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ORIGINAL ARTICLE

Prevalence of the metabolic syndrome in the middle-aged and older Chinese population

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Abstract Prevalence of the metabolic syndrome (MetS) is rapidly increasing in developing countries. The aim of the study was to provide the latest nationwide estimate on the prevalence of MetS in china. Using a complex, multistage, probability sampling design, a cross-sectional study was performed in a nationally representative sample of 17,708 adults aged 45 years and older from 28 provinces in 2011–2012. MetS was defined by the "Harmonizing the Metabolic Syndrome (HMS)," the guidelines from the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (modified ATP III) and the International Diabetes Federation (IDF) definition, respectively. Overall, the age-standardized prevalence of MetS defined by the modified ATP III criteria was 33.7 %, but the prevalence defined by the new HMS and IDF definition significantly increased to 43.4 and 36.2 %, respectively. And prevalence of central obesity was considerably higher (52.1 vs. 24.0 %) with the HMS (or IDF) criteria than with the modified ATP III criteria. The age-standardized prevalence of high blood pressure, hyperglycemia, hypertriglyceridemia, and low HDL cholesterol was 54.1, 57.7, 27.6, and 43.1 %, respectively. Prevalence of the metabolic syndrome was rapidly increasing in the middle-aged and older Chinese population. We may bear a higher MetS-related burden and underscore the need for strategies aimed at the prevention, detection, and treatment of MetS and special attention should be paid to elderly women population.

Keywords Metabolic syndrome · Prevalence · Cross-sectional studies · China

Introduction

The metabolic syndrome (MetS) is a multiplex risk factor of diabetes [1], cardiovascular disease (CVD) [2], and all-cause mortality [3], and prevalence of the MetS is rapidly increasing in developing countries [4–6]. According to previous national surveys, the prevalence of the MetS was 9·8 % in Chinese adults aged 35–74 years from the 2000 to 2001 International Collaborative Study of Cardiovascular Disease in ASIA (InterASIA) [7], and was 8.5 % from 2002 National Health and Nutrition Survey (NHANS) [8] both defined by the National Cholesterol Education Program Adult Treatment Panel III (ATP III, and modified ATP III) criteria [9, 10].

The definitions of MetS proposed by the ATP III and the International Diabetes Federation (IDF) [11] are often used in publications. Recently, the experts, who come from the International Diabetes Federation and the American Heart Association/National Heart, Lung, and Blood Institute, have built a unify criteria—Harmonizing the Metabolic Syndrome (HMS) [12]. The main differences among the modified ATP III, IDF, and HMS definitions are that the IDF makes a threshold value for waist circumference as obligatory, and the HMS makes population- and country-specific cut points for elevated waist circumference and three abnormal findings out of five would qualify a person for the metabolic syndrome. However, the previous national surveys rarely provided the prevalence of MetS defined by the HMS and IDF criteria. Therefore, we provide the latest nationwide estimate on the prevalence of MetS.

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Methods

All data collected in the China Health and Retirement Longitudinal Study (CHARLS) are maintained at the China Center for Economic Research (CCER), part of the National School of Development of Peking University, Beijing, China. The project team filed an ethical review application to Ethical Review Committee (IRB) at Peking University in January 2011. After a revision of the Informed Consent section, the survey obtained approval. We only used data collected in CHARLS of Chinese people aged 45 years or older [13, 14].

The detailed sampling design has been published previously [13, 14]. Briefly, the CHARLS used multistage probability sampling method to select representative of people aged 45 and over in china. In the first stage, all county-level units was stratified by region and within region by urban districts or rural counties and per capita statistics on gross domestic product (GDP); 150 county-level units within 28 provinces were randomly selected with the probability-proportional-to-size (PPS) sampling technique. In the second stage, neighborhoods (shequ or juweihui) in urban areas and administrative villages (cun) in rural areas were used as primary sampling units (PSUs), which were the lowest level of government organization, and 3 PSUs within each county-level unit were selected using PPS sampling. In the third stage, all of the dwellings in each selected primary sampling unit were selected from the frame based on maps, which constructed by a mapping/listing software named CHARLS-GIS on Google Earth maps with the support of local informants. Finally, one resident aged 45 years in each sampled household within each PSU was randomly selected as a participant in the survey. If the chosen household had more than one age-eligible member, one such member was randomly selected, and his or her spouse who was also aged 45 years was also included in the survey. All stages of the sampling were conducted by computer to avoid human manipulation.

The CHARLS is a nationally representative longitudinal survey of persons in China 45 years of age or older, which obtained information on demographic background, health status and functioning, health care and insurance, work, retirement, and pension. The interviewers were trained at Peking University by CHARLS staff members, and the interviews took place in respondents' households using a face-to-face computer-assisted personal interview (CAPI) technology. The interviewers also carried equipments to measure the health functioning and performance in respondents' homes. After completing the household interviews, respondents were invited to the local office of China Center for Disease Prevention and Control (CDC) or to township hospitals, where trained nurses drew 8-mL samples of fasting blood. The CHARLS survey was conducted from May 2011 to March 2012 in 28 provinces of China. Overall, out of the total estimated number (12,740) of age-eligible households, CAPI interviews were conducted on a total of 17,708 individuals aged 45 years living in 10,287 households with the overall response rate of 80 %. Among all study participants, 13,978 individuals (78.9 %) provided anthropometric and physical performance measures. The target sample for taking blood samples was the entire group of 17,708 main respondents and spouses from the main CHARLS national baseline. Out of this, we collected blood samples for 11,847 individuals, a response rate of 67 % (women 69 % vs. men 65 %) [13–15].

Data collection was conducted in examination centers at local health stations or community clinics in the participants' residential areas by trained staff according to the standard protocol [14]. Waist circumference was measured at the level of their navel by the Soft measure tape (Manufacturer: Krell Precision Co. Ltd., Yangzhou, China). Respondents were asked to remove any bulky clothing and place the tape measure around their waist at the level of their navel. The respondents were instructed to stand up, inhale and slowly exhale, and hold their breath at the end of the exhale. Blood pressure was measured on the respondent's left arm three times at 45-s intervals by Omron™ HEM-7112 Monitor (Manufacturer: Omron Co., Ltd., Dalian, China). Respondents were instructed to sit down with both feet on the floor and their left arm comfortably supported with the palm facing up. Respondents were asked to roll their sleeve up unless they had on a short sleeve shirt or a thin shirt. The bottom of the cuff was approximately half an inch above the elbow and the air tube ran down the middle of the respondent's arm.

The overnight fasting blood specimens were collected from each respondent by medically trained staff from the China CDC at centralized locations, based on a standard protocol [14, 15]. First, a 2-mL tube of blood was used for a complete blood count (CBC) test, which was performed at county CDC stations or town/village health centers. Second, a 4-mL tube of whole blood was processed and divided into plasma and buffy coat within the same timeframe as the CBC measurement (the CBC was measured within 141 min of collection and the median time from collection to CBC assay was 97 min) and during shipment at 4 °C. After that, the plasma was stored in three 0.5-mL cryovials and the buffy coat in a separate cryovial, which were immediately stored frozen at −20 °C and then transported to the China CDC in Beijing within 2 weeks where they were placed at −80 °C in a deep freezer.

The study measured glucose, uric acid, high-sensitivity CRP, and a lipid panel (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and triglycerides) from frozen plasma or whole blood samples, which assays were performed at the Youanmen Center for Clinical Laboratory of Capital Medical University that has regular external quality assessment organized by the Chinese Ministry of Health. The assay method of glucose, total cholesterol (TC), and high-density lipoprotein cholesterol (HDL-C) was all Enzymatic colormetric test; the coefficient of variation (CV) of within-

assay was 0.90, 0.80, and 1.00 %, respectively; the CV of between-assay was 1.80, 1.70, and 1.30 %, respectively [15].

According to the modified ATP III criteria [8, 10], the MetS was defined as the presence of three or more of the following risk factors: (1) central obesity: waist circumference ≥88 cm in women, ≥102 cm in men; (2) hypertriglyceridemia: serum triglyceride concentration ≥1.7 mmol/L; (3) low HDL: HDL-cholesterol concentration <1.3 mmol/L in women or <1.0 mmol/L in men; (4) high blood pressure: blood pressure ≥130/85 mmHg or known treatment for hypertension; (5) hyperglycemia: serum glucose concentration ≥5.6 mmol/L or known treatment for diabetes. According to the IDF criteria [11], MetS was defined as the presence of central obesity (waist circumference ≥80 cm in women, ≥90 cm in men.) plus two or more of the following factors: the definition for hypertriglyceridemia, low HDL, high blood pressure, and hyperglycemia were the same as those of the modified ATP III. According to the HMS criteria [12], MetS was defined as the presence of three or more of the following risk factors: the definition for central obesity, hypertriglyceridemia, low HDL, high blood pressure, and hyperglycemia were the same as those of the IDF (according to the 2005 IDF recommended the best cut-off point value of WC to screen DM for Chinese adults, central obesity was defined as WC of 90 cm or more in men and 80 cm or more in women [16]).

This data was analyzed to provide precise estimates on the prevalence of MetS. All calculations were weighted to represent the overall Chinese adult population aged 45 years or older on the basis of 2010 Chinese population census data [17]. Weight coefficients were derived from the Chinese population census data, the complex survey design, and non-response rate of the current survey to obtain national estimates; and for the analysis of individual biomarkers, the different set of weights were needed because just over 20 % of the respondents did not get biomarkers taken, so the CHARLS did the same type of inverse probability weighting adjustment [15, 18]. The age-standardized prevalences were also calculated with the use of data on the population distribution in China in 2010 [17]. Standard errors were calculated with the Taylor-linearization method. *P* values were two-sided, and *P* values <0.05 were considered significant. All data analyses involved the use of SAS system, version 9.1 (SAS Institute Inc.).

Results

Baseline characteristics of the subjects are given in Table 1.

The age-standardized prevalence of high blood pressure, hyperglycemia, hypertriglyceridemia, and low HDL cholesterol was 54.1, 57.7, 27.6, and 43.1 %, respectively. Prevalence of central obesity with the HMS criteria (or IDF criteria) was considerably higher than with the modified ATP III criteria (52.1 vs. 24.0 %); the prevalence of one subject having ≥1, ≥2, ≥3, ≥4, and 5 components of the MetS was 86.9, 60.8, 33.7, 15.7, and 5.0 % based on the modified ATP III criteria, respectively, and was 89.7, 67.5, 43.3, 21.6, and 8.0 % based on the HMS criteria (or IDF criteria), respectively. Prevalence of MetS based on the HMS criteria was 43.4 %, which was much higher than based on the IDF and modified ATP III criteria (33.7 and 36.2 %, respectively). The prevalence of hypertriglyceridemia, low HDL cholesterol, components number of MetS, and MetS was higher among women than among men based on these three criteria. The higher prevalence of individual components (except hyperglycemia), components number of MetS, and MetS was in urban areas than in rural areas based on these three criteria (Table 2).

Among women, based on the modified ATP III criteria, the prevalence of hyperglycemia, high blood pressure, and central obesity increased with age. The prevalence of MetS components number and MetS increased with age based on the HMS, modified ATP III, and IDF criteria, respectively, but the prevalence of one subject having ≥4 and 5 components of MetS and MetS increased with age until 75 years of age, when the prevalence began to lower. Among men, the prevalence of hypertension, one subject having ≥1 and ≥2 components of MetS increased with age, whereas the prevalence of hypertriglyceridemia and one subject having 5 components of MetS decreased with age (Table 3).

Discussion

In this national representative sample of Chinese adults, the prevalence of the metabolic syndrome was 43.4, 33.7, and 36.2 % based on the HMS, IDF, and modified ATP III criteria, respectively. In terms of absolute numbers, it represents approximately 190.0 million (with 71.0 million men and 119.1 million women), 161.8 million (with 52.9 million men and 109.0 million women), and 152.7 million (with 55.3 million men and 97.4 million women) Chinese adults aged 45 years or older affected with metabolic syndrome based on the HMS, IDF, and modified ATP III criteria, respectively.

This nationwide survey provides the latest and reliable nationwide estimate of the prevalence of MetS. Furthermore, to our knowledge, this study is the first large-scale national representative epidemiological data in China that are available to compare the prevalence of MetS defined by the HMS, modified ATP III, and IDF criteria, respectively. To avoid introducing bias during the estimation, standard protocols [14] of the measurement along with strict training processes for data collection were used.

Several previous national studies [7, 8, 19, 20] have documented the prevalence of the metabolic syndrome in China. The International Collaborative Study of Cardiovascular Disease in ASIA (InterASIA) [7], which conducted a cross-sectional survey in a nationally representative sample of 15,

Table 1 Demographic, anthropometric, and plasma biochemical characteristics of participants according to gender, 2011–2012

Characteristic	Men	Women	*P* value
Mean age (95 % CI, year)	60.4 (60.1, 60.7)	59.1 (58.8, 59.3)	<0.0001
Urban residence (95 % CI, %)	33.9 (32.5, 35.3)	36.0 (34.7, 37.3)	0.1747
High school or higher level of education (95 % CI, %)	38.7 (37.2, 40.1)	21.2 (20.1, 22.3)	<0.0001
Mean fasting glucose (95 % CI, mmol/L)	6.1 (6.1, 6.2)	6.1 (6.1, 6.2)	0.0360
Mean waist circumference (95 % CI,– cm)	83.9 (83.6, 84.3)	84.6 (84.3, 85.0)	0.0241
Mean systolic blood pressure (95 % CI, mmHg)	130.7 (130.0, 131.3)	131.0 (130.4, 131.6)	0.1654
Mean diastolic blood pressure (95 % CI, mmHg)	76.2 (75.9, 76.6)	75.5 (75.1, 75.8)	0.0027
Mean triglycerides (95 % CI, mmol/L)	2.1 (2.1, 2.2)	2.4 (2.3, 2.4)	<0.0001
Mean HDL cholesterol (95 % CI, mmol/L)	1.3 (1.3, 1.3)	1.3 (1.3, 1.3)	0.5377

Data are mean (SE) or percentage (SE)

540 Chinese adults aged 35–74 years in 2000–2001, provided the best comparison data for our study. In the InterASIA study, the age-standardized prevalence of MetS by the modified ATP III criteria was 9·8 % in men and 17·8 % in women. Compared to the InterASIA study, the prevalences of the MetS among men with age 45–54, 55–64, and 65–74 increased more than fold (the trend was 10.5–23.2, 11.3–24.4, and 10.4–23.7 %, respectively); the prevalence among women with the 45–54,

Table 2 The age-standardized prevalence of individual components and the number of components of MetS based on the criteria of HMS, modified ATP III, and IDF, 2011–2012

	Men			Women			Total
	Urban	Rural	Total	Urban	Rural	Total	
MetS components							
High blood pressure	62.2 (3.1)	49.5 (1.5)	55.1 (1.8)	57.2 (2.0)	50.2 (1.3)	53.4 (1.2)	54.1 (1.3)
Hyperglycemia	58.2 (2.9)	57.1 (1.5)	57.8 (1.6)	57.4 (2.4)	57.9 (1.6)	57.7 (1.5)	57.7 (1.3)
Hypertriglyceridemia	28.1 (2.8)	22.7 (1.1)	25.4 (1.5)	30.7 (1.5)	28.9 (1.5)	29.8 (1.1)	27.6 (1.1)
Low HDL cholesterol	38.4 (2.4)	25.6 (1.5)	31.8 (1.6)	59.5 (3.1)	48.4 (1.7)	53.9 (1.9)	43.1 (1.6)
Central obesity modified ATP III*	7.3 (1.0)	4.1 (0.5)	5.5 (0.5)	44.6 (2.8)	37.7 (1.4)	40.8 (1.6)	24.0 (1.0)
Central obesity HMS (or IDF) †	40.7 (2.3)	24.5 (1.4)	31.5 (1.4)	76.4 (2.1)	65.9 (1.5)	70.7 (1.5)	52.1 (1.3)
Number of components of MetS by modified ATP III							
One or more	87.4 (1.6)	81.2 (0.9)	84.0 (1.0)	91.1 (1.0)	88.3 (0.7)	89.6 (0.7)	86.9 (0.7)
Two or more	56.7 (3.1)	47.2 (1.4)	51.3 (1.5)	74.6 (2.2)	65.3 (1.3)	69.5 (1.4)	60.8 (1.0)
Three or more	29.2 (2.0)	19.2 (1.1)	23.6 (1.1)	46.0 (3.0)	40.8 (1.5)	43.1 (1.6)	33.7 (1.1)
Four or more	10.9 (1.2)	6.7 (0.7)	8.5 (0.7)	25.6 (2.0)	19.8 (1.1)	22.4 (1.1)	15.7 (0.8)
Five	2.0 (0.4)	1.0 (0.3)	1.5 (0.2)	10.6 (1.2)	6.5 (0.6)	8.4 (0.6)	5.0 (0.4)
MetS by NCEP	29.2 (2.0)	19.2 (1.1)	23.6 (1.1)	46.0 (3.0)	40.8 (1.5)	43.1 (1.6)	33.7 (1.1)
Numbers of components of MetS by HMS (or IDF)							
One or more	89.1 (1.5)	82.9 (0.9)	85.7 (0.9)	94.5 (0.7)	92.6 (0.6)	93.5 (0.5)	89.7 (0.6)
Two or more	63.1 (3.3)	52.6 (1.4)	57.2 (1.5)	81.3 (1.7)	73.4 (1.2)	77.0 (1.2)	67.5 (1.0)
Three or more	39.9 (2.6)	25.8 (1.2)	31.9 (1.3)	60.0 (3.3)	48.8 (1.5)	53.9 (2.0)	43.3 (1.3)
Four or more	20.3 (1.6)	10.7 (0.8)	14.8 (1.0)	31.1 (2.5)	25.3 (1.3)	27.9 (1.4)	21.6 (0.9)
Five	6.9 (1.0)	3.6 (0.5)	5.0 (0.5)	13.1 (1.4)	9.0 (0.7)	10.9 (0.7)	8.0 (0.6)
MetS by HMS	39.9 (2.6)	25.8 (1.2)	31.9 (1.3)	60.0 (3.3)	48.8 (1.5)	53.9 (2.0)	43.3 (1.3)
MetS by IDF	31.0 (2.2)	16.6 (1.0)	22.8 (1.3)	55.7 (3.6)	42.8 (1.5)	48.7 (2.1)	36.2 (1.5)

Data are adjusted percentage (SE); *waist circumference ≥88 cm for women and ≥102 cm for men; †waist circumference ≥80 cm for women and ≥90 cm for men

MetS metabolic syndrome, *HMS* Harmonizing the Metabolic Syndrome; *modified ATP III* U.S. National Cholesterol Education Program Adult Treatment Panel III, *IDF* International Diabetes Federation

Table 3 Age- and sex-specific prevalence of individual components and the number of components of MetS based on the criteria of HMS, modified ATP III, and IDF, 2011–2012

	45–54		55–64		65–74		75+	
	Men	Women	Men	Women	Men	Women	Men	Women
MetS components								
High blood pressure	47.7 (2.8)	40.6 (3.2)	54.6 (2.5)	54.0 (1.6)	63.5 (2.5)	67.8 (4.1)	72.7 (2.9)	79.9 (2.7)
Hyperglycemia	54.1 (3.6)	51.5 (2.3)	58.2 (2.9)	63.3 (1.7)	58.2 (2.4)	60.5 (3.2)	70.8 (4.8)	61.2 (3.7)
Hypertriglyceridemia	29.7 (2.2)	26.3 (1.6)	25.7 (1.6)	31.3 (1.4)	18.7 (1.6)	36.1 (3.4)	17.5 (4.1)	29.6 (3.2)
Low HDL cholesterol	33.9 (1.8)	54.8 (2.3)	30.0 (1.8)	52.5 (1.9)	30.4 (3.4)	56.8 (2.9)	31.1 (4.2)	49.8 (3.9)
Central obesity modified ATP III*	6.2 (0.9)	35.7 (2.1)	5.1 (0.7)	43.2 (1.5)	5.3 (0.9)	44.9 (3.0)	4.0 (1.3)	47.3 (4.5)
Central obesity HMS (or IDF)†	33.6 (2.4)	69.9 (2.1)	30.1 (2.3)	70.5 (1.5)	34.5 (3.6)	73.9 (2.0)	22.7 (3.4)	69.6 (3.2)
Number of components of MetS by modified ATP III								
One or more	82.4 (1.5)	85.7 (1.2)	84.5 (1.3)	90.3 (0.8)	84.7 (1.7)	94.5 (0.9)	87.9 (1.9)	95.6 (1.2)
Two or more	47.6 (2.9)	63.5 (2.4)	50.6 (2.8)	69.1 (1.6)	57.5 (2.7)	78.2 (2.0)	58.3 (3.6)	81.6 (2.2)
Three or more	23.2 (2.0)	35.0 (2.1)	24.4 (1.7)	46.0 (1.6)	23.7 (3.9)	51.5 (3.4)	22.1 (3.5)	53.7 (3.7)
Four or more	9.8 (1.2)	17.3 (1.5)	8.1 (0.9)	25.1 (1.4)	7.2 (1.0)	28.9 (2.1)	7.0 (1.6)	24.4 (3.2)
Five	2.1 (0.5)	5.5 (0.7)	0.9 (0.2)	10.2 (0.8)	1.5 (0.5)	12.6 (1.5)	0.7 (0.4)	7.5 (1.6)
MetS by NCEP	23.2 (2.0)	35.0 (2.1)	24.4 (1.7)	46.0 (1.6)	23.7 (3.9)	51.5 (3.4)	22.1 (3.5)	53.7 (3.7)
Numbers of components of MetS by HMS (or IDF)								
One or more	84.5 (1.4)	91.7 (0.9)	86.2 (1.2)	93.1 (0.6)	85.7 (1.7)	96.0 (0.7)	88.9 (1.9)	97.6 (0.6)
Two or more	54.6 (3.0)	71.8 (2.0)	56.0 (3.1)	76.9 (1.3)	63.7 (2.4)	85.0 (1.5)	60.5 (3.5)	85.5 (1.9)
Three or more	31.3 (2.3)	47.6 (3.1)	32.4 (2.2)	55.0 (1.7)	34.5 (3.7)	63.8 (2.8)	28.8 (3.7)	59.9 (3.4)
Four or more	15.3 (1.6)	22.2 (1.6)	14.6 (1.2)	30.8 (1.5)	15.0 (4.2)	34.5 (2.6)	12.9 (3.1)	31.5 (3.5)
Five	6.4 (0.9)	8.0 (1.1)	4.4 (0.7)	12.4 (0.9)	4.2 (0.8)	15.5 (1.6)	3.1 (1.1)	10.6 (1.8)
MetS by HMS	31.3 (2.3)	47.6 (3.1)	32.4 (2.2)	55.0 (1.7)	34.5 (3.7)	63.8 (2.8)	28.8 (3.7)	59.9 (3.4)
MetS by IDF	23.4 (2.0)	43.2 (3.2)	21.8 (1.9)	50.3 (1.7)	25.9 (4.0)	57.5 (3.1)	18.6 (3.4)	51.8 (3.4)

Data are adjusted percentage (SE); *waist circumference ≥88 cm for women and ≥102 cm for men; †waist circumference ≥80 cm for women and ≥90 cm for men

MetS metabolic syndrome, *HMS* Harmonizing the Metabolic Syndrome, *modified ATP III* U.S. National Cholesterol Education Program Adult Treatment Panel III, *IDF* International Diabetes Federation

55–64, and 65–74 year age group all increased almost two times (the trend was 17.5–35.0, 28.0–46.0, and 28.6–51.5 %, respectively), and which increased more or less 20 percentage points in elderly women.

However, the InterASIA study did not provide the prevalence of MetS based on the HMS and IDF criteria. The growth in the prevalence of MetS may be greater if the HMS or IDF definition was used, because the IDF definition requires central obesity as a requisite for diagnosis of the MetS, and the HMS and IDF definition proposes lower cut-off points for waist circumferences than the modified ATP III in Chinese population (90 vs. 102 cm in men, 80 vs. 88 cm in women). The China Health and Nutrition Survey [19], which included a total of 52,621 Chinese adults from 1993 to 2009, showed that the prevalence of central obesity increased 3.9 percentage points from 9.1 to 13.0 % according to the modified ATP III criteria during the period of 2000–2009, but the prevalence of central obesity increased 8.6 percentage points from 28.8 to 37.4 % according to the HMS or IDF criteria. Therefore, the burden of MetS rapidly increased in 2000–2012, especially in the elderly women. The rapid aging of the population, urbanization, and changes in lifestyle and diet, with the consequent epidemic of individual components, such as central obesity [21] and hypertension [22], have probably contributed to this rapid increase.

In the USA, data from the National Health and Nutrition Examination Survey (NHANES) from 1999 to 2010 [5] indicated that the prevalence of the MetS defined by the ATPIII criteria was 22.90 % in the US adult population aged 20 years or older, and data from the combined 1999–2006 NHANES [23] showed that the age-adjusted prevalence of MetS defined by the ATP III criteria was 34.2 %. In the Republic of Korea, data from the 2007 Korean National Health and Nutrition Examination Surveys [24] showed that the age-adjusted prevalence of MetS defined by the ATPIII criteria was 31.3 % in Koreans over 20 years of age, more than 40 % in Koreans age 50–59, and nearly 65 % in Koreans age 60–69, respectively. Comparing with prevalence in the corresponding age group, the prevalence of MetS in China was much less than the

prevalence in the USA and Republic of Korea, but the prevalence of MetS among the elderly women was only slightly lower than the prevalence in the developed countries.

In our study, the prevalence of MetS in China was lower in men than in women, in rural areas than in urban areas, and in younger than in older women, which are consistent with those studies [7, 8, 19]. According to previous epidemiological studies, the individual components of MetS (hypertension, central obesity, diabetes, and dyslipidemia) were higher in urban areas than rural areas due to the great differences in socioeconomic status, lifestyle, and medical services [25]. For example, the prevalence and the treatment of hypertension were substantially lower in rural areas than in urban areas [26], and the prevalence of diabetes was also higher in urban than in rural residents from the 2010 China Noncommunicable Disease Surveillance [27]. Higher intake in dietary lipids and alcohol and lower physical activity [28] are a few of the lifestyle behaviors [29] that are associated with urbanization might help explain this disparity. As our results showed, the major differences of individual components of MetS between the gender were the prevalence of abdominal obesity (5.5 % men vs. 40.8 % women based on the ATPIII definition; 31.8 % men vs. 70.7 % women based on the HMS or IDF definition) and low HDL cholesterol (31.8 % men vs. 53.9 women), which were primarily attributable to the gender difference in prevalence of MetS, especially among the elderly. And the MetS was also more prevalent in older women than in younger, which might be due their postmenopausal status that could increase central obesity [30]. The elderly women were the high-risk population of MetS, so we need to pay special attention to this high-risk population on precaution of the MetS.

This study indicates that the metabolic syndrome was a rapidly increasing health burden in the Chinese middle-aged and elderly population. We may bear a higher MetS-related burden and underscore the need for strategies aimed at the prevention, detection, and treatment of MetS and special attention should be paid to elderly women population.

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Compliance with ethical standards

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Conflict of interest The author declares that there is no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the Medical Ethics Committee of Peking University and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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