Published in final edited form as:

Int J Stroke. 2015 April ; 10(3): 388–395. doi:10.1111/ijss.12343.

Neighborhood socioeconomic status and the prevalence of stroke and coronary heart disease in rural China: a population-based study

Xun Tang¹, Daniel T. Laskowitz^{2,3}, Liu He⁷, Truls Østbye⁴, Janet Prvu Bettger^{3,5}, Yang Cao⁷, Na Li⁹, Jingrong Li⁸, Zongxin Zhang⁸, Jianjiang Liu⁹, Liping Yu⁹, Haitao Xu⁹, Yonghua Hu^{1,*}, and Larry B. Goldstein^{2,6,*}

¹Department of Epidemiology and Biostatistics, Peking University Health Science Center, Beijing, China

²Department of Neurology, Duke University Medical Center, Durham, NC, USA

³Duke Clinical Research Institute, Duke University Medical Center, Durham, NC, USA

⁴Duke Global Health Institute, Duke University Medical Center, Durham, NC, USA

⁵Duke School of Nursing, Duke University Medical Center, Durham, NC, USA

⁶Durham Veterans Affairs Medical Center, Durham, NC, USA

⁷Division of Non-Communicable Disease Control and Community Health, Chinese Center for Disease Control and Prevention

⁸The First Hospital of Fangshan District, Beijing, China

⁹Fangshan District Bureau of Health, Beijing, China

Abstract

Background—Lower neighborhood-level socioeconomic status (SES) is associated with an increased risk of vascular disease in developed countries.

Aims—This study aims to identify village- and individual-level determinants of stroke and coronary heart disease (CHD) in a rural Chinese population.

Methods—We analyzed data from a population-based survey of 14,424 rural Chinese adults aged over 40-years from 54 villages. Primary outcomes were stroke and CHD prevalence. Village-level SES was determined from the Chinese government's official statistical yearbook. Individual-level characteristics were obtained by in-person interviews. Prevalence rate ratios (RR) and 95% confidence intervals (95% CI) were calculated using generalized linear mixed models with log link function to explore associations of village-level SES and individual social, demographic, and cardiovascular risk factors with stroke or CHD. Variance was expressed using the median rate ratio (MRR) and interval rate ratio (IRR).

*Correspondence to: Larry B. Goldstein, MD, Box 3651, Duke University Medical Center, Durham, NC 27710, USA. golds004@mc.duke.edu ; or Yonghua Hu, MD, Department of Epidemiology and Biostatistics, Peking University Health Science Center, Beijing, 100191, China. yihu@bjmu.edu.cn.

Conflict of interest: None declared.

Results—Villages accounted for significant variability in the prevalence of stroke (MRR=1.70; 95% CI:1.42-1.94; $P<0.05$) and CHD (MRR=1.59; 95% CI:1.35-1.78, $P<0.05$) with village-level income alone accounted for 10% and 13.5% of between-village variation in stroke and CHD, respectively. High-income villages were at higher risk of both stroke (RR=1.69, 95% CI: 1.09~2.62) and CHD (RR=1.63, 95% CI:1.13~2.34) than lower-income villages. Among individual-level risk factors, hypertension was associated with a higher prevalence of stroke (RR=2.33, 95% CI:1.93-2.80) than CHD (RR=1.58, 95% CI:1.38-1.82), whereas obesity was only associated with CHD (RR=1.43, 95% CI:1.23-1.66). In addition, there was an interaction between age and income; residents of higher income villages age<60 had a higher prevalence of CHD (RR=1.58, 95% CI:1.15-2.18), but not stroke.

Conclusions—There were differences in vascular risk across rural villages in China, with higher lifetime stroke and CHD prevalence in higher income villages. For CHD, neighborhood effects were stronger among younger residents of high-income villages. The results may have implications for public health interventions targeting populations at risk.

Keywords

Stroke; coronary heart disease; neighborhood effects; cardiovascular risk factors; China

Introduction

Cardiovascular diseases (CVD), including stroke and coronary heart disease (CHD) are the leading causes of death in China (1). Accumulating evidence suggests that neighborhood socioeconomic context influences the risk of stroke and CHD and contributes to disparities in CVD outcomes, even after adjustment for other risk factors (2-5). Research in rural Chinese populations, however, is limited (6).

Aims

We hypothesized that stroke and CHD would disproportionately affect disadvantaged persons in rural Chinese communities. To test this hypothesis, we identified village- and individual-level variables associated with prevalent stroke and CHD using data from a large population-based cross-sectional survey. Specific questions included determining: 1. the degree to which stroke and CHD prevalence were attributable to village-level income; 2. village- and individual-level determinants of CVD; and 3. whether there are interactions between village- and individual-level risk factors.

Methods

Subjects

This cross-sectional study was conducted between May 2009 and August 2010 in the rural towns of Qinglonghu and Dashiwo in Fangshan District, located 45-kilometers southwest of downtown Beijing, China. All people who were aged 40 years and above and living in towns we sampled were invited in our study, and a total of 14,424 residents aged over 40-years were enrolled from 54 villages (overall participation rate 69.0%). The study design was

published previously (7) and was approved by the Ethics Committee of Peking University Health Sciences Center.

Data collection

Trained investigators using a structured questionnaire and physical examination obtained individual-level data in community healthcare centers in the participant's residential area. Education and occupation were considered indicators of an individual's SES over their adult life. Marital status was an indicator of family support. Demographics, modifiable lifestyle (cigarette smoking and alcohol consumption), and other cardiovascular risk factors (hypertension, diabetes, obesity) and a history of prior stroke or CHD were recorded. Blood pressures were measured three times at the right brachial artery using standard mercury sphygmomanometers after the participant had rested for 5 minutes in a seated position. Height was measured without shoes using a fixed stadiometer and weight without heavy clothing.

In rural areas of China, all populations are grouped in villages, each of which has a community healthcare center to provide primary health care services. Although a neighborhood is generally considered a geographically localized community within a larger city, town, suburb or rural area, for the purposes of this study, a participant's village was considered to be his or her neighborhood. Participants in this study had similar access to their village's community healthcare center. Even if living in isolated homes, individuals in rural China are still grouped into villages where they receive their medical care. They are included in the socioeconomic data for their village. Annual per capita income for each village was obtained from the Statistical Yearbook of Fangshan District 2008 (<http://fsh.bjstats.gov.cn/sjfb/ndsj/index.htm>).

Definitions of CVD and risk factors

Stroke and CHD were defined as described by the World Health Organization CHD/Stroke Community Registers (8). Those with stroke had a history of language or physical impairment with symptoms lasting for more than 24-hours and confirmed as being related to a cerebrovascular cause by brain CT or MRI. CHD was defined as having a history of angina or hospitalization for myocardial infarction with ECG findings, or a history of coronary balloon angioplasty, coronary artery bypass or coronary stent implantation. Disease prevalence refers to lifetime prevalence. Ascertainment of stroke or CHD was based on record-verified self-reported data (7). Local general practitioners, who were familiar with health issues of their patients, participated in the interviews for disease history screening. Diagnoses were confirmed by a neurologist or a cardiologist.

Medical history of diabetes was defined by self-reported current treatment with insulin or oral hypoglycemic agents. Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mmHg, or diastolic blood pressure (DBP) ≥ 90 mmHg, or use of any antihypertensive medication within two weeks. Body mass index (BMI) was calculated as the ratio of weight to height squared (kg/m^2). Obesity was defined as BMI $\geq 30 \text{ kg/m}^2$. Those who smoked more than 100 cigarettes in their lifetime were designated as smokers. Smokers who had quit more than 1 year prior to the evaluation were categorized as former smokers. Current

alcohol-consumption was defined as more than 14.0 grams of pure alcohol every day for at least 1 year; those who quit drinking for more than 1-year were categorized as former drinkers.

Statistical Analysis

Continuous measures were expressed as means $\pm$ standard deviations (SD), and categorical variables as percentages. Statistical analyses of characteristics across groups were performed using one-way analysis of variance (ANOVA) for continuous measures and chi-square tests for categorical measures. The relationships between village-level and individual-level variables and cardiovascular outcomes were evaluated with generalized linear mixed models with log link function, using SAS *PROC GLIMMIX* procedures (9). The effect of neighborhood was tested as random effects and village-level income was considered as fixed effects in the multilevel analysis. To investigate associations, prevalence rate ratios (RR) and their 95% confidence intervals (95% CI) were calculated from the regression coefficients in the fixed-effects part of the multilevel analysis (10).

The multilevel analysis was implemented in a stepwise manner (9). First, an intercept-only model (Model 0) with no predictors at either level was used to establish whether there was an overall village random-effect term. Second, village-level income was added to the intercept-only model as a fixed effect (Model 1). Third, individual-level variables were added in Model 2. The *variance* (SE) at the village-level was obtained in the random-effects part of the multilevel analysis. The *proportional change in variance* (PCV) between two consecutive models was calculated (11). Thus, Model 1 or Model 2 could be compared with Model 0 to determine the proportion of the total variance explained by village-level income or individual-level variables. Fourth, both village-level income and individual-level variables were incorporated as fixed-effects in Model 3. Individual-level variables were tested as random effects in Model 4 to determine whether there were significant cross-level interactions between individual-level and village-level variables. The cross-level interactions in the multilevel model assessed the degree to which relationships between individual-level variables were moderated by the village-level variable.

We used the median rate ratio (MRR) because cluster-level covariates in a binary model cannot be meaningfully quantitated (12). The MRR translates the village-level variance in the rate ratio scale, and can be interpreted as the increased risk of having CVD if a resident was to move to another village with a higher risk. The MRR is large (>1) if there are important village-level differences (11). The 80% interval rate ratio (IRR-80) was also calculated to integrate the village-level fixed-effects and the random residual variations (12). The interval is narrow if the residual variation between different villages is small and wide if the variation is large. An interval containing the value 1 indicates that the effect of the village-level characteristic is weak when compared with the remaining residual village-level heterogeneity (11).

All *P* values were two-tailed, with statistical significance defined as $P < 0.05$. Analyses were conducted using the Statistical Analysis System version 9.3 (SAS Institute Inc., Cary, NC, USA).

Results

The 14,424 participants included 4,947 men and 9,477 women (age range 40 to 93 years). Of the women, 47.5% (4502/9477) worked in agriculture, 44.0% (4167/9477) were employed in non-agricultural activities, and 5% (808/9477) worked at home. Annual per capita village-level income ranged between 3,814.1 and 15,792.2 RMB (Renminbi is equivalent to CNY or Chinese yuan). The 54 villages were categorized by income tertile (low, 4,858.4 RMB; medium 4,858.4 to 6066.2 RMB; high >6066.2 RMB). Individual-level characteristics are shown in Table 1. The distributions of age, education, occupation, alcohol consumption, history of stroke and CHD, hypertension and blood pressures varied across village groups.

In the multilevel analysis for stroke, the MRR from Model 0 was 1.70 (95% CI:1.42~1.94, $P<0.05$), indicating that neighborhood effects were associated with differences in stroke prevalence. The PCV was 0.10 (i.e., about 10% of the variation in stroke was explained by village-level income independent of individual variables). High-income villages were at higher risk of stroke than lower-income villages (RR=1.69, 95% CI:1.09~2.62; Table 2). The effects of individual-level modifiable cardiovascular risk factors in Models 2 and 3 were similar.

In the multilevel analysis for CHD, the MRR from Model 0 was 1.59 (95% CI:1.35~1.78, $P<0.05$). Results of the multilevel models for CHD are presented in Table 3. Village-level income was associated with CHD ($P=0.011$) with higher-income villages at higher risk (RR=1.63, 95% CI:1.13~2.34). Compared to the intercept-only model (Model 0), the variance in Model 1 associated with village-level CHD was reduced by 13.5% (i.e. $PCV = (0.2357 - 0.2038) / 0.2357$), which was attributable to the addition of village-level income. The IRR-80 for high-income (0.72~3.69) and medium-income (0.55~2.84) villages were wide and included the value 1 (Table 3), indicating that a large proportion of unexplained village-level variation remained. After adding individual-level variables or an interaction term, the random effect for village remained significant in Models 3 and 4, indicating considerable residual unexplained variability. The PCV indicated that 41% [i.e. $(0.2357 - 0.139) / 0.2357$] of the difference among villages was explained by the contextual and individual characteristics included in the Model 3.

There was a differential effect of several vascular risk factors for stroke and CHD. For example, in contrast to the results for CHD in Table 3 and Figure 2, individuals with hypertension had a higher risk of stroke (Table 2; Figure 1), whereas obesity was more strongly associated with CHD.

Due to cross-level interactions between age-group and village-income, prevalence rate ratios for age represent the effect of age among individuals who are in the reference group for income. Similarly, rate ratios for income represent the effect of income among individuals who were in the reference group for age. No cross-level interaction was found for stroke ($P=0.359$), and the effects of age on stroke were similar in three different income level villages (Table 4). In contrast, as shown in Table 4, for younger residents (age < 60), the probability of having CHD was higher for those in high-income villages (RR=1.58, 95% CI:

1.15~2.18, $P<0.01$). The IRR for CHD in high-income villages was 1.11-4.35 (i.e., when randomly choosing two persons with identical individual covariates from a high-income village and a low-income village, the prevalence rate ratio between the two lies within the interval in 80% of the cases). This interval is relatively wide and does not include the value 1, indicating considerable cluster heterogeneity and that the effect of village-level income is large relative to the cluster effect. Therefore, a fairly large proportion of the variation between villages in CHD prevalence may be explained by village-level income.

Discussion

We found differences in the prevalence of stroke and CHD in a rural Chinese population, but contrary to our hypothesis, risk was increased with higher SES. It is commonly assumed that a higher prevalence of risk factors and limited availability of prevention and intervention programs in lower SES neighborhoods lead to higher risks for cardiovascular events and mortality (2, 13, 14). Although our results seem paradoxical, other studies find that in the early stages of economic development, higher social-class individuals may have increased risk for CVD whereas at later stages, higher risk is disproportionately associated with lower social class (15-17). We previously reported diversity in the distribution of CVD and risk factors across different geographic areas in the same population (7). The current study expands these observations, showing that village variation exists even in the same geographic area. Together with our previous observations of prevalent cardiovascular risk factors such as obesity and diabetes (7), we speculate that the increased risk we found with higher village-level SES could be a reflection of nutritional transition.

Smoking, alcohol consumption, hypertension, diabetes and obesity are important risk factors for vascular disease. The association between alcohol consumption and stroke is complex and might be J-shaped. A recent meta-analysis found that heavy alcohol consumption was associated with an overall increased risk of stroke whereas light or moderate alcohol consumption tended to be protective against ischemic stroke. (18) It could partly explain the lower stroke prevalence with alcohol consumption in our study. We found that hypertension was more strongly associated with stroke than CHD, which is supported by a recent review of risk factors suggesting the strongest association is between hypertension and stroke in Chinese (19). Diabetes was associated with a higher risk of CHD than stroke, which is consistent with results from the INTERHEART study (20). Similar to another population-based study in rural Northern China (21), our study found a high prevalence of obesity in the rural Chinese population. This may be explained by the “Western/new affluence” dietary pattern characterized by higher consumption of red meats and fats adopted in this region. A recent study (22) in the same area assessed nutritional characteristics using the Food Frequency Questionnaire in Chinese adults aged over 50 years, and found that a fat-dominated Western diet was related to likelihood of obesity. The high prevalence of diabetes (11.6%) recently reported in a nationally representative survey (23), together with increasing obesity prevalence (24), likely contribute to the increasing prevalence of CHD in China.

The cross-level interaction indicated that the magnitude of village-level variations and strength of contextual effects were modified by age. Village-level SES effects on CHD were much stronger among younger than older adults, which is consistent with the findings from a

large Swedish cohort (13). The more frequent and evenly distributed prevalence of CHD at older ages, together with the better health of survivors in low-income villages, might explain the weaker socioeconomic contextual effect on CHD prevalence in elderly residents (25). Fetal exposure to the severe Chinese famine (1959-1961) is associated with an increased risk of type 2 diabetes (26), hypertension (27) and metabolic syndrome (28) in adulthood, which might also result in the increased risk of CHD for those now aged below 60 years. Alternatively, this might be a consequence of the premature events in individuals who accumulated exposures related to both village-level SES and their individual risk factors, such as hypertension (29). It is particularly important for public health interventions to target premature CVD and address conditions prevailing in specific populations (3, 17); e.g., salt substitution or folic acid supplementation among rural Chinese with hypertension (30, 31).

The main strengths of our study are its large sample and the use of multilevel models. Population-based survey data collected by cluster sampling are inherently hierarchical; individuals are grouped into villages, and villages may be nested within larger regions. Thus, conventional statistical methods are inappropriate as individuals within a village do not represent independent observations (32). By partitioning the variance components, our multilevel analysis evaluated the relative contributions of village-level and individual-level factors to the total variation in CVD.

There are several limitations of our analysis. Individual or household income is not available in population-based surveys of rural Chinese. We therefore used per capita village-level income to assess neighborhood effects (2). Although education can be a proxy for income level in many developed countries (33), this may not be true in rural China. Most rural residents did not have formal education beyond junior high school, which might explain why we found no correlation between educational level and income. The cross-sectional design limits inferences about causal relationships between risk factors and CVD. For example, in low and middle income regions such as rural China, the risk of hemorrhagic stroke may be increased due to inadequately controlled hypertension. Because of our cross-sectional design, cases of fatal hemorrhagic stroke were not included in the survey, which might lead to survival bias. The lower prevalence of hypertension (about 42%) than the worldwide average among people aged over 40 years could be a reflection of this kind of bias. In addition, the rural population had a high prevalence of hypertension in the 1980s; however, over the last two decades there has been a concerted public health effort to combat hypertension in this area, including dietary salt reduction and health education (34). This program may have reduced the rate of hypertension in these communities among those with less severe hypertension who did not die as a result of their disease. Twice as many women as men were surveyed, likely because men in the labor force tend to move to cities such as downtown Beijing for better work opportunities and higher wages. Other studies enrolling subjects in rural China, such as the Asia Pacific Cohort Studies Collaboration (35) had similar proportions of women and men in these areas as in our study. Although the villages in our study were not urban, given their geographic location, they may not be representative of all rural areas in China. They, however, are likely similar to other villages at a similar stage of economic growth and transition.

It should be noted that according to the World Bank income category (low income, US\$ 975 or less; lower-middle income, US\$ 976–3855; <http://www.who.int/goe/publications/atlas/source/>) and official exchange rates (\$1-US= 6.9451 RMB) in 2008, even the “high-income” villages ($6066.2/6.9451=\$873$) in our study were poor; the upper tertile was barely above the suggested poverty level. Considering the theory of purchasing power parity (PPP), we used the “Big Mac index” (The Economist, <http://www.economist.com/content/big-mac-index>) to equalize the prices of an identical basket of goods and services in two countries. For example, the average local price of a Big Mac in the U.S. was \$4.62; in China it was only \$2.74 at market exchange rates. Hence the Chinese Yuan was undervalued by 41% relative to the U.S. dollar on a PPP basis. The “correct” level for the “low” income and “high” income should be $\$700 \times (1+41\%) = \987 and $\$873 \times (1+41\%) = \1230.9 , respectively. They are still among the lower-middle income group. Here, the exchange rate is only used to determine the income level for this area based on the World Bank criteria; According to the International Monetary Fund database (2012), the gross domestic product based on PPP per capita GDP in China was 9,055 current international dollars and still among the developing group (below the world average level Int\$ 11,964) ([http://en.wikipedia.org/wiki/List_of_countries_by_GDP_\(PPP\)_per_capita](http://en.wikipedia.org/wiki/List_of_countries_by_GDP_(PPP)_per_capita)).

In developing areas, the relatively higher income-level villages might be more vulnerable to CVD. People in the “higher” income group of the present study were still “low” income, but as happens throughout the world, they can afford and tend to eat diets high in carbohydrates (rice, noodles, sweet, and soda) and therefore, although malnourished, tend to be overweight. The groups categorized as “middle” and “low” income in the present study probably could not even afford this diet and were likely also malnourished, but not obese (and thus had some “protection” against diabetes and hypertension). There, however, was not a relationship between obesity and people < 60 years in high income villages (RR=1.07, 95%CI: 0.83-1.39, $P=0.5932$), so the trend for higher rates of CHD in this group may be mediated by other factors such as hyperhomocysteinemia due to lack of folic acid. Our results may not be generalizable to higher income or urban populations.

We found substantial differences across villages in a rural Chinese population with a higher prevalence of stroke and CHD in higher income villages. It is noteworthy that the effect of village-level income alone accounted for 10% and 13.5% of the reduction in neighborhood effects on stroke and CHD, respectively. Recognition of the importance of SES factors for CVD has important implications for practice and policy, as understanding differences in CVD prevalence is critical for the development of effective, targeted prevention and intervention strategies. Further evaluation of village effects including general education, health knowledge and care access in addition to nutritional and lifestyle differences should be considered for future research.

Acknowledgments

This study was supported by the National Natural Science Foundation of China (NSFC 81230066, 81102177, 81172744, 30872173, 30671807), the Young Scholar Scientific Research Foundation of China CDC (2013B104), and the National Institutes of Health (NIH 1D43-TW008308-01). The authors thank all the participants and study staff and Dr. Sean O'Brien (Duke Clinical Research Institute) for helpful suggestions.

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Figure 1. Multilevel model-based estimates of risk effects on stroke prevalence (N=12,988) (Rate Ratio and 95% CI)

Figure 2. Multilevel model-based estimates of risk effects on CHD prevalence(N=12,988) (Rate Ratio and 95% CI)

Demographics, cardiovascular history, risk factors, and physical measurements by village groups with different per capita income levels

Table 1

Characteristics	High-income (n=7039)	Medium-income (n=4292)	Low-income (n=3093)	P-value
Age, years	55.7±9.9	56.2±9.8	56.2±9.7	0.006
Gender, %				0.136
Women	4646(66.0)	2845(66.3)	1986(64.2)	
Men	2393(34.0)	1447(33.7)	1107(35.8)	
Education, %				< 0.001
Illiterate and semiliterate	1242(20.5)	715(17.5)	556(18.6)	
Elementary school	1502(24.8)	1126(27.5)	859(28.8)	
Junior high school	2659(44.0)	1805(44.1)	1243(41.6)	
Senior high school	624(10.3)	433(10.6)	317(10.6)	
College and above	23(0.4)	15(0.4)	12(0.4)	
Occupation, %				0.036
Nonagricultural	3372(55.8)	2223(54.2)	1711(57.3)	
Agricultural	2667(44.2)	1876(45.8)	1276(42.7)	
Marriage, %				0.278
Married	5327(88.1)	3594(87.7)	2623(87.8)	
Widowed	645(10.7)	444(10.8)	310(10.4)	
Divorced	34(0.6)	33(0.8)	32(1.1)	
Single	43(0.7)	29(0.7)	22(0.7)	
Cigarette smoking, %				0.153
Never	4046(67.4)	2710(66.2)	1945(65.1)	
Former	405(6.7)	273(6.7)	230(7.7)	
Current	1554(25.9)	1108(27.1)	811(27.2)	
Alcohol consumption, %				0.035
Never	4571(76.1)	3097(75.7)	2195(73.5)	
Former	268(4.5)	173(4.2)	127(4.3)	
Current	1166(19.4)	823(20.1)	665(22.3)	
Hypertension, %	3091(43.9)	1698(39.6)	1348(43.6)	< 0.001
Diabetes, %	646(9.2)	361(8.4)	257(8.3)	0.226

Characteristics	High-income (n=7039)	Medium-income (n=4292)	Low-income (n=3093)	P-value
Obesity, %	1514(21.8)	850(19.9)	647(21.0)	0.066
Coronary heart disease, %	501(7.1)	231(5.4)	147(4.8)	< 0.001
Stroke, %	318 4.5)	166(3.9)	94(3.0)	0.002
Body mass index, kg/m ²	26.0±3.8	26.1±3.8	26.1±3.9	0.704
Systolic blood pressure, mmHg	131.4±17.8	130.0±17.5	131.6±17.5	< 0.001
Diastolic blood pressure, mmHg	82.1±10.0	81.8±9.6	83.0±10.1	< 0.001

Table 2

Multilevel models of stroke prevalence (N=12,988)

	Model 1	Model 2	Model 3
Fixed effects			
<i>Area-level income</i>			
Low (4858 RMB)	Reference		Reference
Medium (4858~6066 RMB)	1.42(0.90~2.24)		1.36(0.91~2.03)
<i>80% interval rate ratio (IRR-80)</i>			
High (>6066 RMB)	0.54~3.71		0.63~2.96
	1.69(1.09~2.62) *		1.66(1.13~2.44) *
<i>80% interval rate ratio (IRR-80)</i>			
	0.65~4.41		0.76~3.61
<i>Individual-level variables</i>			
Age group (>60 yrs)		1.59(1.32~1.91) ***	1.59(1.32~1.91) ***
Sex (Men)		2.02(1.62~2.52) ***	2.02(1.62~2.52) ***
Education (Below senior high school)		1.42(0.97~2.06)	1.42(0.97~2.06)
Occupation (Agricultural)		1.56(1.30~1.87) ***	1.56(1.30~1.87) ***
Marital status (Widowed/divorced/single)		0.98(0.78~1.23)	0.98(0.78~1.24)
Cigarette smoking (Current/former)		1.48(1.20~1.82) ***	1.47(1.20~1.82) ***
Alcohol consumption (Current/former)		0.82(0.66~1.02)	0.82(0.66~1.02)
Hypertension (Yes)		2.33(1.93~2.80) ***	2.33(1.93~2.80) ***
Diabetes (Yes)		2.03(1.65~2.49) ***	2.02(1.65~2.48) ***
Obesity		0.94(0.75~1.18)	0.94(0.75~1.18)
Random effects			
Between-group variation (S.E.)	0.281(0.077) *	0.220(0.076) *	0.184(0.071) *
Median rate ratio (MRR)	1.65	1.56	1.50

* $P<0.05$;** $P<0.01$;*** $P<0.001$.

Table 3

Multilevel models of CHD prevalence (N=12,988)

	Model 1	Model 2	Model 3
Fixed effects			
<i>Area-level income</i>			
Low (4858 RMB)	Reference		Reference
Medium (4858~6066 RMB)	1.26 (0.86~1.83)		1.21(0.87~1.68)
<i>80% interval rate ratio (IRR-80)</i>			
High (>6066 RMB)	0.55~2.84		0.61~2.37
	1.63(1.13~2.34)*		1.55(1.13~2.13)**
<i>80% interval rate ratio (IRR-80)</i>	0.72~3.69		0.79~3.04
<i>Individual-level variables</i>			
Age group (>60 years)		2.20(1.89~2.56)***	2.20(1.89~2.56)***
Sex (Men)		0.90(0.74~1.09)	0.90(0.75~1.09)
Education (Below senior high school)		1.03(0.78~1.36)	1.02(0.77~1.36)
Occupation (Agricultural)		1.33(1.15~1.55)***	1.34(1.16~1.55)***
Marital status (Widowed/divorced/single)		1.10(0.93~1.31)	1.10(0.93~1.31)
Cigarette smoking (Current/former)		1.32(1.12~1.55)**	1.32(1.12~1.55)**
Alcohol consumption (Current/former)		0.93(0.76~1.14)	0.93(0.76~1.14)
Hypertension (Yes)		1.58(1.38~1.81)***	1.58(1.38~1.82)***
Diabetes (Yes)		2.30(1.98~2.69)***	2.31(1.98~2.69)***
Obesity		1.44(1.24~1.67)***	1.43(1.23~1.66)***
Random effects			
Between-group variation (S.E.)	0.204 (0.067)*	0.167(0.065)*	0.139(0.063)*
Median rate ratio (MRR)	1.54	1.47	1.42

* $P<0.05$;** $P<0.01$;*** $P<0.001$

Table 4

Cross-level interaction effects for age and income

	CHD	Stroke
<i>Age >60 vs. 60-years</i>		
Low-income villages	3.56(2.44~5.20) ***	1.77(1.13~2.77) *
Medium-income villages	2.21(1.66~2.94) ***	1.54(1.10~2.16) *
High-income villages	1.97(1.62~2.39) ***	1.53(1.19~1.97) ***
<i>In individuals age 60-years</i>		
Village-level income: high vs. low	1.58(1.15~2.18) **	1.67(1.13~2.47) *
Village-level income: medium vs. low	1.23(0.88~1.72)	1.37(0.91~2.06)
<i>In individuals age >60-years</i>		
Village-level income: high vs. low	1.26(0.90~1.78)	1.44(0.95~2.17)
Village-level income: medium vs. low	1.05(0.73~1.51)	1.18(0.77~1.82)

Tests of interaction between age and income level were $P=0.017$ for CHD and $P=0.359$ for stroke.

* $P<0.05$;

** $P<0.01$;

*** $P<0.001$