Published in final edited form as:

Int J Cardiol. 2016 September 15; 219: 404–409. doi:10.1016/j.ijcard.2016.06.033.

Systolic Blood Pressure and Cardiovascular Mortality In Middle-Aged and Elderly Adults – The Singapore Chinese Health Study

Angela S. Koh, MBBS, MPH^{1,2,*}, Mohammad Talaei, MD, MPH³, An Pan, PhD⁴, Renwei Wang, MD⁵, Jian-Min Yuan, MD, PhD^{5,6}, and Woon-Puay Koh, MBBS, PhD^{2,3,*}

¹National Heart Centre Singapore, Singapore

²Duke-NUS Medical School, Singapore

³Saw Swee Hock School of Public Health, National University of Singapore, Singapore

⁴Department of Epidemiology and Biostatistics, Ministry of Education Key Laboratory of Environment and Health, and State Key Laboratory of Environmental Health (incubation), School of Public Health, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei, China

⁵Division of Cancer Control and Population Sciences, University of Pittsburgh Cancer Institute, Pittsburgh, Pennsylvania, USA

⁶Department of Epidemiology, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, Pennsylvania, USA

Abstract

Background—While elevated systolic blood pressure (SBP) is related to cardiovascular disease (CVD) mortality, it is unclear if the optimal SBP level may differ by age or presence of underlying CVD.

Objective—We investigated the association between SBP categories and CVD mortality among middle-aged and elderly adults with and without CVD history.

Methods—We used data from 30,692 participants of the population-based Singapore Chinese Health Study who had blood pressures measured using a standard protocol at ages 48–85 years between 1994 and 2005. Information on lifestyle factors were collected at recruitment (1993–1998) and during follow-up interviews (1999 and 2004). Mortality was identified via nationwide registry linkage up to 31 December 2014.

Corresponding author: Angela S. Koh, National Heart Centre Singapore, 5 Hospital Drive, Singapore 169609, Telephone: +65 67048961.

*This author takes responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation

The authors report no relationships that could be construed as a conflict of interest.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Results—SBP 120-139mmHg category was associated with lowest risk of CVD mortality in both age-groups of <60 and 60+ years, as well as in those with and without underlying coronary heart disease or stroke. Overall, compared to this category, CVD risk was non-significantly increased in lower SBP categories and significantly increased in the higher SBP categories. The risk estimates associated with elevated SBP were higher among those <60 years compared to their older counterparts, but less distinct between those with and without underlying CVD.

Conclusion—SBP 120-139mmHg was associated with the lowest risk of CVD mortality in middle aged and elderly adults, regardless of underlying CVD. Although risks in both adult groups were similar, there is a greater risk associated with higher SBP among those aged below 60 years, highlighting a greater urgency of treatment in this younger group.

Keywords

Epidemiology; blood pressure; cardiovascular disease; mortality; hypertension; systolic

Introduction

Elevated systolic blood pressure (SBP) is a well-established risk factor for the development of cardiovascular disease (CVD) and stroke(1). Although prospective cohort studies have established strong graded positive associations between SBP and risk of cardiovascular disease (2;3), few cohorts have examined differences in associations between SBP and cardiovascular disease mortality based on age group and in the presence of prior cardiovascular disease.

In particular, the impact of SBP on middle-aged adults below the age of 60 years deserves more study. To date, the Eighth Joint National Committee (JNC-8) guidelines (4) have not been able to provide conclusive guidelines on managing SBP for hypertensive subjects aged below 60 years old. Using expert opinion rather than evidence, the panel has recommended a treatment target of <140 mmHg for SBP in adults aged below 60 years. Hence, more studies among adults aged below 60 years are required to provide evidence-based recommendation on the optimal SBP category for in reducing CVD mortality among middle-aged adults versus their more elderly counterparts, and to investigate if the effect of SBP on CVD mortality is modified by underlying history of CVD.(5;6)

In addition, for the elderly population, JNC-8 had increased the upper limit of optimal therapeutic goal of SBP to 150 mmHg. Since this recommendation by JNC-8, data from various cohorts (2;7) continue to demonstrate excess risks persisting in the 140-150 mmHg category relative to lower SBP ranges. Such studies have focused on the elderly aged above 60 years (8) who are free of baseline CVD. While important, these studies do not address if similar risk associations are also present among elderly with underlying history of CVD. This group with prevalent CVD deserves greater attention because they might be at risk of recurrent cardiovascular events, and also because their numbers are expected to increase with aging populations and better cardiovascular treatment methods.

There is also insufficient information on the risks of CVD mortality at SBP below 140mmHg for elderly with prior CVD. A study of 4408 participants from large community-

based cohorts reported continuous positive association between SBP and heart failure risk in the elderly with SBP levels as low as 115mmHg, with over half of incident heart failure events occurring in individuals with SBP <140mmHg (3). Cohorts such as these have not included elderly with prior CVD. As elderly individuals with prior CVD are at high risk of recurrent cardiovascular events and subsequent CVD mortality, data from cohorts that have elderly with prior CVD are urgently needed to provide some answers on the impact of SBP below 140mmHg in such high-risk elderly individuals.

In this study derived from the Singapore Chinese Health Study cohort, we examine the impact of systolic blood pressure on CVD mortality over a mean follow-up period of about a decade, focusing on elucidating the optimal SBP category associated with lowest risks among middle-aged and elderly adults, with and without prior CVD.

Material and Methods

Study population

The design of the SCHS has been described previously (9). Briefly, 35,303 Chinese women and 27,954 Chinese men aged 45–74 years of age were enrolled in this population-based cohort study between April 1993 and December 1998. The study participants were restricted to two major dialect groups in Singapore, which are the Hokkien and the Cantonese who originated from Fujian and Guangdong provinces in Southern China. During the enrolment period, all the study participants were residents of government housing estates, where 86% of the Singapore population resided at the time of recruitment. At recruitment, information on demographics, lifestyle factors (physical activity, sleep duration, tobacco use, and alcohol intake), usual diet, and medical history was obtained through in-person interviews using structured questionnaires. Between 1999 and 2004, 52,322 participants were re-contacted for telephone interviews to update information on lifestyle factors and medical history (10).

During April 1994 to December 1999, a random 3% of the study participants donated blood and single-void urine specimens for research. Between January 2000 and April 2005, we extended the biospecimen collection to 32,543 participants, which represented a consent rate of about 60% of surviving cohort participants at that time. These participants underwent blood pressure measurement before biospecimen collection. A total of 30,692 participants with blood pressure measurements and who participated in the follow-up 1 interviews were included in the current analysis. This study was approved by the Institutional Review Board at the National University of Singapore, and all enrolled subjects provided informed consent.

Assessment of blood pressure and other covariates

For each participant, blood pressure was measured in a seated position by trained staff using Omron automatic digital blood pressure monitor HEM-705CP, and the measurements were made three times at three-minute intervals and the average of the readings was used. Information on medical history of hypertension and use of antihypertensive medications was updated during the visit for blood pressure measurements.

Participants self-reported their history of medical conditions diagnosed by physicians, including diabetes, hypertension, coronary heart disease, and stroke at recruitment and

follow-up 1 interviews. Participants who had cancer at baseline were identified either through self-reports or via linkage with the nationwide Singapore Cancer Registry (n=1,843). Body mass index (BMI, in kg/m²) was calculated by body weight in kg divided by square of height in meter.

Assessment of Mortality

Information on date and cause of death was obtained through linkage analysis with the nationwide registry of birth and death in Singapore. Primary cause of death was used for analysis. Vital status for cohort participants was updated through December 31, 2014. As of December 31, 2014, only 41 subjects from this cohort were known to be lost to follow-up due to migration out of Singapore or for other reasons. This suggests that emigration among participants is negligible in this cohort and that vital statistics in follow-up is virtually complete. Underlying causes of death were coded according to the International Classification of Diseases, Ninth Revision; codes 390-459 were used for cardiovascular deaths, codes 410-414 for CHD deaths, codes 430-438 for stroke deaths.

Statistical Analysis

Person-years for each participant were calculated from the date of blood pressure measurement to the date of death, lost-to-follow up or December 31, 2014, whichever came first. Cox proportional hazards were used to examine associations between SBP and CVD mortality risk. SBP was categorized into 6 categories: <100 mmHg, 100-119 mmHg, 120-139 mmHg, 140-159 mmHg, 160-179 mmHg, and 180 mmHg. In the multivariate models, we adjusted for age (continuous), sex, dialect group (Hokkien, Cantonese), level of education (none, primary school, secondary school or more), cigarette smoking (none, ex, current smoker), alcohol intake (never, monthly, weekly, daily), moderate physical activity level (none, 0.5-3.9 hours/wk, 4.0 hours/wk), sleep duration (<5, 6-8, 9 h/d), BMI (<20.0, 20.0-23.9, 24.0-27.9, 28.0 kg/m²), history of comorbidities at recruitment for follow-up 1 (diabetes, CHD, and stroke) and use of antihypertensive medications among those with history of hypertension.

We defined the middle-aged group as those who were below 60 years of age at blood pressure measurement and elderly group as those 60 years and above. We separately analyzed the associations between SBP and CVD mortality in these two subgroups. Further stratified analysis in both age groups was made *a priori* by self-reported history of physician diagnosed CHD and stroke. Additional sensitivity analysis was done after further adjustment for diastolic blood pressure (DBP). All the statistical analyses were conducted using SAS 9.1 (SAS Institute Inc, Cary, NC), with 2-sided *P* value less than 5% as statistical significance. *P* for trend was calculated by introducing SBP groups to the models as continuous variable.

Results

The mean ($\pm$ SD) age of participants at blood pressure measurement was 63.0 (7.8), 11582 (38%) of them aged < 60 years old and 17,097 (55.7%) were women. Table 1 represents characteristics of participants according to the categories of SBP. The subgroups with higher

SBP were older and less educated, and had higher prevalence of current smokers and regular alcohol drinkers. Compared to the subgroups with lower SBP, these groups also had higher proportion of men, higher BMI levels and had higher prevalence of history of CHD, stroke, and diabetes.

During 346,085 person-years, we found 2012 cases of CVD mortality comprising 1,165 cases of CHD mortality and 545 cases of stroke mortality. Figure 1 showed that using SBP 120-139 mmHg as the reference, there was a significant, dose-dependent positive association between higher SBP categories and CVD mortality in both age-groups (<60 years and 60 years or older), although the risk estimates were higher in the younger group.

Compared to the reference category (SBP 120-139 mmHg), the HRs (95% CI) of SBP 140-159 mmHg, 160-179 mmHg, and >180 mmHg were 1.61 (1.13-2.29), 2.25 (1.45-3.50), and 4.84 (2.89- 8.10) in participants younger than 60 years old and 1.27 (1.11-1.44), 1.68 (1.46-1.94), and 2.45 (2.07-2.89) in older participants, respectively. In SBP categories below 120 mmHg, the risk of CVD mortality was increased in both age groups but none of the risk estimates reached statistical significance.

Similar associations between SBP and risk of CVD mortality were present in those aged below 60 years (Figure 2) and in older adults (Figure 3), regardless of prior CVD history. In all the analysis, SBP 120-139 mmHg had the lowest association with risk of CVD mortality. Notably, participants with prior CVD history aged >60 years had a significantly increased risk of CVD mortality when SBP <100 mmHg (HR 2.11, 95% CI 1.16-3.84).

Table 2 and Table 3 showed the risk of coronary heart disease mortality and stroke mortality across systolic blood pressure categories, stratified by age group and prior CVD history. In individuals older than 60 years, there was a trend of increased CHD and stroke mortality risk with increasing SBP compared to SBP 120-139 mmHg regardless of prior CVD history. This pattern was similar among younger individuals with prior CVD. The older participants with prior history of CVD had significant CHD mortality risk at SBP <100mmHg.

The association of SBP and CVD mortality was further adjusted for diastolic blood pressure (DBP) in sensitivity analysis (supplementary table 1). The observed associations in total population remained statistically significant regardless of age groups although it was slightly ameliorated in participants younger than 60 years but slightly strengthened in older ones. As for participants without prior history of CVD, no change was observed in sensitivity analysis in individuals older than 60 years.

Although the inverse association between SBP<100 mmHg and total CVD mortality in older participants with prior CVD history appears to have disappeared after adjustment for DBP (supplementary table 1; HR 1.59 (0.84-3.02), the inverse association between SBP<100mmHg in older participants with prior CVD history is suggestive for increased CHD mortality risk at SBP <100mmHg (supplementary table 2; HR 1.88 (0.94-3.76)) and significant for increased stroke mortality at SBP 100-119mmHg (supplementary table 3; HR 2.00 (1.03-3.88). Taken together, these data suggest increased risks of CVD mortality at SBP below 120mmHg in older participants with prior CVD.

Discussion

In this large-scale population based cohort study, SBP above the 120-139mmHg category was associated with increased risk of CVD, CHD, and stroke mortality. These associations were observed in middle-aged and elderly adults, with and without prior cardiovascular disease. The risk estimates were generally higher in middle-aged participants below 60 years at recruitment, compared to their older counterparts.

The evidence of optimal SBP in middle-aged adults with prior CVD is scarce and cohort studies that have looked at younger or middle aged adults focused primarily on participants without prior CVD (5;6;11;12). Although a large pooled cohort (11) of 67309 Japanese individuals (40-89 years) showed significant increases in risks of CVD deaths from SBP 120mmHg and above, their investigation focused on CVD-free adults only. In contrast, our findings suggest that SBP of 120-139mmHg category was optimal even for middle-aged adults with prior CVD. Even the recent findings from the Systolic Blood Pressure Intervention Trial (SPRINT) (5) that showed an association between lower SBP and better cardiovascular outcomes, did not recruit subjects with diabetes or a previous history of stroke. In contrast, our observational study included both middle aged and elderly adults with diabetes and history of prior cardiovascular disease, thus enhancing generalizability of our data.

Our results are important because with advances in cardiovascular care, the prevalence of cardiovascular disease among adults who survive cardiovascular disease is likely substantial. In the United States, by 2030, 40.5% of the US population is estimated to have some form of cardiovascular disease (13). Data on how to manage adults with prior CVD will impact large sectors of the population. Therefore, our findings fills a current gap not answered by clinical trials or observational cohorts who have not studied adults with prevalent CVD. Furthermore, our data may provide useful reference for future interventional studies that investigate the impact of lower SBP categories below 140mmHg on subjects with prior CVD.

Few observational studies (2) have looked at the impact of SBP below 140 mmHg, particularly in elderly with prior CVD. We demonstrate evidence that the optimal SBP category is 120-139mmHg even among elderly with prior CVD. In addition, we studied additional categories of lower SBP ranges such as SBP 100-119mmHg and SBP below 100mmHg to better understand the risks of associated with lower SBP ranges. For example, although a study by Kim et al (14) reported that a SBP of 120mmHg or less was associated with 61% greater risk of stroke, acute myocardial infarction and death compared to a SBP of 131-141mmHg, they could not exactly provide information about what SBP category below 120mmHg was associated with those adverse risks. Their category of SBP below 120mmHg was a broad category that included SBP from 92mmHg to below 120mmHg. In our data, we could show that among elderly with prior CVD, SBP below 100mmHg was the category that was associated with increased CVD mortality, and also specifically for CHD-related mortality. Finally, we show this over a longer term follow-up, compared to other studies that have only studied participants with prior CVD for shorter term follow-up (15;16). Our longer term results enhances the message about the enduring impact of such risks.

Limitations and strengths

Several limitations need to be considered when interpreting our results. First, the study was based on a blood pressure measurement on a single occasion, and it did not account for regression dilution bias and misclassification. Therefore, the results of the study are likely to underestimate the true association. Second, our study is observational and therefore does not allow for causal inferences. Third, we did not examine the association of diastolic blood pressure and pulse pressure on cardiovascular mortality outcomes, apart from including sensitivity analyses adjusting for diastolic blood pressure. Fourth, cardiovascular structure and function measures such as vascular stiffness were not collected in this cohort, therefore we could not examine the underlying mechanisms of the systolic blood pressure and mortality association observed in the present analysis. Fifth, our participants were middle-aged to older adults of Chinese ancestry; our findings may not be generalizable to even younger individuals or other ethnic/racial groups. Sixth, numbers of events were not large enough to permit detailed analysis in the SBP < 100 mmHg range. Finally, it is still possible that adjustments may not have accounted for unknown confounders, leading to the possibility of residual confounding.

However, the present analysis has several strengths. The prospective design and near complete long-term follow-up using national mortality data is a strength. The large sample size and number of outcomes contributes to statistical power in this analysis. Our results are likely to be generalizable to a wide age range of adult men and women given that our samples were obtained from across the nation with sizeable gender representation. Finally, by pre-specifying SBP 120-139 mmHg as the reference stratum, our results may be easily comparable to future trials investigating lower SBP thresholds for cardiovascular outcomes.

Conclusions

Our study provided evidence that keeping SBP between 120 and 139 mmHg is optimal for both middle-aged and elderly adults with or without prior CVD. We provided clinically relevant basis for future clinical trials to confirm the impact of lower systolic blood pressure thresholds, according to age groups and cardiovascular risk profiles.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We thank Siew-Hong Low of the National University of Singapore for supervising the field work of the Singapore Chinese Health Study. Finally, we acknowledge the founding, longstanding principal investigator of the Singapore Chinese Health Study, Mimi C. Yu.

Sources of Funding: This work was supported by the United States National Institutes of Health (NIH R01 CA144034 and UM1 CA182876). Angela S. Koh is supported by a career grant awarded by the Singapore National Medical Research Council (NMRC/TA/0031/2015). The funder had no role in the design and conduct of the study; collection; management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

References

1. Black HR. The paradigm has shifted to systolic blood pressure. *J Hum Hypertens*. 2004 Dec; 18(2):S3–S7. [PubMed: 15592571]
2. Banach M, Bromfield S, Howard G, Howard VJ, Zanchetti A, Aronow WS, et al. Association of systolic blood pressure levels with cardiovascular events and all-cause mortality among older adults taking antihypertensive medication. *Int J Cardiol*. 2014 Sep; 176(1):219–26. [PubMed: 25085381]
3. Butler J, Kalogeropoulos AP, Georgiopoulou VV, Bibbins-Domingo K, Najjar SS, Sutton-Tyrrell KC, et al. Systolic blood pressure and incident heart failure in the elderly. The Cardiovascular Health Study and the Health, Ageing and Body Composition Study. *Heart*. 2011 Aug; 97(16):1304–11. [PubMed: 21636845]
4. James PA, Oparil S, Carter BL, Cushman WC, Dennison-Himmelfarb C, Handler J, et al. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). *JAMA*. 2014 Feb 5; 311(5):507–20. [PubMed: 24352797]
5. Wright JT Jr, Williamson JD, Whelton PK, Snyder JK, Sink KM, Rocco MV, et al. A Randomized Trial of Intensive versus Standard Blood-Pressure Control. *N Engl J Med*. 2015 Nov 26; 373(22):2103–16. [PubMed: 26551272]
6. Harmsen P, Lappas G, Rosengren A, Wilhelmsen L. Long-term risk factors for stroke: twenty-eight years of follow-up of 7457 middle-aged men in Goteborg, Sweden. *Stroke*. 2006 Jul; 37(7):1663–7. [PubMed: 16728686]
7. Zheng L, Li J, Sun Z, Zhang X, Hu D, Sun Y. Relationship of Blood Pressure With Mortality and Cardiovascular Events Among Hypertensive Patients aged ≥ 60 years in Rural Areas of China: A Strobe-Compliant Study. *Medicine (Baltimore)*. 2015 Sep; 94(39):e1551. [PubMed: 26426621]
8. Mohebi R, Mohebi A, Ghanbarian A, Momenan A, Azizi F, Hadaegh F. Is systolic blood pressure below 150 mm Hg an appropriate goal for primary prevention of cardiovascular events among elderly population? *J Am Soc Hypertens*. 2014 Jul; 8(7):491–7. [PubMed: 25064771]
9. Hankin JH, Stram DO, Arakawa K, Park S, Low SH, Lee HP, et al. Singapore Chinese Health Study: development, validation, and calibration of the quantitative food frequency questionnaire. *Nutr Cancer*. 2001; 39(2):187–95. [PubMed: 11759279]
10. Butler LM, Koh WP, Lee HP, Tseng M, Yu MC, London SJ. Prospective study of dietary patterns and persistent cough with phlegm among Chinese Singaporeans. *Am J Respir Crit Care Med*. 2006 Feb 1; 173(3):264–70. [PubMed: 16239624]
11. Fujiyoshi A, Ohkubo T, Miura K, Murakami Y, Nagasawa SY, Okamura T, et al. Blood pressure categories and long-term risk of cardiovascular disease according to age group in Japanese men and women. *Hypertens Res*. 2012 Sep; 35(9):947–53. [PubMed: 22739419]
12. Miura K, Daviglus ML, Dyer AR, Liu K, Garside DB, Stamler J, et al. Relationship of blood pressure to 25-year mortality due to coronary heart disease, cardiovascular diseases, and all causes in young adult men: the Chicago Heart Association Detection Project in Industry. *Arch Intern Med*. 2001 Jun 25; 161(12):1501–8. [PubMed: 11427097]
13. Heidenreich PA, Trogdon JG, Khavjou OA, Butler J, Dracup K, Ezekowitz MD, et al. Forecasting the future of cardiovascular disease in the United States: a policy statement from the American Heart Association. *Circulation*. 2011 Mar 1; 123(8):933–44. [PubMed: 21262990]
14. Kim J, Gall SL, Nelson MR, Sharman JE, Thrift AG. Lower systolic blood pressure is associated with poorer survival in long-term survivors of stroke. *J Hypertens*. 2014 Apr; 32(4):904–11. [PubMed: 24509123]
15. Ovbiagele B, Diener HC, Yusuf S, Martin RH, Cotton D, Vinisko R, et al. Level of systolic blood pressure within the normal range and risk of recurrent stroke. *JAMA*. 2011 Nov 16; 306(19):2137–44. [PubMed: 22089721]
16. Benavente OR, Coffey CS, Conwit R, Hart RG, McClure LA, Pearce LA, et al. Blood-pressure targets in patients with recent lacunar stroke: the SPS3 randomised trial. *Lancet*. 2013 Aug 10; 382(9891):507–15. [PubMed: 23726159]

Figure 1. Adjusted hazard ratio (95% confidence interval) of cardiovascular disease mortality according to systolic blood pressure groups

Figure 2. Adjusted hazard ratio (95% confidence interval) of cardiovascular disease mortality according to systolic blood pressure groups in participants aged less than 60 years

Figure 3. Adjusted hazard ratio (95% confidence interval) of cardiovascular disease mortality according to systolic blood pressure groups in participants aged 60 years and more

Table 1
Characteristics of participants according to systolic blood pressure groups

	Systolic blood pressure (mmHg)					
	<100	100-119	120-139	140-159	160-179	180
n (%)	880 (2.9)	6174 (20.1)	10870 (35.4)	8111 (26.4)	3392 (11.1)	1265 (4.1)
Age (y), mean $\pm$ SD	58.6 $\pm$ 6.9	60.0 $\pm$ 7.0	62.3 $\pm$ 7.4	64.6 $\pm$ 7.5	66.6 $\pm$ 7.6	67.8 $\pm$ 7.5
Female sex, n (%)	658 (74.8)	3960 (64.1)	5928 (54.5)	4170 (51.4)	1712 (50.5)	669 (52.9)
Dialect group, n (%)						
Hokkien	484 (55.0)	3177 (51.5)	5528 (50.9)	4016 (49.5)	1665 (49.1)	614 (48.5)
Cantonese	396 (45.0)	2997 (48.5)	5342 (49.1)	4095 (50.5)	1727 (50.9)	651 (51.5)
Education, n (%)						
None	146 (16.6)	1100 (17.8)	2199 (20.2)	2011 (24.8)	1003 (29.6)	435 (34.4)
Primary level	366 (41.6)	2683 (43.5)	4926 (45.3)	3736 (46.1)	1572 (46.3)	589 (46.6)
Secondary level	368 (41.8)	2391 (38.7)	3745 (34.5)	2364 (29.2)	817 (24.1)	241 (19.1)
Smoking, n (%)						
None	680 (77.3)	4564 (73.9)	7501 (69.0)	5223 (64.6)	2107 (62.1)	783 (61.9)
Ex-smoker	75 (8.5)	722 (11.7)	1689 (15.5)	1521 (18.8)	687 (20.3)	240 (19.0)
Current smoker	125 (14.2)	888 (14.4)	1680 (15.5)	1367 (16.8)	598 (17.6)	242 (19.1)
Alcohol, n(%)						
None	741 (84.2)	5052 (81.8)	8844 (81.4)	6717 (82.8)	2844 (83.8)	1060 (83.8)
Monthly	54 (6.1)	488 (7.9)	837 (7.7)	518 (6.4)	164 (4.8)	62 (4.9)
Weekly	67 (7.6)	494 (8.0)	906 (8.3)	607 (7.5)	256 (7.5)	88 (7.0)
Daily	18 (2.1)	140 (2.3)	283 (2.6)	269 (3.3)	128 (3.8)	55 (4.4)
Physical activity of moderate intensity per week, n(%)						
None	693 (78.8)	4732 (76.6)	8291 (76.3)	6163 (76.0)	2562 (75.5)	978 (77.3)
1-<4 hours	128 (14.6)	967 (15.7)	1626 (15.0)	1210 (14.9)	499 (14.7)	182 (14.4)
4 hours and above	59 (6.7)	475 (7.7)	953 (8.8)	738 (9.1)	331 (9.8)	105 (8.3)
Sleep hours/day, n (%)						
5 hours or less	84 (9.5)	543 (8.8)	1013 (9.3)	798 (9.8)	377 (11.1)	157 (12.4)
6 to 8 hours	743 (84.4)	5234 (84.8)	9200 (84.6)	6785 (83.6)	2771 (81.7)	1020 (80.6)
9 hours or more	53 (6.0)	397 (6.4)	657 (6.0)	528 (6.5)	244 (7.2)	88 (7.0)

	Systolic blood pressure (mmHg)					
	>100	100-119	120-139	140-159	160-179	180
Body mass index (kg/m ²), mean $\pm$ SD	21.2 $\pm$ 3.3	22.3 $\pm$ 3.4	23.3 $\pm$ 3.5	23.6 $\pm$ 3.5	23.9 $\pm$ 3.6	23.6 $\pm$ 3.5
Diastolic blood pressure (mmHg), mean $\pm$ SD	62.3 $\pm$ 5.8	70.9 $\pm$ 6.4	78.3 $\pm$ 7.4	84.6 $\pm$ 8.5	90.5 $\pm$ 9.8	98.6 $\pm$ 12.0
Diabetes, n (%)	55 (6.2)	505 (8.2)	1398 (12.9)	1424 (17.6)	762 (22.5)	338 (26.7)
Coronary heart disease, n (%)	52 (5.9)	368 (6.0)	801 (7.4)	686 (8.5)	351 (10.4)	125 (9.9)
Stroke, n (%)	16 (1.8)	126 (2.0)	361 (3.3)	390 (4.8)	204 (6.0)	96 (7.6)
Antihypertensive medications among those with hypertension, n (%)						
None	24 (2.7)	293 (4.7)	879 (8.1)	969 (11.9)	553 (16.3)	272 (21.5)
On medication	79 (9.0)	1087 (17.6)	3621 (33.3)	3700 (45.6)	1788 (52.7)	720 (56.9)

Table 2
Hazard ratio (95% confidence interval) of coronary heart disease mortality according to systolic blood pressure groups

	Overall Cases	HR (95% CI)*	No prior CVD history Cases	HR (95% CI)§	Prior CVD history Cases	HR (95% CI)§
Age < 60 years						
SBP <100	0	-	0	-	0	-
SBP 100-119	19	0.91 (0.52-1.59)	13	0.75 (0.39-1.45)	6	1.56 (0.55-4.45)
SBP 120-139	40	1.00	30	1.00	10	1.00
SBP 140-159	37	1.31 (0.82-2.07)	24	1.15 (0.66-2.00)	13	1.77 (0.75-4.18)
SBP 160-179	18	1.89 (1.06-3.38)	11	1.62 (0.79-3.33)	7	2.91 (1.03-8.24)
SBP 180	14	4.95 (2.61-9.38)	10	5.69 (2.66-12.1)	4	4.01 (1.16-13.9)
Age 60 years						
SBP <100	19	1.85 (1.16-2.95)	8	1.34 (0.66-2.74)	11	2.82 (1.49-5.33)
SBP 100-119	85	0.99 (0.78-1.27)	51	0.92 (0.67-1.27)	34	1.09 (0.73-1.62)
SBP 120-139	252	1.00	158	1.00	94	1.00
SBP 140-159	340	1.31 (1.11-1.55)	216	1.29 (1.05-1.58)	124	1.35 (1.03-1.77)
SBP 160-179	215	1.60 (1.33-1.93)	143	1.60 (1.27-2.01)	72	1.60 (1.17-2.18)
SBP 180	126	2.39 (1.92-2.98)	86	2.50 (1.91-3.28)	40	2.03 (1.39-2.96)

* Adjusted for age, sex, dialect groups, education level, body mass index, smoking status, alcohol intake, physical activity, sleep duration, history of CHD, stroke, and diabetes, as well as antihypertensive medications count

§ Adjusted for all variables above except history of CHD and stroke

Table 3
Hazard ratio (95% confidence interval) of stroke mortality according to systolic blood pressure groups

	Overall Cases	HR (95% CI)*	No prior CVD history Cases	HR (95% CI)§	Prior CVD history Cases	HR (95% CI)§
Age < 60 years						
SBP <100	3	3.03 (0.83-11.1)	3	4.03 (1.03-15.7)	0	-
SBP 100-119	11	1.49 (0.65-3.38)	9	1.64 (0.64-4.20)	2	1.10 (0.18-6.95)
SBP 120-139	13	1.00	9	1.00	4	1.00
SBP 140-159	20	2.18 (1.07-4.44)	16	2.60 (1.13-5.97)	4	2.03 (0.45-9.07)
SBP 160-179	10	2.94 (1.25-6.92)	8	3.81 (1.42-10.2)	2	1.50 (0.21-10.8)
SBP 180	4	4.00 (1.27-12.6)	4	5.81 (1.71-19.7)	0	-
Age 60 years						
SBP <100	3	0.72 (0.23-2.28)	2	0.65 (0.16-2.67)	1	0.99 (0.13-7.38)
SBP 100-119	47	1.28 (0.91-1.81)	32	1.15 (0.76-1.74)	15	1.64 (0.87-3.12)
SBP 120-139	106	1.00	79	1.00	27	1.00
SBP 140-159	141	1.25 (0.97-1.61)	100	1.21 (0.9-1.62)	41	1.52 (0.93-2.48)
SBP 160-179	118	2.03 (1.55-2.65)	88	1.99 (1.46-2.72)	30	2.34 (1.38-3.98)
SBP 180	69	2.92 (2.14-3.98)	49	2.84 (1.97-4.1)	20	3.41 (1.88-6.18)

* Adjusted for age, sex, dialect groups, education level, body mass index, smoking status, alcohol intake, physical activity, sleep duration, history of CHD, stroke, and diabetes, as well as antihypertensive medications count

§ Adjusted for all variables above except history of CHD and stroke