	0.70
Cohabitation												
Spouse only (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Children and/or grandchildren only	1.29	0.82 to 2.05	0.27	2.36	1.02 to 5.45	0.05	1.17	0.62 to 2.20	0.63	0.89	0.32 to 2.50	0.83
Spouse and/or grandchildren and/or parents	1.04	0.83 to 1.31	0.73	1.23	0.78 to 1.93	0.37	1.13	0.84 to 1.53	0.41	0.54	0.31 to 0.94	0.03
Others	1.13	0.67 to 1.92	0.65	1.09	0.39 to 3.06	0.87	0.88	0.45 to 1.73	0.71	0.52	0.18 to 1.56	0.25
None	1.33	0.85 to 2.07	0.21	1.58	0.68 to 3.64	0.29	0.81	0.43 to 1.56	0.54	1.00	0.37 to 2.72	1.00
Visiting children or other relatives												
Everyday (referent)	1	–	–	1		–	1		–	1	–	–

Continued

Table 1 Continued

	Hypertension											
	Undetected			Untreated			Uncontrolled			Controlled		
	OR*	95% CI	p Value†	OR*	95% CI	p Value†	OR*	95% CI	p Value†	OR*	95% CI	p Value†
At least weekly	0.79	0.62 to 1.00	0.05	0.91	0.57 to 1.44	0.68	0.73	0.54 to 1.00	0.05	0.83	0.50 to 1.38	0.47
At least monthly or less often	1.11	0.82 to 1.50	0.52	1.28	0.71 to 2.33	0.41	0.97	0.66 to 1.45	0.90	1.19	0.64 to 2.23	0.58
More than yearly or never	1.67	0.97 to 2.89	0.07	5.00	2.13 to 11.72	<0.01	1.30	0.61 to 2.77	0.49	1.77	0.51 to 6.21	0.37
Help available when needed												
Yes (referent)												
No	1.26	0.87 to 1.81	0.22	0.74	0.32 to 1.74	0.49	1.87	1.13 to 3.11	0.02	0.20	0.02 to 1.77	0.15
CVD risk factors												
Waist circumference*												
Below action level 1 (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Between action levels 1 and 2	1.28	0.99 to 1.65	0.06	2.31	1.47 to 3.62	<0.01	2.69	1.95 to 3.69	<0.01	2.08	1.24 to 3.49	0.01
Above action level 2	1.91	1.46 to 2.50	<0.01	1.87	1.11 to 3.15	0.02	3.76	2.71 to 5.22	<0.01	2.19	1.28 to 3.75	<0.01
Smoking status												
Never smokers (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Ex-smokers	0.58	0.38 to 0.89	0.01	0.91	0.41 to 2.00	0.81	0.52	0.29 to 0.94	0.03	0.70	0.26 to 1.84	0.46
Current smokers	0.76	0.58 to 1.00	0.05	0.63	0.35 to 1.11	0.11	0.66	0.45 to 0.97	0.03	0.47	0.22 to 0.98	0.04
Drinking alcohol in the past 2 years												
No (referent)	1		–	1		–	1		–	1		–
Yes	1.14	0.90 to 1.45	0.27	1.01	0.62 to 1.64	0.98	0.68	0.48 to 0.97	0.03	0.94	0.52 to 1.73	0.85
Hypercholesterolaemia												
No (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Yes	0.80	0.49 to 1.32	0.38	2.38	1.27 to 4.45	0.01	1.85	1.21 to 2.81	<0.01	2.71	1.55 to 4.74	<0.01
Heart diseases (ischaemic, valve disease or others)												
No (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Yes	0.94	0.69 to 1.29	0.72	1.93	1.20 to 3.09	0.01	2.14	1.57 to 2.90	<0.01	2.78	1.77 to 4.35	<0.01
Diabetes												
No (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Yes	1.01	0.62 to 1.62	0.98	0.77	0.29 to 2.04	0.60	1.62	1.03 to 2.54	0.04	1.78	0.93 to 3.42	0.08
Activity of daily living (score)												
0 (referent)	1	–	–	1	–	–	1	–	–	1	–	–
1–4	1.57	0.96 to 2.54	0.07	0.97	0.37 to 2.52	0.95	2.77	1.61 to 4.77	<0.01	1.24	0.48 to 3.18	0.66
≥5	1.12	0.65 to 1.93	0.69	0.80	0.28 to 2.33	0.69	1.06	0.51 to 2.18	0.88	0.89	0.25 to 3.10	0.85
Depression and dementia status												

Continued

Table 1 Continued

	Hypertension											
	Undetected			Untreated			Uncontrolled			Controlled		
	OR*	95% CI	p Value†	OR*	95% CI	p Value†	OR*	95% CI	p Value†	OR*	95% CI	p Value†
No (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Depression subcase	1.10	0.67 to 1.82	0.71	1.65	0.71 to 3.82	0.24	1.05	0.53 to 2.08	0.89	1.28	0.37 to 4.40	0.70
Depression case	1.13	0.72 to 1.77	0.60	0.75	0.25 to 2.23	0.60	1.16	0.60 to 2.25	0.66	1.08	0.29 to 4.05	0.91
Dementia subcase	1.44	1.07 to 1.93	0.02	1.20	0.66 to 2.17	0.55	1.09	0.72 to 1.66	0.68	1.12	0.54 to 2.34	0.77
Dementia case	0.83	0.58 to 1.18	0.30	1.23	0.63 to 2.41	0.55	1.50	0.91 to 2.49	0.11	1.84	0.63 to 5.39	0.27
Depression and dementia status‡												
No dementia/depression subcase or case (referent)	1	–	–	1	–	–	1	–	–	1	–	–
Dementia subcase or case	1.14	0.90 to 1.44	0.28	1.19	0.75 to 1.90	0.47	1.22	0.88–1.71	0.24	1.26	0.68 to 2.37	0.47

*ORs, calculated by logistic regression analysis, were adjusted for all variables listed in the Table above.
†p Values indicate the degree of significance for ORs.
‡Analysis for dementia subcases and case versus all others.
CVD, cardiovascular disease.

Table 2 Incidence rate and HR of stroke in people with different hypertensive status—the Anhui cohort study, China

Hypertension status	Incident stroke (n)	Person-years	Incidence rate per 1000 person-years at risk of stroke	Model 1			Model 2		
				HR	95% CI	p Value	HR	95% CI	p Value
No hypertension	58	8000.2	7.25	1	–	–	1	–	–
Undetected hypertension	71	5822.5	12.19	1.63	1.15 to 2.32	0.006	1.57	1.10 to 2.24	0.013
Untreated hypertension	16	1001.7	15.97	2.21	1.26 to 3.86	0.006	1.97	1.11 to 3.51	0.020
Uncontrolled hypertension	59	2921.8	20.19	3.34	2.28 to 4.88	<0.001	3.06	2.08 to 4.51	<0.001
Controlled hypertension	7	881.5	7.94	1.34	0.60 to 2.99	0.473	1.18	0.52 to 2.68	0.690
Total	211	18627.7	11.33	–	–	–	–	–	–
All of undetected, untreated and uncontrolled hypertension	**146**	**9746**	**14.98**	2.16	1.58 to 2.93	0.001	**1.99**	**1.46 to 2.72**	**<0.001**

Bold type indicates significant association.
Hypertension is defined as systolic ≥140 or diastolic blood pressure ≥90 mm Hg or treated with antihypertensive agents
Hazard ratios calculated using Cox regression analysis.
Model 1 adjusted for age, sex, waist circumference, smoking status, alcohol consumption in the past 2 years, rural–urban living and educational level.
Model 2 adjusted for age, sex, waist circumference, smoking status, alcohol consumption in the past 2 years, rural–urban living, educational level, marital status, living status, frequency of visiting children/other, help available when needed, hypercholesterolaemia, heart diseases, diabetes, activities of daily living, depression and dementia.

untreated and uncontrolled hypertension, the adjusted HR was 2.2-fold (1.6–2.9). Further adjustments for social support and co-morbidities marginally reduced HR values.

Estimated number of stroke cases China prevented by controlling BP

Based on stroke data from our present study and representative general adult population,[23 24] using the equation described in the online supplement 2, the numbers of incident stroke cases that could be prevented by the degree of reduction in the proportions of individuals with hypertension in China were calculated (table 3). We estimated that 56 480 stroke cases could be prevented each year (19 535 from undetected, 5696 from untreated and 31 250 from uncontrolled hypertension) if the proportion of those with hypertension could be reduced by 10% from the current level, and up to 282 402 stroke cases could be prevented if the reduction were halved.

DISCUSSION

We have shown that the management of hypertension is suboptimal in China and worse than most developed and developing countries.[25] More than half of the cohort participants in the present study had hypertension at the start of the survey with less than half receiving a physician's diagnosis of hypertension and only approximately one-third were treated. Less than 8% of patients had their BP adequately controlled by antihypertensive medications. Individuals with undetected, untreated and uncontrolled hypertension had increased the risk of stroke by between 1.6-fold and 3.3-fold.

Findings from our study are consistent with previous surveys in China showing that 44.7% of participants were aware of hypertension[26] and although one in six Chinese adults were hypertensive, only a quarter were aware of it.[4] The present study has also shown similar findings to those in lower income and middle-income countries.[27] We comprehensively examined a number of factors that were influential in the awareness and management of hypertension among a large cohort of older Chinese adults. In general, undetected, untreated or uncontrolled hypertension was more likely to emerge among the socioeconomically disadvantaged such as individuals living in rural areas, with low education and occupation and those with chronic conditions. It is likely that those with undetected or untreated hypertension, mostly found in rural community, have limited access to medical care or lack essential knowledge of general health risk, particularly for conditions that do not express overt symptoms such as hypertension. This may in part be compounded by the unavailability or unaffordability of antihypertensive drugs to individuals of lower socioeconomic status. Studies have shown that most rural residents in China continue to endure a triad of low education, low income and low occupation.[28 29] Surprisingly we found that current and ex-smokers had reduced ORs of undetected and

Table 3 Projected number of stroke saved in China through reducing the proportions of people with untreated and uncontrolled hypertension

	Reduction in hypertension															
	10%			25%			50%			75%			90%			
	n	Minimum	Maximum	n	Minimum	Maximum	n	Minimum	Maximum	n	Minimum	Maximum	n	Minimum	Maximum	
Hypertension																
Undetected	19535	3197	42622	48837	7992	106554	97675	15983	213108	146512	23975	319662	175814	28770	383594	
Untreated	5696	740	14410	14239	1851	36026	28479	3702	72052	42718	5553	108078	51262	6664	129693	
Uncontrolled	31250	16030	53756	78124	40074	134390	156248	80148	268779	234372	120222	403169	281247	144266	483803	
Total	56480	19967	110788	141201	49917	276970	282402	99833	553939	423603	149750	830909	508323	179700	997090	

The algorithms used can be found in the online supplement 2.

uncontrolled hypertension. Explanation for this paradoxical relationship may be that smokers/ex-smokers more frequently than non-smokers have their general health checked that includes BP monitoring and treatment. Under-reporting of smoking by non-smokers may also explain this observation. With regard to the finding of the correlates of controlled hypertension (eg, associated with low level of education), it may simply reflect risk factors for hypertension versus normotension. Other factors such as higher salt intake among Chinese[30] probably play a major role in the development and sustenance of hypertension. Dietary assessment was not included in the present study. Compliance with medication is also a major issue and is considered to be responsible for half of antihypertensive drug failures.[31]

Hypertension and stroke in China

It is important to reiterate that although information on stroke was obtained by self-report method, diagnosis of stroke in older people could be valid.[32] Although stroke care in urban areas of China has improved significantly in recent years, the standard of care remained poor in rural areas where only a small proportion of patients with acute stroke were admitted to hospital.[33] It is well documented that Chinese farmers have minimal medical insurance, particularly during the transitional period of political reform between 1978 and 1999.[34] By contrast, urban dwellers were more likely to benefit extensive medical cover provided by the local government or their employers.[34]Although China's healthcare system is being strengthened,[35] most of primary care services offered in rural areas are still operated mainly at grassroots clinics led by less-qualified staff.[36 37]

The observations in the present study that the similar risk of stroke among hypertensive individuals with controlled BP to that of normotensive individuals are important and encouraging to both healthcare professionals and patients. These findings are in line with intensive BP control among other groups of patients such as patients with diabetes to reduce the risk of stroke.[38] Although the risk of stroke increases with BP, there is no clear threshold to indicate a safe BP due to its continuous nature. However, the WHO has reported that the risk of CVD begins to rise from BP as low as 115/75 mm Hg, and recommended a treatment target of <140/90 mm Hg to reduce cardiovascular complications.[39]

In conclusion, in China, hypertension is frequently undetected or inadequately treated. With a reasonable goal of a 50% reduction of hypertension load, as compared with present figures, to achieve an appropriate management of hypertension, around a quarter of a million cases *per annum* could potentially be removed from incidence of stroke.

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