

Prevalence and Associated Factors of Metabolic Syndrome in Chinese Middle-Aged and Elderly Population: A Nationally Cross-Sectional Study

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Abstract

Background: Currently, China has an increasingly aging population. However, the prevalence of metabolic syndrome (MetS) in this high-risk population for metabolic diseases remains unknown. To investigate the age and gender specific prevalence and associated factors of MetS in Chinese middle-aged and elderly population, we did the study on it.

Methods: Data were retrieved from China Health and Retirement Longitudinal Study (CHARLS) and subjected to descriptive statistics. Further, univariate logistic regression was used to evaluate the relevant factors, and then multivariate logistic regression was selected to construct the final model.

Results: In present study, a total of 10,834 participants were included. The overall prevalence of MetS was 32.97% as defined by International Diabetes Federation and 29.75% under National Cholesterol Education Program - The Adult Treatment Panel III criteria. With aging, prevalence of MetS descended in males, while ascended in females. In the >70 years old group, the prevalence of MetS was three times higher in females than that in males (50.43% versus 16.03%). Across all age groups and sexes, the prevalence of MetS in urban areas was significantly higher than in rural areas. In addition, regardless of gender, the prevalence was highest for those living in the north region (28.41% for males & 51.74% for females) and lowest for those living in the southwest region (13.91% for males & 31.58% for females). Finally, two specific correlates, afternoon nap and blood urea nitrogen (BUN), were identified in present study ($P < 0.05$).

Conclusion: The prevalence of MetS varied in different age groups, sexes, living areas and regions and was associated with afternoon nap and BUN.

Background

Metabolic syndrome (MetS), also known as syndrome X, is composed of abdominal obesity, insulin resistance, dyslipidemia and hypertension [1]. Currently, with the growing of China's economy and the aid of scientific progress, threats from communicable diseases gradually decline [2] and hazards from metabolic diseases like MetS surge [3]. It was revealed that patients with MetS had higher odds of numerous cancers including prostate cancer [4], breast cancer [5] etc., cardiovascular diseases comprising stroke [6], coronary heart disease [7] etc. and other miserable diseases like lower urinary tract symptoms [8], which heavily affected people's daily lives and burdened medical systems. According to previous study, these increased risks are much more evident for the aged than the young [1]. Hence, exploring the prevalence and associated factors of MetS in the specific high-risk group, the middle-aged and elderly population in China, remains requisite.

There are diverse ways to construct MetS such definitions from World Health Organization (WHO), National Cholesterol Education Program-The Adult Treatment Panel III (NCEP-ATP III) and International Diabetes Federation (IDF) [9]. Amid them, definitions from NCEP-ATP III and IDF are widely adopted in researches. In the U.S., under the definition of NCEP-ATP III, an overall prevalence of 33% from 2003 to 2012 was recorded [10], which slightly increased to 34.7% in 2011–2016 [11]. This figure ascended to 46.7% when it came to those aged 60 years or older [10]. In Iran, a meta-analysis of 69 studies disclosed a prevalence of 30.4% [12].

Among them, prevalence in women and the aged were significantly higher than men and the young. Similar conclusions are also seen in Bangladesh [13], Peru [14], Portugal [15] and et al [16]. In 2015, a meta-analysis enrolling 35 studies reported a pooled prevalence of 24.5% in the overall population and this number significantly increased in females and the age [17]. These literatures disclosed observational results in the overall population, however, against the background of aging in China, no specific study targeting Chinese middle-aged and elderly population is designed to investigate the prevalence and associated factors, which limits further understanding of this high-risk group.

To date, diverse associated factors are investigated comprising age [18], living areas [9], educational levels [19], physical activities [20] etc. Although the majority of previous studies [21–23] indicated that risk factors and its negative effects in different ages and gender are different, a few studies showed the opposite conclusion [16], needing further exploring. What's more, risk factors identified previously are explored in the overall population and few studies are performed in the aged. It was revealed that a total of 111 million people aged 65 years above resided in China (8.2% of the country residents) [24]. Performing specific study targeting the aged seems imminent, which is what we do in this survey.

In the present study, data from China Health and Retirement Longitudinal Study (CHARLS), was downloaded and subjected to analyses. This program is specially designed to evaluate the health status in Chinese middle-aged and elderly population and owns a good national representation, providing us a chance to scan the age and gender specific prevalence and associated factors of MetS in the aged in China.

Methods

Study sample and data cleansing

To scan the prevalence of MetS in Chinese middle-aged and elderly population, dataset from CHARLS Follow-up Questionnaire (2015) was downloaded and subjected to further data cleansing. In CHARLS, probabilities proportional to size (PPS) was selected to sample across the whole China, which finally covered 28 provinces and 150 counties. Further detailed description regarding this representative program could be accessed in their official website (<http://charls.pku.edu.cn/>) or publications [25]. In this national cross-sectional survey, a total of 21,095 participants aged 40 years old above were enrolled. In virtue of the missing values of covariates and unqualified blood samples, data cleansing was performed (see Fig. 1). Finally, 10,834 participants whose blood were collected under fasting status were remained and subjected to further analyses.

Definition of MetS and data collection

Currently, there were diverse definitions to construct MetS such as NCEP-ATP III, IDF etc. Of note, the definition of IDF considers the ethnic characteristics of the Chinese and has lower cutoff values than other definitions, which benefits early diagnosis and intervention. Hence, we mainly adopted IDF's definition to scan the prevalence of MetS. Besides, for comparison with the results of other studies employing different definitions, we also used the NCEP-ATP III definition to scan the morbidity of MetS. The definition of IDF requires abdominal obesity and two or more of the following: hyperglycemia, low HDL cholesterol, high blood

triglycerides and hypertension. As for NCEP-ATP III, presence of any three or more of the components stated above is sufficient to diagnose MetS. Detailed definitions of IDF and NCEP-ATP III could be viewed in previous literatures [9].

To construct MetS, five components, namely waistline, HDL, triglycerides, blood glucose and blood pressure, are requisite. All the measurement of these five components were carried out by well-trained researchers from Chinese Center for Disease Control and Prevention (CCDC). Tapes were placed over the clothing around the waist at the level of the navel to measure waistlines. Participants were asked to be relaxed and seated until three blood pressure measurements were completed. Final blood pressures were recorded using the average of three measurements. For assessing blood biomarkers, the night before the blood collection, participants were asked to fast until the next morning. Venous blood of participants was collected and centrifuged into plasma, which was immediately stored at -20°C for transporting to CCDC in Beijing within two weeks. Blood biomarkers including HDL, blood glucose, LDL etc. were determined using enzymatic colorimetric tests.

Covariates

In present study, covariates comprising individual characteristics, blood biomarkers and medical histories were collected. Individual behaviors included age, gender, marital status, depression, sleeping time, afternoon nap, geographic region, smoking, alcohol consumption and body mass index (BMI). Age was divided into four groups: 40–50 years old, 50–60 years old, 60–70 years old and > 70 years old as Xiong et al did [26]. Marital status consisted of two groups. One included the married or cohabitated and others incorporating the divorced, widowed, married but not living with spouses were classified as another group. Participants with scores ≥ 10 assessed by Center for Epidemiologic studies Depression scale (CESD)-10 questionnaire were seen as depressed patients [27]. Sleeping time was stratified into 0–6 hours, 6–8 hours and > 8 hours. Afternoon nap was gathered as yes and no. Their living regions were also recorded as rural region and urban region. Rural region only referred to villages and other regions were unified as urban region. Smoking and alcohol consumption were also collected and stratified according to their status. Smoking was reported as yes, no and quitted. Alcohol consumption was divided as never, drunk but less than once a month and drunk but more than once a month.

Blood biomarkers consist of uric acid, low density lipoprotein, total cholesterol and blood urea nitrogen. Hyperuricemia was defined as a blood uric acid concentration higher than $420\ \mu\text{mol/L}$ in men and $357\ \mu\text{mol/L}$ in women. LDL was classified into two groups: $\geq 120\ \text{mg/dl}$ and $< 120\ \text{mg/dl}$. Total cholesterol was classified into $\geq 200\ \text{mg/dl}$ and $< 200\ \text{mg/dl}$. As Zhang's study [28], BMI was split into $< 18.5\ \text{Kg/m}^2$, $< 24\ \text{Kg/m}^2$, $< 28\ \text{Kg/m}^2$ and $\geq 28\ \text{Kg/m}^2$. After referring to Arihan's research [29], BUN was divided as 0–20 mg/dl and > 20 mg/dl. Furthermore, medical histories including liver diseases, kidney diseases, digestive diseases, arthritis and rheumatism were recorded. Due to the different living and cultural habits, living localities of the participants were also categorized into six regions as previous study did [30], which were East (Jiangsu, Fujian, Shanghai, Shandong, Zhejiang, Jiangxi and Anhui), North (Shanxi, Hebei, Beijing, Tianjin and Inner Mongolia), North-East (Jilin, Liaoning and Heilongjiang), North-West (Qinghai, Shanxi, Xinjiang and Gansu), South-Central (Hunan, Henan, Guangdong, Hubei and Guangxi) and South-West (Sichuan, Chongqing, Yunnan and Guizhou).

Statistical Analysis

Data, composed of continuous data and categorical data in present study, were presented as mean \pm SD and proportions (%), respectively. Descriptive statistics were performed to investigate the prevalence and distribution of MetS in different subgroups. Further, univariate logistic regression was adopted to evaluate the associated factors with MetS. Covariates with P values < 0.05 were enrolled into final model assessed by multivariate logistic regression. All the analyses were made by R 3.6.3 and all the figures were drawn by R 3.6.0 and GraphPad Prism 8.0 (GraphPad Software Inc., San Diego, CA, USA). P < 0.05 (two-sided) was considered statistically significant.

Results

Baseline characteristics and prevalence of MetS in grouped population

In total, 10,834 participants aged 40 years old above were enrolled in this study. A total of 18 covariates were collected and the distribution of participants in these covariates were shown in Table 1. The overall prevalence of MetS was 32.97% (95% CI = 32.09–33.86) under IDF definition and 29.75% (95% CI = 28.90-30.62) under NCEP-ATP III definition. The specific prevalence among different variables was displayed (see Table 1).

Table 1
Baseline population characteristics and prevalence in grouped population

Characteristics	Total participants (%)	IDF			NCEP-ATP III		
		Cases	Prevalence (%)	95% CI	Cases	Prevalence (%)	95% CI
Total	10834 (100.00)	3572	32.97	32.09–33.86	3223	29.75	28.90–30.62
Age groups,							
40–50	2202 (22.32)	600	27.25	25.43–29.15	491	22.30	20.61–24.09
50–60	3472 (32.05)	1196	34.45	32.88–36.05	1057	30.44	28.93–32.00
60–70	3459 (31.93)	1225	35.41	33.84–37.03	1137	32.87	31.32–34.46
>70	1701 (15.70)	551	32.39	30.21–34.66	538	31.63	29.46–33.88
Gender							
Male	4977 (45.94)	1107	22.24	21.11–23.42	1035	20.80	19.69–21.95
Female	5857 (54.06)	2465	42.09	40.83–43.36	2188	37.36	36.13–38.60
Marital status							
Married/Cohabitated	9002 (83.09)	2931	32.56	31.60–33.53	2637	29.29	28.36–30.24
Others	1832 (16.91)	641	34.99	32.84–37.21	586	31.99	29.89–34.16
Depression							
< 10	6595 (66.77)	2142	32.48	31.36–33.62	1869	28.34	27.26–29.44
≥ 10	3282 (33.23)	1099	33.49	31.89–35.12	1038	31.63	30.06–33.24
Sleeping time							
0–6 hours	5292 (50.32)	1704	32.20	30.95–33.47	1548	29.25	28.04–30.49
6–8 hours	4204 (39.98)	1415	33.66	32.24–35.10	1258	29.92	28.56–31.33
> 8 hours	1020 (9.70)	340	33.33	30.50–36.29	308	30.20	27.45–33.09

Characteristics	Total participants (%)	IDF			NCEP-ATP III		
		Cases	Prevalence (%)	95% CI	Cases	Prevalence (%)	95% CI
Geographical region							
Urban	2629 (24.69)	1092	41.54	39.67–43.43	971	36.93	35.11–38.80
Rural	8018 (75.31)	2426	30.26	29.26–31.27	2201	27.45	26.48–28.44
Smoking							
Yes	2937 (27.14)	609	20.74	19.30–22.24	589	20.05	18.64–21.54
No	6504 (60.11)	2545	39.13	37.95–40.32	2254	34.66	33.51–35.82
Quitted	1380 (12.75)	417	30.22	27.85–32.70	378	27.39	25.10–29.81
Alcohol consumption							
Never	6998 (64.66)	2577	36.82	35.70–37.96	2371	33.88	32.78–35.00
Less than once a month	965 (8.92)	285	29.53	26.73–32.50	262	27.15	24.43–30.05
More than once a month	2859 (26.42)	707	24.73	23.18–26.34	588	20.57	19.12–22.09
Afternoon napping							
Yes	6219 (58.73)	2175	34.97	33.80–36.17	1973	31.73	30.58–32.89
No	4371 (41.27)	1317	30.13	28.79–31.51	1169	26.74	25.45–28.08
Uric acid							
Hyperuricemia	1241 (11.45)	639	51.49	48.70–54.27	613	49.40	46.61–52.18
Non-hyperuricemia	9593 (88.55)	2933	30.57	29.66–31.50	2610	27.21	26.33–28.11
Low density lipoprotein							
≥ 120 mg/dl	2673 (24.67)	977	36.55	34.74–38.40	866	32.40	30.65–34.20
< 120 mg/dl	8160 (75.33)	2595	31.80	30.80–32.82	2357	28.88	27.91–29.88

Characteristics	Total participants (%)	IDF			NCEP-ATP III		
		Cases	Prevalence (%)	95% CI	Cases	Prevalence (%)	95% CI
Total cholesterol							
≥ 200 mg/dl	3183 (29.38)	1316	41.34	39.64–43.07	1189	26.58	25.61–27.59
< 200 mg/dl	7651 (70.62)	2256	29.49	28.47–30.52	2034	37.35	35.69–39.05
Body mass index, (BMI)							
< 18.5 Kg/m ²	600 (5.55)	11	1.83	1.02–3.29	38	6.33	4.64–8.59
< 24 Kg/m ²	5096 (47.14)	691	13.56	12.65–14.53	724	14.21	13.28–15.19
< 28 Kg/m ²	3656 (33.82)	1835	50.19	48.57–51.81	1474	40.32	38.74–41.92
≥ 28Kg/m ²	1459 (13.50)	1026	70.32	67.92–72.61	977	66.96	64.50–69.33
Blood urea nitrogen, (BUN)							
0–20 mg/dl	9356 (86.36)	3157	33.74	32.79–34.71	3157	30.21	29.28–31.14
> 20 mg/dl	1478 (13.64)	415	28.08	25.84–30.43	415	26.86	24.66–29.18
Liver diseases							
Yes	428 (3.95)	158	36.92	32.46–41.61	136	29.67	28.80–30.55
No	10406 (96.05)	3414	32.81	31.91–33.72	3087	31.78	27.52–36.36
Kidney diseases							
Yes	687 (6.34)	230	33.48	30.04–37.10	210	30.57	27.23–34.13
No	10147 (93.66)	3342	32.94	32.03–33.86	3013	29.69	28.81–30.59
Digestive system diseases							
Yes	2463 (22.73)	771	31.30	29.50–33.16	723	29.35	27.59–31.19

Characteristics	Total participants (%)	IDF			NCEP-ATP III		
		Cases	Prevalence (%)	95% CI	Cases	Prevalence (%)	95% CI
No	8371 (77.27)	2801	33.46	32.46–33.48	2500	29.87	28.89–30.85
Arthritis or rheumatism							
Yes	3589 (33.13)	1251	34.86	33.31–36.43	1168	32.54	31.03–34.10
No	7245 (66.87)	2321	32.04	30.97–33.12	2055	28.36	27.34–29.41

Age and gender specific prevalence of MetS and its components

It was noted that with aging, prevalence of MetS under IDF definition in males descended, while ascended in females (see Fig. 2A). In the > 70 years old group, the prevalence of MetS in females was three times higher than that in males (50.43%, 95% CI = 46.98–53.88 versus 16.03%, 95% CI = 13.76–18.59). In Fig. 2B, with aging, the increasing and decreasing trend for the prevalence of abdominal obesity remained identical in females and males, respectively. As for hyperglycemia, prevalence in both overall population and females increased. However, this increasing trend in males was not observed in the > 70 years old group (see Fig. 2C). What's more, the prevalence of low HDL in females was nearly the same in all four age groups and thereof in males increased from 40–50 years old to 60–70 years, but decreased in the > 70 years old group (see Fig. 2D). In Fig. 2E, the prevalence of high triglycerides in overall population and females fluctuated but this prevalence in males remained its downward trend in all four age groups. In Fig. 2F, the increasing trend of hypertensive patients was obvious in both males, females and overall population.

Age and gender specific prevalence of MetS in urban and rural areas

In Fig. 3A, the prevalence of MetS in urban areas increased from 30.94% (95% CI = 27.22–34.92) to 43.37% (95% CI = 40.09–46.72) and then fluctuated (45.54% in 60–70 years old group and 44.16% in > 70 years old group). In females, this prevalence ascended in all four age groups (30.86% in 40–50 years old group, 50.21% in 50–60 years old group, 56.55% in 60–70 years old group and 61.66% in > 70 years old group). In males, this prevalence fluctuated in all the four age groups (31.05% in 40–50 years old group, 34.74% in 50–60 years old group, 34.40% in 60–70 years old group and 27.36% in > 70 years old group).

In rural areas, as in urban areas, the female and overall population were showed the same increasing and fluctuating trends, respectively (see Fig. 3B). However, in the male population, the prevalence of MetS was revealed a fluctuating trend in urban areas contrast to a decreasing trend in rural areas. Among the male population in rural areas the prevalence of MetS was 21.70% in 40–50 age group, 20.97% in 50–60 age group, 18.55% in 60–70 age group and 12.76% in > 70 age group.

Gender specific prevalence in different regions.

In Fig. 4A, people living in north region had the highest prevalence (40.91%, 95% CI = 38.44–43.42) and people living in south-west region had the lowest prevalence (23.06%, 95% CI = 21.14–25.11). In Fig. 4B and 4C, this phenomenon still existed in both males and females (13.91% [95% CI = 11.72–16.43] for males in south-west region, 28.41% [95% CI = 25.17–31.88] for males in north region, 31.58% [95% CI = 28.62–34.71] for females in south-west region, 51.74% [95% CI = 48.28–55.19] for females in north region).

Associated factors of MetS in the middle-aged and elderly population

In Table 2, results from univariate logistic regression revealed that age, gender, marital status, afternoon nap, hyperuricemia, LDL, total cholesterol, obesity defined by BMI, arthritis and rheumatism were positively corrected with MetS ($P < 0.05$). Living in rural areas, smoking, alcohol consumption, low body weight defined by BMI, BUN, digestive system diseases were negatively associated with MetS ($P < 0.05$). After adjusted by multivariate logistic regression, this positive association was still observed in covariates comprising age, gender, living in urban areas, smoked but quitted now, afternoon nap, hyperuricemia, elevated total cholesterol and obesity defined by BMI ($P < 0.05$). Negative association was observed in living rural areas, elevated LDL, low body weight defined by BMI and elevated BUN ($P < 0.05$).

Table 2
Adjusted OR for the prevalence of metabolic syndrome

Characteristics	Crude OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age group,				
40–50	1.00 (reference)	-	1.00 (reference)	-
50–60	1.40 (1.25–1.58)	< 0.001	1.75 (1.52–2.02)	< 0.001
60–70	1.46 (1.30–1.65)	< 0.001	2.26 (1.95–2.62)	< 0.001
>70	1.28 (1.11–1.47)	< 0.001	2.86 (2.37–3.44)	< 0.001
Gender				
Male	1.00 (reference)	-	1.00 (reference)	-
Female	2.54 (2.33–2.76)	< 0.001	3.00 (2.56–3.50)	< 0.001
Marital status				
Married/Cohabitated	1.00 (reference)	-	1.00 (reference)	-
Others	1.11 (1.00-1.24)	< 0.05	1.10 (0.96–1.26)	0.158
Depression				
< 10	1.00 (reference)	-	-	-
≥ 10	1.05 (0.96–1.14)	0.316	-	-
Sleeping time				
0–6 hours	0.94 (0.86–1.02)	0.133	-	-
6–8 hours	1.00 (reference)	-	-	-
> 8 hours	0.99 (0.85–1.14)	0.844	-	-
Geographical area				
Urban	1.00 (reference)	-	1.00 (reference)	-
Rural	0.61 (0.56–0.67)	< 0.001	0.70 (0.63–0.78)	< 0.001
Smoking				
Yes	0.41 (0.37–0.45)	< 0.01	1.10 (0.94–1.30)	0.240
No	1.00 (reference)	-	1.00 (reference)	-
Quitted	0.67 (0.59–0.76)	< 0.001	1.24 (1.03–1.49)	< 0.05
Alcohol consumption				
Never	1.00 (reference)	-	1.00 (reference)	-
Less than once a month	0.71 (0.62–0.83)	< 0.001	0.99 (0.83–1.18)	0.905

Characteristics	Crude OR (95% CI)	P value	Adjusted OR (95% CI)	P value
More than once a month	0.56 (0.51–0.62)	< 0.001	0.93 (0.81–1.06)	0.282
Afternoon napping				
Yes	1.25 (1.15–1.36)	< 0.001	1.30 (1.17–1.44)	< 0.01
No	1.00 (reference)	-	1.00 (reference)	-
Uric acid				
Hyperuricemia	2.41 (2.14–2.72)	< 0.001	2.07 (1.78–2.41)	< 0.001
Non-hyperuricemia	1.00 (reference)	-	1.00 (reference)	-
Low density lipoprotein				
≥ 120 mg/dl	1.24 (1.13–1.35)	< 0.001	0.53 (0.45–0.62)	< 0.001
< 120 mg/dl	1.00 (reference)	-	1.00 (reference)	-
Total cholesterol				
≥ 200 mg/dl	1.69 (1.55–1.84)	< 0.001	2.02 (1.74–2.34)	< 0.001
< 200 mg/dl	1.00 (reference)	-	1.00 (reference)	-
Body mass index, (BMI)				
< 18.5 Kg/m ²	0.12 (0.07–0.22)	< 0.001	0.10 (0.05–0.19)	< 0.001
< 24 Kg/m ²	1.00 (reference)	-	1.00 (reference)	-
< 28 Kg/m ²	6.42 (5.79–7.12)	< 0.001	6.73 (6.01–7.53)	< 0.001
≥ 28Kg/m ²	15.11 (13.16–17.34)	< 0.001	15.86 (13.62–18.45)	< 0.001
Blood urea nitrogen, (BUN)				
0–20 mg/dl	1.00 (reference)	-	1.00 (reference)	-
> 20 mg/dl	0.77 (0.68–0.87)	< 0.001	0.82 (0.71–0.96)	< 0.05
Liver disease				
Yes	1.20 (0.98–1.46)	0.077	-	-
No	1.00 (reference)	-	-	-
Kidney diseases				
Yes	1.02 (0.87–1.21)	0.770	-	-
No	1.00 (reference)	-	-	-
Digestive system diseases				

Characteristics	Crude OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Yes	0.91 (0.82-1.00)	< 0.05	0.95 (0.84–1.08)	0.446
No	1.00 (reference)	-	1.00 (reference)	-
Arthritis or rheumatism				
Yes	1.14 (1.04–1.24)	< 0.01	1.00 (0.89–1.12)	0.985
No	1.00 (reference)	-	1.00 (reference)	-

Discussion

Considering the huge amount of aging population in China, investigating the age and gender specific prevalence and associated factors of MetS in Chinese middle-aged and elderly population is of great significance. A nationally representative project targeting the aged, CHARLS, helps realize it.

In the present study, the prevalence of MetS in the participants aged 40 years and older was 32.97% based on IDF definition. Under NCEP-ATP III definition, it was 29.75%. According to Li's report, in 2010–2012, this figure in Chinese adults aged 18 years and older was 24.2% under NCEP-ATP III definition [23]. In He's study, in the overall population, it was 9.5% in 2002 and 18.7% in 2010–2012 [31]. These figures revealed that the aged had higher odds of MetS, which were in lines with other studies [9, 32]. Based on IDF criteria, the prevalence of MetS was 45.5% in Tunisia, 37.4% in Iran and 53.9% in Gwalior, a city in India [33, 34]. Compared with studies in other countries, prevalence reported in the present study seems lower than these countries, which may be attributed to different races, lifestyles etc. In the aging population, the prevalence was 35% in 40–59 years group and 46.7% in the > 60 years group in the U.S [10]. Prevalence of MetS in aging population were high but still lower than developed countries. In addition, in 2009, this number was 31.5% among people over 35 years old in Jiangsu province, China [35], which indicated that the trend of MetS in aging population did not vary wildly.

It is noteworthy that with aging, the prevalence of MetS descends in males, while ascends in females. This trend is also observed in Korean [36], Indian [34], Spanish [37] etc., which may be partly attributed to hormone secretion. According to Jeenduang's study, prevalence of MetS was 29.37% in postmenopausal women, while was 16.97% in premenopausal women [38]. Hormones hidden behind menopause may lead to this alteration [39]. However, one previous article performed in U.S. presented an opposite observational result that males had higher prevalence of MetS than females [40]. This finding may be biased by their limited samples, which still needs more evidences.

Furthermore, our study also found that the prevalence of MetS in urban areas was significantly higher than one in rural areas. Sedentary lifestyles in modern cities may account for this finding [41]. Of note, with aging, this upward trend of MetS prevalence in females was not observed in males, especially for those settling in rural areas who displayed a downward trend. This result was in line with previous studies performed in China [17], India [42], sub-Saharan Africa [43] and Mexico [44] but contrary to Lee's study in the middle-aged Koreans [45]. Study from Javier concluded that men were more susceptible to the urbanization-associated

worsening of cardiometabolic health [44], which may partly clarify this disparity. Notwithstanding, the specific reasons remain hazy. Besides hormones and lifestyles stated above, a number of other potential factors may contribute to this difference including household income, educational levels and annual cost of healthcare etc [46, 47].

This disparity of MetS prevalence was also detected in different regions. Regardless of gender, participants had the highest prevalence in the north region and the lowest in the southwest region. According to previous reports [48], it may be linked to dietary nutrient intake. It is well-known that residents in north region mainly eat food made of flour, such as noodles, which is rich in carbohydrates. It was well known that intake of carbohydrate and sodium was closely associated with the increased risk of MetS [45]. Moreover, a diet rich in carbohydrates was thought to be a principal reason of aggravation glucose intolerance [49] and dyslipidemia [50]. Therefore, improving the diet structure seems sensible for those participants.

In this special aging population, a number of relevant factors consisting of age, gender, living areas etc. were identified, as revealed by previous literature [51]. However, two pivotal factors comprising afternoon nap and BUN are little reported elsewhere. On the basis of Maria's study [52], participants with afternoon nap (< 30 minutes/day) had lower risks of suffering MetS in the overall population, contrary to what we reported. This discrepancy may be due to the different definition of afternoon nap in their study. According to Cao's study of 27,009 participants (mean age 63.6 years), nappers with longer nap duration had fairly higher rate of hypertension [53]. The design of Maria's study was limited in the < 30 minutes/day group, which may constrain this conclusion. More importantly, BUN > 20 mg/dl was also determined to be a negative correlate. In Arora's study, both metabolically healthy obesity (MHO) and metabolically unhealthy obesity (MUO) displayed normal kidney function [54]. However, their target population was children and adolescents. This risk in different population varied, which raised a reminder of renal function in this particular middle-aged and elderly MetS patients.

The present study has several defects. First, although some associated factors were identified here, however, this association still awaits further cohort study to demonstrate in this specific population. Second, this study enrolled the whole aging population instead of one specific gender into analyses, which limited further understanding of its relevant factors by gender. We plan to address this issue in future studies.

Conclusion

In Chinese middle-aged and elderly population, the overall prevalence of MetS was 32.97% as defined by IDF and 29.75% under NCEP-ATP III criteria. The prevalence varied in different age groups, sexes, living areas and regions and was associated with afternoon nap and elevated BUN.

Abbreviations

BMI: body mass index; IDF: International Diabetes Federation; NCEP-ATP III: National Cholesterol Education Program - The Adult Treatment Panel III; MetS: metabolic syndrome; CES-D: Epidemiologic Studies Short Depression Scale; CHARLS: China Health and Retirement Longitudinal Study; CCDC: Chinese Center for

Disease Control and Prevention; BUN: blood urea nitrogen; MHO: metabolically healthy obesity; MUO: metabolically unhealthy obesity; PPS: probabilities proportional to size.

Declarations

Ethics approval and consent to participate: The CHARLS study was approved by research ethics committees of Peking University (IRB00001052-13074). All participants provided written informed consent. No experimental interventions were performed.

Consent to publish Not applicable.

Availability of data and materials: The data that support the findings of this study are available from China Health and Retirement Longitudinal Study (CHARLS) website (<http://charls.pku.edu.cn/>). The full datasets used in this analysis are available from the corresponding author upon reasonable request.

Competing Interests: The authors declare no conflict of interest.

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Figures

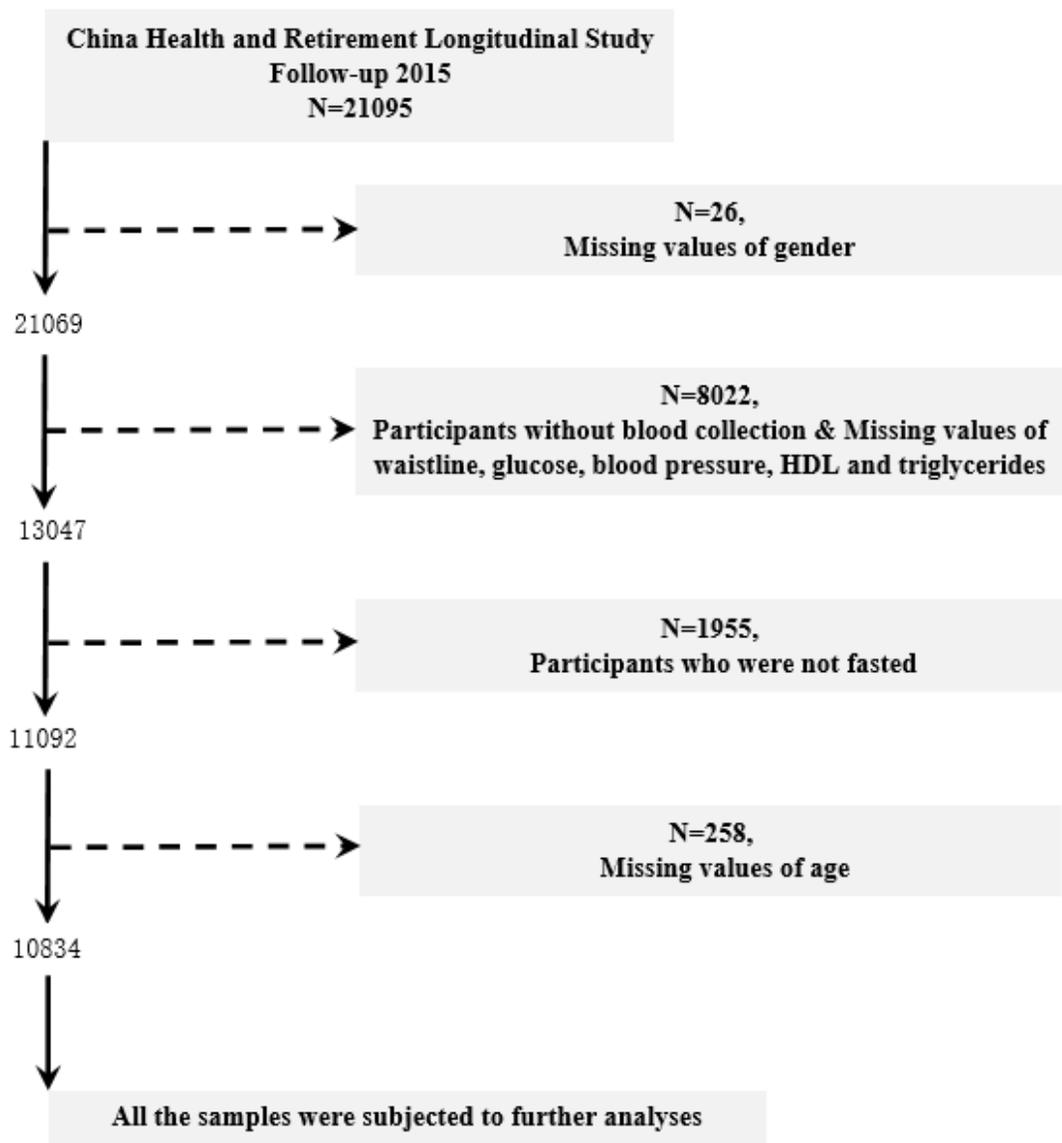


Figure 1

Flowchart of data cleansing Notes: HDL = High density lipoprotein.

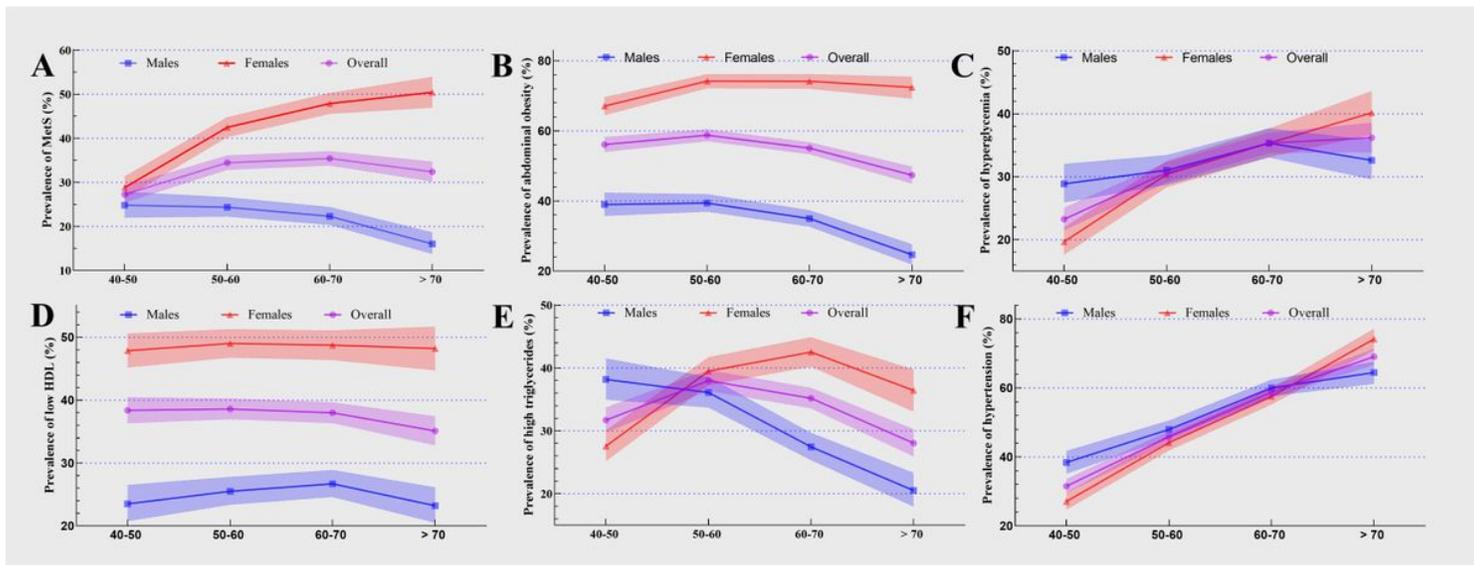


Figure 2

Age and gender specific prevalence of metabolic syndrome and its components Notes: MetS = Metabolic Syndrome; HDL = High density lipoprotein.

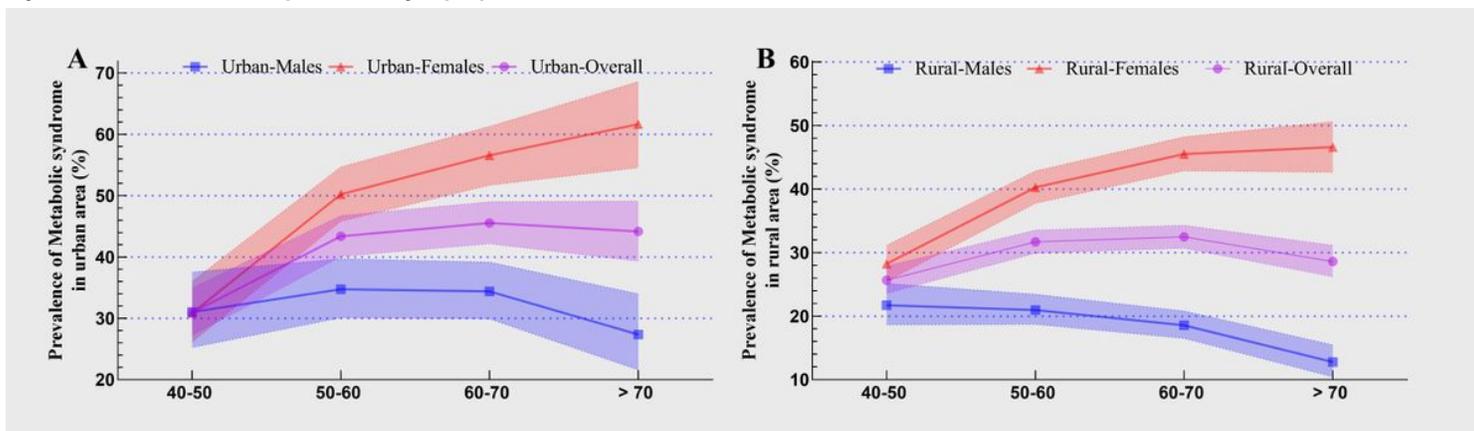


Figure 3

Age and gender specific prevalence of metabolic syndrome in urban and rural areas

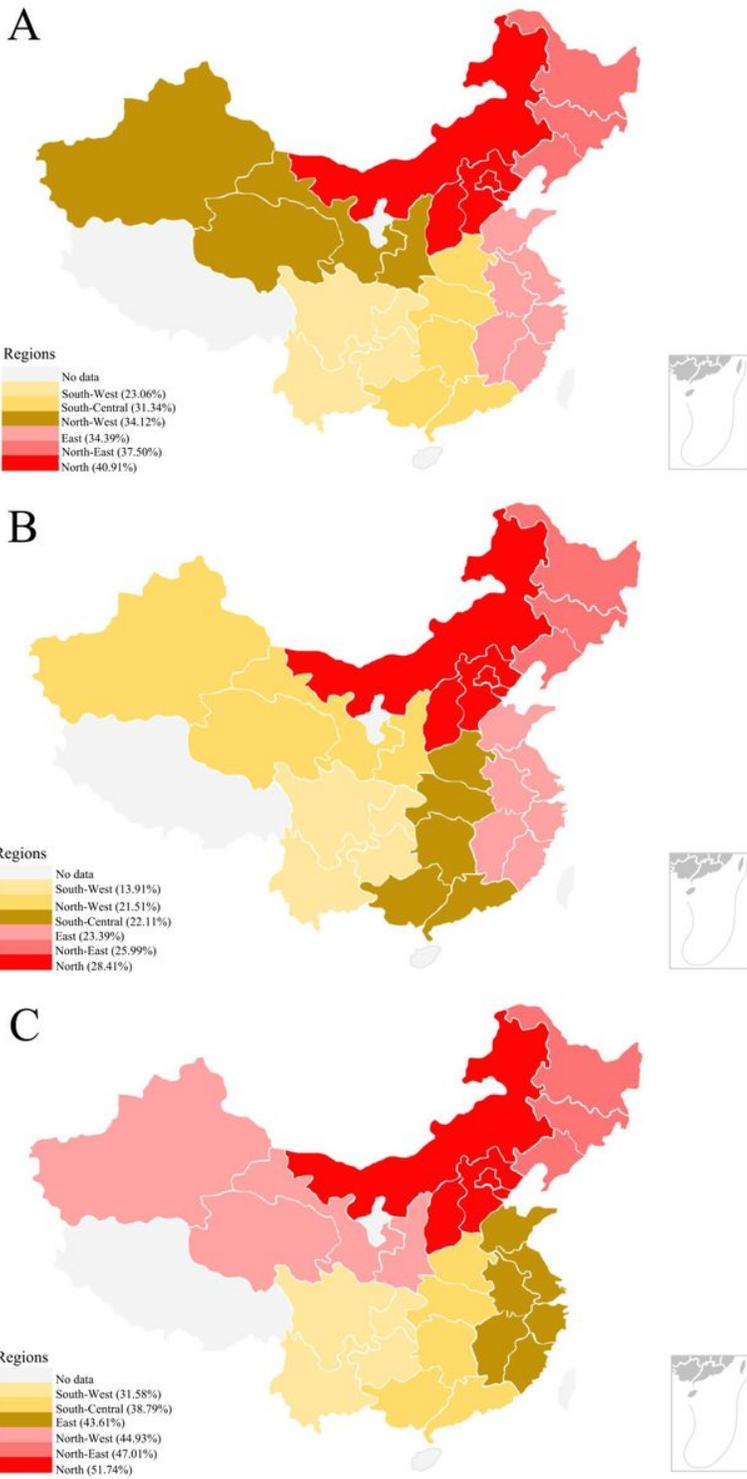


Figure 4

Gender specific prevalence of metabolic syndrome in different regions Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

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