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4 **Is metabolic syndrome the symbol of economic development and social transformation?**  
5 **Evidence from the China National Stroke Prevention Project**  
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3 **Abstract**

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5 **Background**

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7 Increase of Metabolic syndrome (MetS) is associated with economic development and  
8 changes of lifestyle. Understanding current prevalence and distribution of MetS in China is  
9 important for preventing associated health complications.  
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13 **Methods**

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15 The present analysis used data from a nationally study in 2014-2015. We defined MetS by  
16 different definitions, and compared results of the present study and previous nationally  
17 representative studies to illustrate possible temporal changes in MetS prevalence.  
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23 **Results**

24  
25 The estimated prevalence of MetS was 18.4% by the ATP III criteria, 34.0% by the revised  
26 ATP III criteria, and 26.9% by IDF criteria. The prevalence was higher in women, older  
27 adults, those with lower education level, and in economically developed regions.  
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31 Contrasting with previous national studies, adults in urban areas had a lower rate of MetS  
32 than those in rural areas (odds ratio 0.94; 95% CI 0.92 -0.97). And rural adults had worse  
33 deterioration or less improvement in abdominal obesity, overweight, hypertension, and high  
34 fasting plasma glucose, than urban adults, which was particularly striking for women.  
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39 **Conclusions**

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41 While measures to prevent and control cardiovascular diseases need to be strengthened in  
42 China, rapid increasing risk factors among rural residents and women should be prioritised  
43 in making public health policy decisions.  
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47 **Key words:** Metabolic syndrome; Prevalence; Trends; Epidemiology  
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3 **Key Messages**  
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5 1. Our study assessed prevalence and temporal changes of MetS among Chinese population  
6 with the most recently completed and the largest sample size.  
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9 2. The current prevalence of MetS was higher in women, older adults, those with lower  
10 education level, and in economically developed regions and the CVD risk factors among  
11 rural residents and women should be prioritised in making public health policy decisions.  
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13 3. A comparison of results of the present study and previous national studies showed that  
14 rural adults had worse deterioration or less improvement in abdominal obesity, overweight,  
15 hypertension, and high fasting plasma glucose, than urban adults, which was particularly  
16 striking for women.  
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3 **Introduction**  
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6 The morbidity and mortality of cardiovascular disease (CVD) are increasing in China, as in  
7 other low-and-middle income countries, while CVD mortality has been declining in  
8 high-income western countries since 1980s (1-3). The metabolic syndrome (MetS) refers to a  
9 cluster of metabolic factors associated with the risk of CVD, including abdominal obesity,  
10 high blood pressure, dyslipidaemia and dysglycaemia(4). The prevalence and distribution of  
11 MetS in population are important indicators for making public health decisions regarding the  
12 control of CVD epidemic(5).  
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20 There were several nationally representative studies that provided data on the  
21 prevalence of MetS in China. The International Collaborative Study of Cardiovascular  
22 Disease in Asia (InterASIA) in 2000-2001 was a cross-sectional study of a nationally  
23 representative sample of 15,540 Chinese adults aged 35-74 years(6). In 2007-2008, A  
24 sample of 46,024 Chinese aged 20 years and over were included in the National Diabetes  
25 and Metabolic Disorders Survey (NDMDS)(7). The China Health and Nutrition Survey  
26 (CHNS) in 2009 examined metabolic risk factors among a sample of 7488 adults(8). The  
27 2010 China Noncommunicable Disease Surveillance (CNCDS) included 97,098 participants  
28 from 31 provinces in China(9). Results of these national studies showed an increasingly  
29 high prevalence of MetS in China. In addition, it was found that the prevalence of MetS was  
30 generally higher in women, among older adults, and in urban residents(6-9). However, it is  
31 often difficult to compare the results of different studies, due to different sampling methods,  
32 participant age range, and definitions of MetS used.  
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45 The China National Stroke Prevention Project (CSPP) survey in 2014-2015 was a  
46 recently completed cross-sectional study that included 109,551 participants aged  $\geq 40$  years  
47 from 30 provinces in China. In the present study, we used data from the CSPP to estimate  
48 the current prevalence of MetS in China. We also compared results of CSPP and previous  
49 nationally representative studies to reveal changes in the prevalence of MetS over time in  
50 China.  
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## Methods

### Design and participants of the CSPP study

The CSPP was administrated by the National Project Office of Stroke Prevention and Control, and carried out in 30 provinces in China from October 2014 to November 2015. Using a 2-stage stratified cluster sampling method, 200 project areas were firstly selected in proportion to the local population size and the numbers of counties. Then an urban community and a rural village were selected from each project area as primary sampling units according to geographical locations and suggestions from local hospitals. The cluster sampling method was used in every primary sampling unit and all residents aged  $\geq 40$  years were surveyed during the primary screening.

All participants received information on the study and provided written informed consent to participate. Questionnaire completion and physical examination were conducted by trained staff in primary health care institutions, to collect data on demographic characteristics, medical history, behavioural risk factors, height, weight, waist circumference, and blood pressure. The assessment of stroke risk was based on the following variables: hypertension, atrial fibrillation, current smoking, dyslipidaemia, diabetes, physical inactivity, obesity or overweight ( $BMI \geq 26 \text{kg/m}^2$ ), and family history of stroke. Participants with  $\geq 3$  risk factors or with prior TIA or stroke were considered at high risk of stroke, and those with  $< 3$  risk factor but having hypertension, diabetes, atrial fibrillation, or heart valve disorders were categorised as at intermediate risk of stroke. Low risk of stroke was defined as having  $< 3$  risk factors and without the above CVD conditions.

According to the screening plan, participants at high risk of stroke were invited for further laboratory tests, carotid ultrasound, and electrocardiogram. However, a large number of participants at intermediate or low risk of stroke were also undergone additional laboratory tests. A total of 726,451 participants were included in the CSPP survey in 2014-2015, and 109,551 of them received additional laboratory tests. In the current study, the analysis of MetS was based on data from 109,551 participants who had completed all

laboratory examinations.

### **Data from other relevant studies**

Data from previous nationally representative studies of MetS in China were obtained to compare results of different studies and to illustrate changes in the prevalence of MetS over time. We were able to access the original data from the CHNS(8, 10). For other national scale studies of MetS in China (InterASIA(6), NDMDS(7), and CNDS(9)), we had to rely on results reported in published articles. We have attempted to make results from different studies as comparable as possible in terms of participant age and the definition of MetS in analysis.

### **Definition of Metabolic Syndrome**

The metabolic syndrome was defined by different definitions, including National Cholesterol Education Programme (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (NCEP ATP III) criteria(11), revised NCEP ATP III for Asian-Americans(12), and the updated International Diabetes Federation (IDF)(13) definition (see Supplementary file-1).

### **Data Analysis**

We calculated the prevalence of MetS by gender, age, location (urban or rural), and the level of socio-economic development, weighted by age and sex distribution of the 2014 population in China. Because relatively more participants at high risk of stroke were included in the analysis of MetS, the prevalence of MetS were weighted according to the level of stroke risk in all CSPP participants. The *t* test and Chi-square test were used for statistically testing continuous and categorical variables. Logistic regression analysis was conducted to estimate the association between MetS and other variables including age, gender, urban/rural location, education level, and economic development. In addition, the discrepancy in the prevalence of MetS between urban and rural areas was measured by using prevalence rate ratio(14).

Analyses were conducted using SPSS 19.0 (SPSS Inc., Chicago, Ill).

### **Ethical approval**

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3 The CSPP study protocol was approved by the Ethics committee of the XuanWu Hospital  
4 Institutional Review Board, Capital Medical University (Beijing, China).  
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## 7 **Results**

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10 Table 1 shows the basic characteristics of the 109,551 participants who were included in the  
11 analysis and 616,900 participants without laboratory tests. The included participants were  
12 relatively older, and less likely from rural areas or under developed regions. As expected,  
13 the risk of stroke was much higher for the included participants compared with those not  
14 included. The proportion of low risk participants was 40.2% for the included participants  
15 and 76.3% for those who were not included.  
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22 The estimated prevalence of MetS by the ATP III criteria without adjusting for stroke  
23 risk level was presented in supplementary file-2. The overall prevalence of MetS (ATP III  
24 criteria) was 25.1%, and it was clearly associated with the level of stroke risk  
25 (supplementary file-2). After adjusting for the stroke risk, the estimated prevalence of MetS  
26 for Chinese adults aged  $\geq 40$  in 2014-2015 was 18.4% by the ATP III criteria, 34.0% by the  
27 revised ATP III criteria, and 26.9% by the IDF criteria (Table 2). The prevalence of MetS  
28 was statistically significantly higher in women, older adults, rural residents, adults with low  
29 level of education, and in economically developed regions (Table 3).  
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## 38 **Comparison of results of different studies**

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40 We were able to compare sex- and age-specific prevalence of MetS (using the ATP III  
41 definition) with the results of other three nationally representative studies (InterASIA(6),  
42 CHNS(8), and CNCDS(9)) (Figure 1). The prevalence of MetS in 2014-2015 by the CSPP  
43 study was generally higher than that in 2000-2001, but often lower than that in 2009 and  
44 2010 (Figure 1). The high prevalence of MetS estimated by the CNCDS study in 2010 is  
45 particularly noteworthy, compared with other studies in 2000-2010, 2009, and 2014-2015.  
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51 Figure 2 shows the prevalence rate ratio of MetS in urban and rural areas, according to  
52 results of the CSPP and four previous studies(6-9). Results of previous studies indicated a  
53 higher prevalence of MetS in urban adults, with a prevalence rate ratio of 1.47 in 2000-2001,  
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3 1.27 in 2007-2008, 1.36 in 2009, and 1.18 in 2010. However, the overall prevalence rate  
4 ratio was 0.91 (95% CI: 0.89 -0.93), indicating a lower rate of MetS in urban adults, by  
5 2014-2015 (Figure 2a). While rural and urban men had similar prevalence of MetS in  
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7 2014-2015 (Figure 2b), rural women had a much higher prevalence than urban women in  
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9 2014-2015 (Figure 2c).  
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13 Data from three nationally representative studies (InterASIA(6), CHNS(8), and CSPP)  
14 are available to compare the prevalence of MetS components in 2000-2001, 2009, and  
15 2014-2015 in China (Table 4). The rate of abdominal obesity was increased by 134.5%  
16 between 2000-2001 and 2009, and the increase was much greater in men than in women,  
17 particularly in rural areas. The prevalence of abdominal obesity was increased by 142.4% in  
18 rural areas, much greater than that (75.6%) in urban areas, between 2000-2001 and 2009.  
19  
20 The overall prevalence of abdominal obesity in China was somewhat reduced by -13.6%  
21 between 2009 and 2014-2015 (Table 4). However, the reduction in the prevalence of  
22 abdominal obesity between 2009 and 2014-2015 was more substantial in urban adults,  
23 particularly in men. Compared with that in urban adults, the prevalence of abdominal  
24 obesity in rural adults was lower in 2000-2001 (7.2% vs. 10.1%), similarly high in 2009  
25 (17.5% vs. 17.7% or 18.7% vs. 18.8%), and higher in 2014-2015 (18.7% vs. 14.5%) (Table  
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38 The overall prevalence of hypertriglyceridemia in China was increased by 36.9%  
39 between 2000-2001 and 2009, and by 8.9% between 2009 and 20014-20015 (Table 4). The  
40 increase was more substantial in rural adults than those in urban areas: 43.6% vs 10.7%  
41 during 2000-2001 and 2009, and 11.9% vs. 2.2% during 2009 and 2014-2015. The  
42 prevalence of hypertriglyceridemia was similarly high among rural and urban adults (38.0%  
43 vs 38.4%) by 2014-2015.  
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50 Results in Table 4 indicated a fluctuated change in the prevalence of low HDL  
51 cholesterol, reduced by -24.8% between 2000-2001 and 2009 and increased by 24.7%  
52 between 2009 and 2014-2015. The prevalence of low HDL cholesterol in 2014-2015 was  
53 actually similar to that in 2000-2001.  
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3 The overall prevalence of hypertension was not changed significantly between  
4 2000-2001 and 2009, and increased by 15.9% between 2009 and 2014-2015 (Table 4).  
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6 Particularly, the recent increase in the prevalence of hypertension was greater in rural adults  
7 than that in urban adults (29.7% vs. 4.5%). Rural adults had a higher prevalence of  
8 hypertension than those in urban areas (58.4% vs. 48.8%) by 2014-2015.  
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12 The overall prevalence of high fasting glucose or diabetes in China was increased by  
13 10.5% between 2000-2001 and 2009, and reduced by -14.0% between 2009 and 2014-2015.  
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15 Such changes were occurring mainly among male adults, particularly in rural areas.  
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17 Compared with urban adults, the prevalence of fasting glucose or diabetes among rural men  
18 was increased more greatly (37.0% vs. 10.2%) between 2000-2001 and 2009, and reduced  
19 somewhat less (-20.3% vs. -29.4%) between 2009 and 2014-2015. The prevalence of high  
20 fasting glucose or diabetes was higher in urban areas in 2000-2001 and 2009, and the  
21 difference between rural and urban areas was no longer obvious by 2014-2015 (Table 4).  
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29 The prevalence of overweight in rural adults was increased by 24.5% between  
30 2000-2001 and 2009 and by 14.2% between 2009 and 2014-2015, while it was reduced by  
31 -10.4% and -2.4%, respectively, in urban adults (Table 4). Compared with adults in urban  
32 areas, those in rural areas had a relatively low prevalence of overweight in 2000-2001 (26.6%  
33 vs. 39.1%) and in 2009 (33.1% vs. 35.1%), which was no longer the case in 2014-2015  
34 (38.8% vs. 35.1%) (Table 4).  
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## 41 **Discussions**

42 The estimated prevalence of MetS among adults aged  $\geq 40$  years in 2014-2015 in China was  
43 18.4% overall (13.2% in men and 23.7% in women) by the ATP III criteria. It was  
44 considerably higher by using the revised NCEP ATP III criteria (34.0% overall, 27.1% in  
45 men and 40.9% in women), or by using the IDF definition (26.9% overall, 18.4% in men  
46 and 35.7% in women). The overall rate of MetS (18.4% based on the ATP III definition) in  
47 China remains lower than that in the United States (about 35% among adults aged  $\geq 20$  years  
48 in 2011-2012)(15), in Europe (about 24%)(16), and in Brail (28.9%)(17). However, it is  
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3 already a serious public health problem due to the rapid population aging, behavioural and  
4 socioeconomic changes. According to the ATP III definition, 107 million Chinese adults  
5 aged 40-74 had metabolic syndrome. The number of adults with abdominal obesity and  
6 overweight was 96 million and 182 million, respectively, among adults aged 40-74 in  
7 2014/15 in China. Furthermore, among Chinese adults aged 40-74 in 2014/15, there were  
8 307 million with high blood pressure, 78 million with high fasting plasma glucose, 222  
9 million with hypertriglyceridemia, and 182 million with low HDL cholesterol. The  
10 estimated number of adults with MetS will be much higher if the revised NCEP ATP III or  
11 IDF criteria were used.  
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21 Compared with results of previous cross-sectional studies, the prevalence of MetS  
22 estimated by the CSPP study in 2014-2015 was higher than that in 2000-2001, but often  
23 lower than the estimated prevalence in 2009 and 2010. A possible explanation is that public  
24 health measures taking to control cardiovascular conditions in China have some effects on  
25 reduced deterioration or increased improvement in MetS among adults. For example, the  
26 prevalence of abdominal obesity and high fasting plasma glucose among urban adults was  
27 lower in 2014-2015 than that in 2009. Because of different sampling and analysis methods,  
28 however, the results of the across-study comparison need to be interpreted with caution, and  
29 further studies are required to confirm the temporal trends in the prevalence of MetS in  
30 Chinese adults.  
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40 The CSPP study confirmed findings from previous studies that the prevalence of MetS  
41 was higher in women, older adults, those with low level of education, and in economically  
42 developed regions. Contrasting with previous nationally representative studies in China, the  
43 2014-2015 CSPP study was the first to show that the MetS was more prevalent in rural  
44 areas than that in urban areas. The CSPP study revealed that rural adults had worse  
45 deterioration and/or less improvement in abdominal obesity, overweight, hypertension, and  
46 high fasting plasma glucose, than urban adults. In addition, the discrepancy in MetS  
47 between rural and urban adults was most striking for women.  
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56 Evidence from global nutrition transition suggested that urban residents generally have

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3 higher prevalence of obesity and overweight in low-income or less developed nations, but  
4 rural residents will catch up quickly along with economic development(18). For example,  
5 although women with the highest wealth and education had the highest prevalence of  
6 overweight and obesity in 39 low and middle income countries, the increase of overweight  
7 was greater among women with the lowest wealth and education(19). The present study  
8 indicated that Chinese adults in rural areas are not only catching up quickly, but also  
9 possibly have overtaken those in urban areas regarding obesity and related MetS problems.  
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17 The speed of nutrition transition and socioeconomic development in China is uniquely  
18 rapid, which will lead to swift geographic and temporal changes in MetS. Cardiovascular  
19 diseases are expected to increase considerably in future due to population ageing and high  
20 prevalence of MetS. However, appropriate public health measures can be implemented to  
21 reduce the burden of cardiovascular diseases. It may be interesting to note that the CSPP  
22 study in 2014-2015 found a lower prevalence of abdominal obesity in urban adults,  
23 compared with the CHNS study in 2009. In addition, the estimated prevalence of high  
24 fasting plasma glucose for men in both rural and urban areas was lower in the CSPP study  
25 in 2014-2015 compared with that in the CHNS study in 2009. However, we should not be  
26 complacent as MetS components remain highly prevalent among Chinese adults. For  
27 example, the prevalence of high blood pressure is high in both rural and urban areas.  
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38 While efforts to prevent and control cardiovascular diseases need to be strengthened for  
39 the whole Chinese population, health decision makers need to be aware of rapid changes in  
40 the distribution of CVD risk factors by sub-population categories. Findings of the present  
41 study clearly indicate that CVD risk factors among rural residents and women should be  
42 prioritised in making public health policy decisions.  
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### 47 **Strengths and Limitations**

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49 The CSPP study was a nationally representative study, the most recently completed, with  
50 the largest sample size to estimate the prevalence of MetS in China. In addition to the  
51 current prevalence of MetS in Chinese adults, we were able to show the possible temporal  
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3 changes in MetS prevalence by comparing results of the present study and previous  
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5 nationally representative studies.  
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Some limitations of the study are worth mentioning. First, the present study included only participants who had additional laboratory test, and the prevalence of MetS will be over-estimated because high risk of stroke was more prevalent among them. However, we were able to cope with this problem by adjusting the estimated prevalence of MetS according to the distribution of stroke risk among all CSPP participants.

To show the possible temporal changes in MetS, we made cross-study comparisons. There may be many alternative explanations for the observed differences between the CSPP and previous studies. Although we have attempted to make the results of different studies as comparable as possible, it was difficult to be certain about the true causes of the difference between different cross-sectional studies. Availability of individual participant data from all relevant studies should help improve comparison of results across studies. However, so far we were able to access individual participant data for only one previous study (CHNS<sup>8</sup>), in addition to the CSPP study.

### **Conclusions**

Prevalence of metabolic syndrome has been rapidly increasing and remains high, particularly in women and rural areas, among middle-aged and elderly adults in China. While efforts to prevent and control cardiovascular diseases need to be strengthened for the whole population, rapid increasing risk factors among rural residents and women should be prioritised in making public health policy decisions. It should also be a concern for health decision makers in other developing countries which are experiencing socio-economic transformation.

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3 **Acknowledgments**  
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36 **Conflict of interests**  
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38 The authors report no conflicts of interest  
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3 **Figure legends:**  
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5 **Figure 1: Rates of prevalence of MetS (ATP III criteria) estimated by different**  
6 **nationally representative studies.** Results of CHNS and CSPP were obtained by analyses  
7 of original individual participant survey data, while results of InterASIA and CNCDS were  
8 based on the published reports. The comparison of CSPP results and other studies for the  
9 35-44 age group should be cautious as adults aged 35-39 were not included in the CSPP  
10 survey.  
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20 **Figure 2: Ratio of prevalence rates of MetS in urban and rural areas in China, results**  
21 **from five nationally representative studies between 2000/01 and 2014/15.**  
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**Table 1. The main characteristics of CSPP participants in 2014-2015**

Characteristic	Included (n=109551)	Not included (n=616900)	P value
Mean age(mean, SD)	59·23±11·01	56·88±11·44	<0·001
Age groups (%):			<0·001
40-49	22·8	32·3	
50-59	28·6	29·5	
≥60	48·6	38·2	
Sex (%):			<0·001
Men	45·4	47·0	
Women	54·6	53·0	
Education (%):			<0·001
Primary school and below	42·3	41·4	
Middle school	35·0	37·1	
High school or the equivalent	15·5	14·8	
University or other tertiary degree	7·3	6·7	
Location (%)			<0·001
Urban	52·3	46·6	
Rural	47·7	53·4	
Economic development (%)			<0·001
Under developed	19·4	30·3	
Intermediately developed	54·2	43·8	
Developed	26·4	25·9	
Stroke risk (%)			<0·001
Low	40·2	76·3	
Intermediate	10·0	14·5	
High (≥3 risk factors)	35·9	6·6	
History of TIA	5·7	1·2	
History of stroke	8·3	1·4	
Smoking status			<0·001
Current smokers (%)	18·0	3·5	
Former smokers (%)	3·4	0·5	
Current drinking (%)	13·8	1·8	<0·001
Physical inactivity (%)	28·4	16·7	<0·001

**Table 2: Prevalence of MetS by different definitions in 2014-2015**

	N	% (95% CI)		
		NCEP ATP III	Revised NCEP ATP III	IDF
Overall	109551	18.4% (18.2%, 18.7%)	34.0% (33.7%, 34.3%)	26.9% (26.7%, 27.2%)
Sex:				
Men	49789	13.2% (12.9%, 13.6%)	27.1% (26.7%, 27.6%)	18.4% (18.1%, 18.8%)
Women	59762	23.7% (23.3%, 24.1%)	40.9% (40.5%, 41.3%)	35.7% (35.3%, 36.1%)
Age group:				
40-49	24937	13.3% (12.8%, 13.7%)	27.3% (26.7%, 27.8%)	21.4% (20.8%, 21.9%)
50-59	31376	18.5% (18.1%, 19.0%)	34.2% (33.6%, 34.7%)	27.4% (26.8%, 27.9%)
>=60	53238	22.8% (22.4%, 23.2%)	39.4% (38.9%, 39.8%)	31.3% (30.9%, 31.7%)
Location:				
Urban	57298	17.8% (17.5%, 18.2%)	33.1% (32.7%, 33.5%)	26.7% (26.3%, 27.0%)
Rural	52253	19.6% (19.3%, 20.0%)	35.6% (35.1%, 36.0%)	27.7% (27.3%, 28.1%)
Economic:				
Underdeveloped	21272	15.1% (14.5%, 15.7%)	30.8% (30.2%, 31.5%)	23.6% (23.0%, 24.2%)
Intermediately	59365	19.0% (18.6%, 19.3%)	34.1% (33.7%, 34.5%)	28.7% (28.4%, 29.1%)
Developed	28914	19.7% (19.1%, 20.2%)	34.9% (34.3%, 35.5%)	26.3% (25.8%, 26.9%)
Smoking status:				
Never	86210	17.8% (17.6%, 18.1%)	33.3% (32.9%, 33.6%)	26.3% (26.0%, 26.6%)
Former	3672	32.2% (30.7%, 33.7%)	49.7% (48.1%, 51.3%)	41.7% (40.1%, 43.3%)
Current	19669	29.1% (28.4%, 29.7%)	47.2% (46.5%, 47.9%)	38.8% (38.1%, 39.5%)
Current drinking:				
No	94485	17.8% (17.5%, 18.1%)	32.8% (32.5%, 33.1%)	25.8% (25.5%, 26.1%)

Notes to Table 2: Estimated rates of the prevalence were weighted by 2014 population in China and adjusted by level of stroke risk in all CSPP participants.

**Table 3: Association between MetS (defined by ATP III) and selected basic variables – results of logistic regression analysis.**

Variables	Odds ratio	95% CI	P value
Sex			
Men	1.00		
Women	2.11	2.05-2.17	<0.001
Age			
40-49	1.00		
50-59	1.65	1.58-1.72	<0.001
≥60	2.05	1.97-2.13	<0.001
Location			
Rural	1.00		
Urban	0.94	0.92-0.97	<0.001
Education			
Primary school and below	1.00		
Middle school	1.01	0.98-1.04	0.692
High school or the equivalent	0.97	0.93-1.01	0.161
University or other tertiary degree	0.82	0.77-0.87	<0.001
Economic development			
Under developed	1.00		
Intermediately developed	1.08	1.04-1.12	<0.001
Developed	1.20	1.15-1.25	<0.001

**Table 4: Prevalence of MetS components and changes over time by sex and location – comparison of results of different studies**

	2000/01 InterASIA (35-74)	2009 CHNS		2014/15 CSPP (40-74)	Percent change % (P value)	
		(35-74)	(40-74)		2000/01- 2009	2009- 20014/15
<b>Abdominal obesity</b>						
Overall	7.7	18.1	19.1	16.5	134.5 (<0.001)	-13.6 (<0.001)
Men	1.7	7.9	7.8	4.8	366.5 (<0.001)	-38.1 (<0.001)
Women	13.9	27.4	29.5	25.9	97.3 (<0.001)	-12.2 (<0.001)
Rural:						
Overall	7.2	17.5	18.7	18.7	142.4 (<0.001)	0.1 (0.992)
Men	1.3	6.9	6.6	5.5	431.5 (<0.001)	-16.0 (0.098)
Women	13.4	27.4	29.9	29.5	104.5 (<0.001)	-1.2 (0.756)
Urban:						
Overall	10.1	17.7	18.8	14.5	75.6 (<0.001)	-23.0 (<0.001)
Men	3.1	8.5	9.0	4.3	175.2 (<0.001)	-52.1 (<0.001)
Women	17.5	25.9	27.8	23.0	48.2 (<0.001)	-17.2 (0.001)
<b>Hypertriglyceridemia</b>						
Overall	24.8	33.9	35.1	38.2	36.9 (<0.001)	8.9 (<0.001)
Men	24.9	38.7	38.5	39.9	55.4 (<0.001)	3.7 (0.169)
Women	24.6	29.5	32.0	36.7	20.1 (<0.001)	14.8 (<0.001)
Rural:						
Overall	23.1	33.2	34.0	38.0	43.6 (<0.001)	11.9 (<0.001)
Men	22.1	37.5	37.1	39.8	69.5 (<0.001)	7.2 (0.032)
Women	24.2	29.1	31.1	36.8	20.3 (<0.001)	18.5 (<0.001)
Urban:						
Overall	32.3	35.8	37.6	38.4	10.7 (0.006)	2.2 (0.499)
Men	37.0	41.4	41.7	40.3	11.8 (0.022)	-3.3 (0.462)
Women	27.3	30.7	33.8	36.7	12.6 (0.034)	8.5 (0.069)
<b>Low HDL cholesterol</b>						
Overall	33.9	25.5	25.1	31.3	-24.8 (<0.001)	24.7 (<0.001)
Men	21.9	17.1	16.3	20.4	-21.7 (<0.001)	25.2 (<0.001)
Women	46.5	33.2	33.2	40.1	-28.5 (<0.001)	20.8 (<0.001)
Rural:						
Overall	33.5	24.1	23.7	29.3	-28.0 (<0.001)	23.7 (<0.001)
Men	29.7	15.8	14.8	20.9	-46.7 (<0.001)	41.5 (<0.001)
Women	47.3	32.0	31.9	36.1	-32.4 (<0.001)	13.2 (<0.001)
Urban:						
Overall	37.3	28.4	28.0	33.1	-23.8 (<0.001)	18.3 (<0.001)
Men	29.7	20.0	19.5	20.5	-32.8 (<0.001)	5.0 (0.504)
Women	45.3	36.0	35.7	43.4	-20.6 (<0.001)	21.6 (<0.001)

<b>High blood pressure or medication use</b>						
Overall	41.2	40.9	45.6	52.8	-0.7 (0.731)	15.9 (<0.001)
Men	44.2	45.7	49.5	55.8	3.3 (0.256)	12.8 (<0.001)
Women	38.0	36.5	42.0	50.6	-3.9 (0.191)	20.5 (<0.001)
Rural:						
Overall	41.5	40.3	45.0	58.4	-2.8 (0.250)	29.7 (<0.001)
Men	44.2	45.1	49.0	60.8	2.0 (0.568)	24.0 (<0.001)
Women	38.7	35.9	41.4	56.8	-7.4 (0.035)	37.2 (<0.001)
Urban:						
Overall	40.8	42.3	46.7	48.8	3.6 (0.289)	4.5 (0.108)
Men	45.1	47.1	50.5	52.5	4.5 (0.326)	4.1 (0.300)
Women	36.2	38.0	43.3	45.8	4.9 (0.325)	5.7 (0.168)
<b>High fasting glucose or medication use</b>						
Overall	12.7	14.0	15.7	13.5	10.5 (0.024)	-14.0 (<0.001)
Men	12.8	16.8	18.2	14.0	30.9 (<0.001)	-23.1 (<0.001)
Women	12.6	11.5	13.4	13.1	-8.7 (0.135)	-2.2 (0.686)
Rural:						
Overall	12.1	13.7	15.2	13.5	13.2 (0.016)	-11.0 (0.007)
Men	11.9	16.3	17.3	13.8	37.0 (<0.001)	-20.3 (<0.001)
Women	12.3	11.3	13.2	13.3	-8.5 (0.231)	0.8 (0.929)
Urban:						
Overall	15.1	14.9	16.9	13.7	-1.3 (0.829)	-18.8 (<0.001)
Men	16.2	17.9	20.1	14.2	10.2 (0.249)	-29.4 (<0.001)
Women	13.6	12.3	13.9	13.0	-9.9 (0.147)	-6.7 (0.409)
<b>Overweight (BMI≥25.0kg/m2)</b>						
Overall	28.9	34.1	34.9	36.7	18.1 (<0.001)	5.1 (0.009)
Men	26.9	34.3	33.9	36.6	27.4 (<0.001)	7.9 (0.007)
Women	31.1	34.0	35.8	36.7	9.4 (0.008)	2.5 (0.366)
Rural:						
Overall	26.6	33.1	34.0	38.8	24.5 (<0.001)	14.2 (<0.001)
Men	23.9	32.7	32.2	36.5	36.7 (<0.001)	13.4 (<0.001)
Women	29.5	33.6	35.6	40.7	13.7 (0.002)	14.2 (<0.001)
Urban:						
Overall	39.1	35.1	36.0	35.1	-10.4 (0.001)	-2.4 (0.452)
Men	39.9	36.7	36.7	37.0	-8.0 (0.090)	0.9 (0.873)
Women	38.1	33.6	35.3	33.5	-11.9 (0.007)	-5.2 (0.247)

Note: Age range for CHNS study(8) used were different to improve the comparability between studies: the InterASIA(6) aged 35-74; CHNS aged 35-74 or 40-74, and CSPP aged 40-74. Percent change over time was calculated by:  $100 \times (\text{rate2} - \text{rate1}) / \text{rate1}$ . ATP III definition was used: abdominal obesity: WC  $\geq 102$ cm for men and WC  $\geq 88$ cm for women;

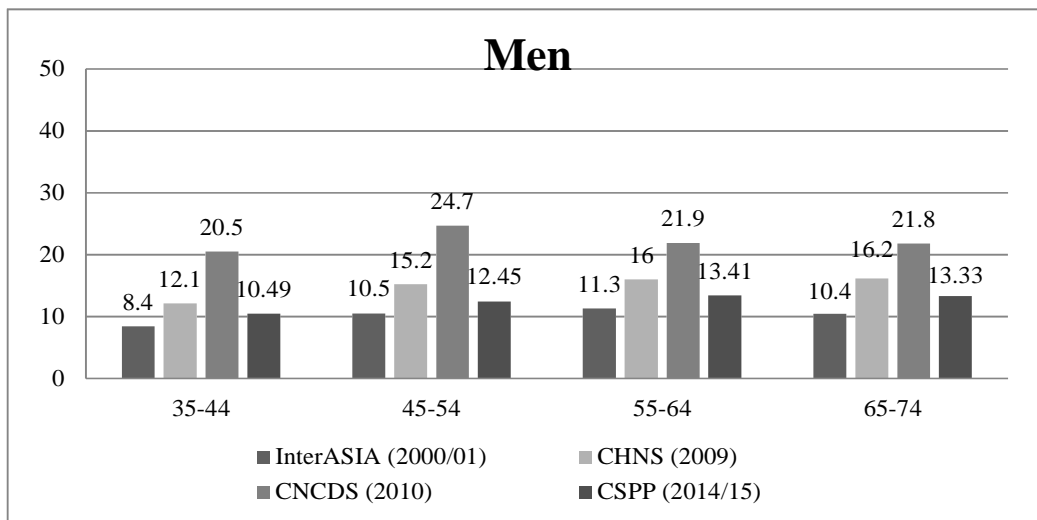
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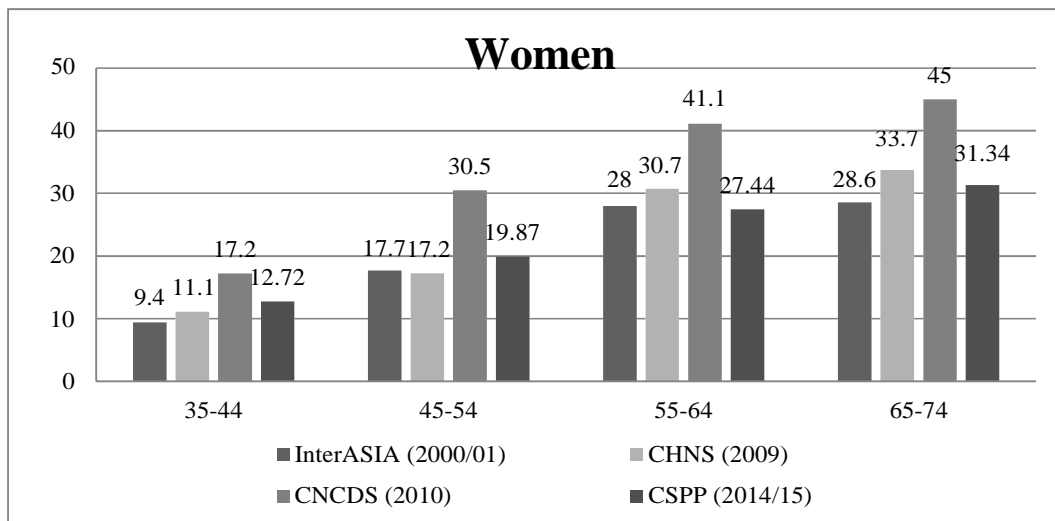
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4 **Figure 1: Rates of prevalence of MetS (ATP III criteria) estimated by different**  
5 **nationally representative studies.**  
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8 Results of CHNS(8) and CSPP (the present study) were based on original individual  
9 participant data, while results of InterASIA(6) and CNCDS(9) were obtained from the  
10 published reports. For the 35-44 age group, the CSPP were based on data from participants  
11 aged 40-44.  
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17 Fig 1a



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36 Fig 1b



**Figure 2: Ratio of prevalence rates of MetS in urban and rural residents in China, results from five nationally representative studies during 2000-2001 and 2014-2015.**

Notes to Figure 2 - The five studies are InterASIA(6), CDMDS(7), CHNS(8), CNCDS(9), and CSPP survey. The prevalence rate ratio >1 indicates a higher prevalence in urban residents, and <1 indicates a lower prevalence in urban residents, compared with that in rural areas.

Fig 2a

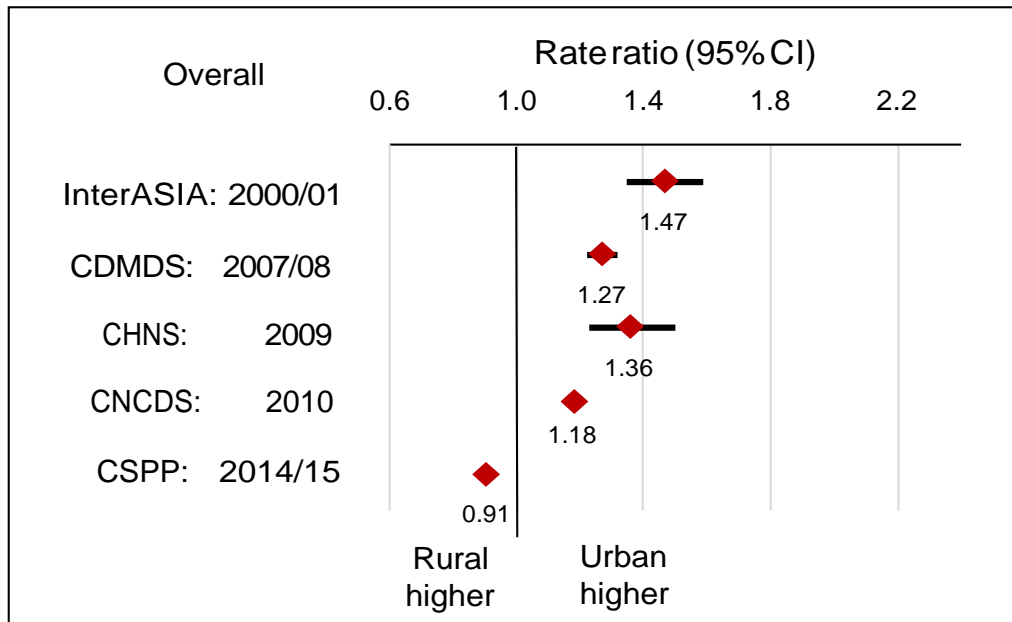


Fig 2b

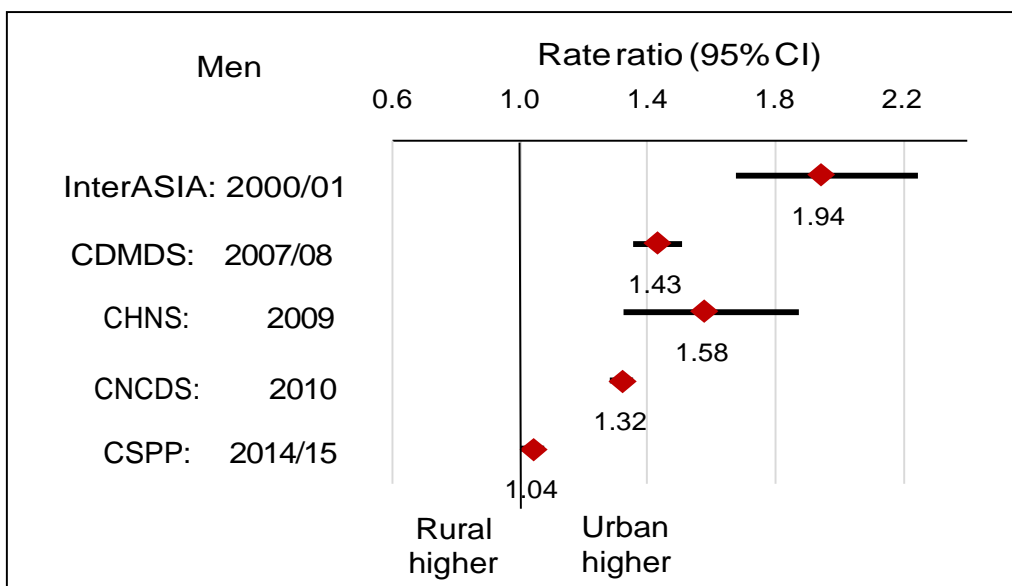
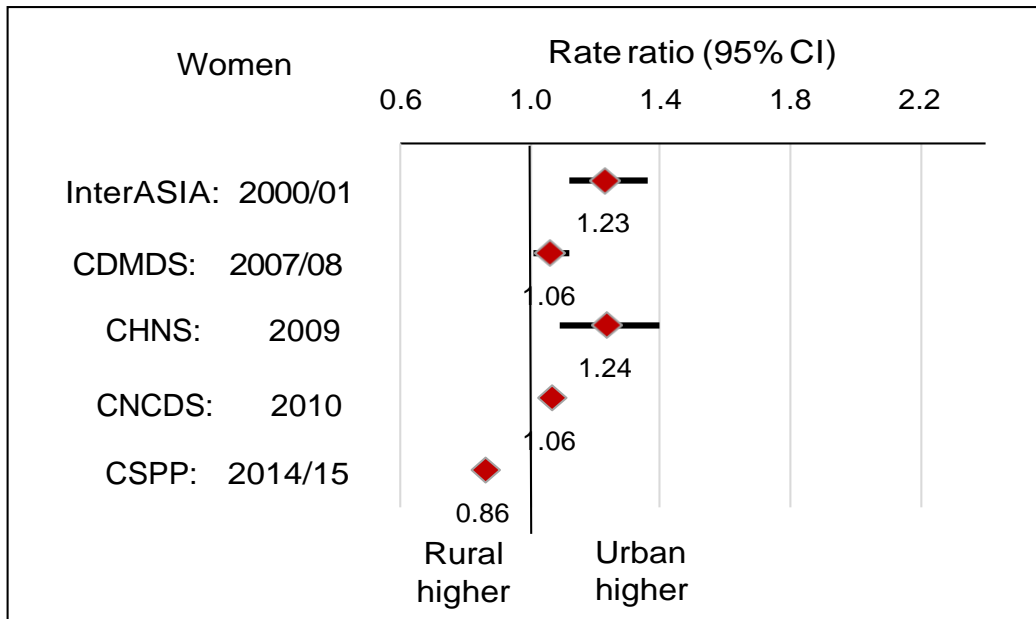


Fig 2c



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## SUPPLEMENTARY FILES

### Supplementary file-1: Definition of the metabolic syndrome

Risk factors	NCEP ATP III(1)	Revised NCEP ATP III(2)	Updated IDF(3)
	At least three risk factors	At least three risk factors	Central obesity plus 2 or more risk factors
central obesity	Men: WC $\geq$ 102cm Women: WC $\geq$ 88cm	Men: WC $\geq$ 90cm Women: WC $\geq$ 80cm	Men: WC $\geq$ 90cm Women: WC $\geq$ 80cm
High BP	SBP/DBP $\geq$ 130/85 mmHg or taking anti-hypertensive drugs	SBP/DBP $\geq$ 130/85 mmHg or taking anti-hypertensive drugs	SBP/DBP $\geq$ 130/85 mmHg or taking anti-hypertensive drugs
High fasting plasma glucose	Fasting glucose $\geq$ 6.1 mmol/L or taking anti-diabetic drugs	Fasting glucose $\geq$ 5.6 mmol/L or taking anti-diabetic drugs	Fasting glucose $\geq$ 5.6 mmol/L or taking anti-diabetic drugs
High triglycerides	Triglycerides $\geq$ 1.7 mmol/L	Triglycerides $\geq$ 1.7 mmol/L	Triglycerides $\geq$ 1.7 mmol/L
Low HDL-C	Men: HDL-C $<$ 1.03 mmol/L Women: HDL-C $<$ 1.29 mmol/L	Men: HDL-C $<$ 1.03 mmol/L Women: HDL-C $<$ 1.29 mmol/L	Men: HDL-C $<$ 1.03 mmol/L Women: HDL-C $<$ 1.29

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**Supplementary file -2: Prevalence of MetS (ATP III criteria) -weighted by sex- age- structure of the 2014 population in China**

	Low risk		Intermediate risk		High risk		Prior TIA		Prior stroke		All included	
	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)	n	% (95%CI)
<b>Overall</b>	44029	12·7%(12·4-13·0)	10916	26·2%(25·3-27·0)	39301	40·3%(39·8-40·8)	6256	26·8%(25·7-27·8)	9049	35·3%(34·3-36·3)	109551	25·1%(24·9-25·4)
<b>Sex:</b>												
Men	19343	8·9%(8·5-9·3)	4431	18·0%(16·8-19·1)	19087	31·1%(30·5-31·8)	2311	20·9%(19·2-22·5)	4617	26·2%(24·9-27·4)	49789	19·2%(18·9-19·6)
Women	24686	16·6%(16·1-17·1)	6485	34·4%(33·3-35·6)	20214	49·5%(48·8-50·2)	3945	32·6%(31·2-34·1)	4432	44·5%(43·0-46·0)	59762	31·1%(30·7-31·5)
<b>Age group:</b>												
40-49	16426	10·6%(10·1-11·1)	1346	25·5%(23·2-27·9)	5658	37·2%(35·9-38·5)	954	23·3%(20·6-25·9)	553	33·7%(29·7-37·6)	24937	18·4%(17·9-18·8)
50-59	13421	13·0%(12·5-13·6)	3113	26·7%(25·2-28·3)	11139	42·1%(41·1-43·0)	1716	29·2%(27·1-31·4)	1987	35·9%(33·8-38·0)	31376	27·0%(26·5-27·4)
>=60	14182	14·9%(14·3-15·5)	6457	26·4%(25·4-27·5)	22504	42·4%(41·7-43·0)	3586	28·7%(27·3-30·2)	6509	36·7%(35·6-37·9)	53238	31·4%(31·0-31·8)
<b>Location:</b>												
Urban	26049	11·3%(10·9-11·7)	5943	24·7%(23·6-25·8)	17995	43·5%(42·8-44·2)	3024	27·5%(25·9-29·1)	4287	37·3%(35·9-38·8)	57298	24·0%(23·6-24·3)
Rural	17980	14·8%(14·3-15·4)	4973	27·7%(26·4-28·9)	21306	37·6%(36·9-38·2)	3232	26·6%(25·0-28·1)	4762	33·6%(32·2-34·9)	52253	25·6%(26·2-26·9)
<b>Economic:</b>												
Underdeveloped	6487	9·9%(9·2-10·7)	1490	24·6%(22·4-26·8)	9692	34·6%(33·7-35·5)	1663	26·2%(24·1-28·3)	1940	32·0%(29·9-34·1)	21272	24·0%(23·4-24·6)
Intermediately	26905	13·1%(12·7-13·5)	5987	26·4%(25·2-27·5)	18255	42·1%(41·4-42·9)	3191	27·1%(25·6-28·6)	5027	34·8%(33·5-36·1)	59365	24·8%(24·4-25·1)