

## Preplanned Studies

## Prevalence of Metabolic Syndrome and Risk Factors Among Chinese Adults: Results from a Population-Based Study — Beijing, China, 2017–2018

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### Summary

#### What is already known about this topic?

Metabolic syndrome (MetS) is one of the most easily available health indicative markers for cardiovascular diseases, and it has become a major public health problem worldwide due to increasing urbanization and aging populations. The prevalence of MetS increased dramatically in China, however, there are no records of MetS defined by the 2017 Chinese Diabetes Society for Beijing by far.

#### What is added by this report?

In this study, the data of 24,412 participants aged 18–74 years from a large population-based study in Beijing was collected. The overall prevalence of MetS among Beijing residents was 24.5%. The prevalence was 35.2% in males and 15.4% in females.

#### What are the implications for public health practice?

Effective public health strategies should target males, people with older age, lower education, higher body mass index, smokers, those who drink alcohol, those who are unemployed or retired, and those who live in rural areas on MetS prevention and control.

Metabolic syndrome (MetS) is characterized as insulin resistance, obesity, hypertension, glucose intolerance, and dyslipidemia. MetS is associated with elevated cardiovascular diseases and chronic diseases. With increasing urbanization and aging populations, the prevalence of MetS increased dramatically in China and became a major public health challenge (1). Meta-analysis revealed that pooled prevalence in the mainland of China was 24.5% during 2005–2015 (2). Genetics, environmental influence, physical activity, diet, and behavior all influence the prevalence of both MetS and its components (3). Beijing, a metropolitan city with an aging population, had no record of the

prevalence of MetS defined by the new criteria for Chinese adults. The current study estimated the prevalence of MetS and its risk factors in Beijing based on a recent large sample study conducted in 2017–2018. The total prevalence of MetS was estimated to be 24.5% among Beijing residents. Males, especially those who lived in the outer suburbs, smokers, and those of older age were associated with an increased risk for MetS.

The data used in the current study came from the baseline dataset of Beijing Population Health Cohort study, which was designed to measure air pollution and health outcomes. Details of the study have been described in a previous publication (4). A stratified, random cluster sampling method was used to select participants from a general population in Beijing in 2017–2018. To ensure the sample size, the survey was conducted with an estimated sample, and if the respondent was not available, another candidate in the list would be surveyed then. Our study included 24,990 individuals from 16 districts, which included urban areas, suburban areas, and outer suburbs to represent a general population of Beijing. Participants were permanent residents living in Beijing for more than 2 years and aged 18–74 years. Among them, 578 individuals without identification number (ID) or repetitive ID were excluded; 24,412 individuals were included in the study. MetS was diagnosed according to the China Diabetes Society (CDS) criteria, which was newly released in 2017 according to Chinese guidelines, where a person has MetS if he or she meets 3 or more of the following criteria: 1) a waist circumference of  $\geq 90$  cm for men and  $\geq 85$  cm for women; 2) a fasting plasma glucose (FPG) of  $\geq 6.1$  mmol/L or previously diagnosed diabetes; 3) a systolic blood pressure (SBP) of  $\geq 130$  mmHg, a diastolic blood pressure (DBP) of  $\geq 85$  mmHg, or previously diagnosed hypertension; 4) a fasting triglyceride level

of  $\geq 1.7$  mmol/L; and 5) a high-density lipoprotein cholesterol (HDL-C) of  $< 1.04$  mmol/L (5).

The prevalence was calculated according to demographic and lifestyle factors and compared means using t-tests and distributions of categories using chi-squared tests. Logistic regression was used to estimate the odds ratios (ORs) and 95% confidence intervals (CIs), adjusting for the main potential confounding variables, including age, body mass index (BMI), education, occupation, smoking habits, alcohol use, and other factors. All data were analysed using SPSS

Statistics for Windows (version 20.0, IBM Corp., Armonk, NY, US). Two-tailed *P* values  $< 0.05$  were considered statistically significant.

Of the total 24,412 participants in the study, 11,418 males and 12,994 females were surveyed. The total prevalence of MetS was 24.5% among Beijing residents. The prevalence of MetS was 35.2% in male participants and 15.4% in female participants. Subjects with MetS were more likely to be 55 years old and above, male, unemployed/student/retired, less educated, smoker, and drinker. (Table 1)

TABLE 1. Prevalence of MetS by demographic characteristics, Beijing, China, 2017–2018.

Characteristics	MetS		Control		<i>P</i>	Prevalence of MetS %
	n	%	n	%		
Age, years Mean (SD)	52.1 (12.9)		43.8 (14.4)		<0.001	
BMI, kg/m <sup>2</sup> Mean (SD)	27.8 (3.7)		24.2 (3.8)		<0.001	
Han ethnic	4,828	96.2	1,4861	95.8	0.199	24.5
Sex					<0.001	
Male	3,301	65.8	6,065	39.1		35.2
Female	1,719	34.2	9,454	60.9		15.4
Age group (years)					<0.001	
$\leq 24$	65	1.3	1,123	7.2		5.5
25–34	636	12.7	4,233	27.3		13.1
35–44	662	13.2	2,771	17.9		19.3
45–54	1,055	21.0	2,981	19.2		26.1
55–64	1,764	35.1	3,048	19.6		36.6
$\geq 65$	838	16.7	1,363	8.8		38.1
BMI group					<0.001	
Normal	1,057	21.1	9,732	62.7		9.8
Overweight	2,806	55.9	4,857	31.3		36.6
Obese	1,157	23.0	930	6.0		55.4
Education					<0.001	
Primary school or lower	617	12.3	1,143	7.4		35.0
Junior high school	1,442	28.7	2,878	18.5		33.4
Senior high school	1,142	22.7	2,949	19.0		27.9
College	808	16.1	3,174	20.5		20.3
Undergraduate and above	1,011	20.1	5,375	34.6		15.8
Marital status					<0.001	
Married	4,601	91.7	12,787	82.4		26.5
Divorced/separated	102	2.0	300	1.9		25.4
Widowed	119	2.4	242	1.6		33.0
Single	198	3.9	2,190	14.1		8.3
Occupation					<0.001	
Farmer, worker, and business	1,072	21.4	2,985	19.2		26.4
Leader, clerk, and technical	1,994	39.7	8,123	52.3		19.7
Others	456	9.1	1,459	9.4		23.8
Unemployment, student, retirement	1,498	29.8	2,952	19.0		33.7

TABLE 1. (Continued)

Characteristics	MetS		Control		P	Prevalence of MetS %
	n	%	n	%		
Residence					<0.001	
Urban	1,368	27.3	5,461	35.2		20.0
Suburban	2,211	44.0	6,471	41.7		25.5
Outer suburbs	1,441	28.7	3,587	23.1		28.6
Smoke					<0.001	
Smoke	2,225	44.3	3,730	24.0		37.4
Do not smoke	2,799	55.7	11,827	76.0		19.1
Alcohol use					<0.001	
Drink	1,002	19.9	2,212	14.2		31.2
Do not drink	4,022	80.1	13,345	85.8		23.2

Note: Values for some characteristics may not be equal to total numbers in each group because of missing values. Abbreviations: SD=standard deviation; MetS=metabolic syndrome; BMI=body mass index.

There was a significant difference between male and female subjects. The mean values for BMI, waist circumference, FPG, and serum triglycerides were higher in males than those in females, while HDL-C was higher in females than in males ( $P<0.001$  for all comparisons). (Table 2)

Multiple logistic regression showed that males, especially those with older age, lower education, higher BMI, smoking, alcohol use, and living in rural areas were associated with MetS. (Table 3)

## DISCUSSION

Based on the baseline dataset of this large population-based study, a quarter of participants had MetS. With the disease burden increasing, especially for chronic diseases, understanding the epidemiology of MetS and exploring risk factors of MetS would be an effective approach for disease prevention and health promotion. This study added evidence that nearly one-

fourth of the Beijing residents in our study had MetS and implied that special attention should be paid among males, people with older age, lower education, higher BMI, smoker, and those lived in rural areas, for the prevention of MetS.

Few country-wide studies were conducted to describe the epidemiology of MetS in adults for all age groups; a previous study focused on older adults ( $\geq 60$  years) or middle-aged people (35–59 years) as they were more susceptible to chronic cardiovascular disease (6). Using the updated CDS criterion (2017), the current study revealed the prevalence in a general population aged 18–74 years. The prevalence of MetS among Beijing residents (24.5%, 95% CI: 24.0%–25.5%) was generally consistent with a 2017 study of MetS in Beijing residents aged from 18 to 79 years (25.6%), which used the International Diabetes Federation criteria (7). The prevalence of MetS in this study was higher than general Xinjiang residents (20.9%) (8) and Qingdao residents (17.8%) (9). Current study showed that the prevalence of MetS

TABLE 2. Characteristics of components of MetS among adults in Beijing, China, 2017–2018.

Characteristics	Male (N=11,418)		Female (N=12,994)		P
	Mean	SD	Mean	SD	
Waist circumference (cm)	90.05	10.898	81.17	10.872	<0.001
SBP (mmHg)	130.16	17.937	123.06	19.582	<0.001
DBP (mmHg)	83.11	11.062	77.90	12.550	<0.001
FPG (mmol/L)	5.85	1.769	5.53	1.515	<0.001
Triglycerides (mmol/L)	2.02	2.079	1.44	1.126	<0.001
HDL-C (mmol/L)	1.31	0.325	1.49	0.335	<0.001

Note: Data were presented as mean and standard deviation for continuous variables or percentage for categorical variables. P value in t-test for means or  $\chi^2$  test for proportion differences between males and females.

Abbreviations: DBP=diastolic blood pressure; FPG=fasting plasma glucose; HDL-C=high-density lipoprotein cholesterol; SBP=systolic blood pressure; MetS=metabolic syndrome; SD=standard deviation.

TABLE 3. Factors associated with MetS by sex in Beijing, China, 2017–2018.

Characteristics	Adjusted odds ratio and 95% CIs	
	Male	Female
Age group (years)		
≤24	1.000	1.000
25–34	2.453 (1.737–3.463)	1.469 (0.692–3.119)
35–44	3.754 (2.600–5.418)	2.854 (1.310–6.219)
45–54	5.445 (3.773–7.857)	4.229 (1.952–9.162)
55–64	6.154 (4.238–8.934)	11.438 (5.248–24.933)
≥65	6.120 (4.127–9.077)	14.502 (6.588–31.921)
BMI group		
Normal	1.000	1.000
Overweight	3.554 (3.200–3.946)	4.564 (3.979–5.237)
Obese	8.547 (7.357–9.930)	12.545 (10.441–15.073)
Education		
Primary school or lower	0.967 (0.764–1.224)	1.187 (0.887–1.588)
Junior high school	1.154 (0.975–1.366)	1.377 (1.065–1.781)
Senior high school	1.290 (1.104–1.506)	1.202 (0.936–1.543)
College	1.318 (1.142–1.520)	1.338 (1.066–1.680)
Undergraduate and above	1.000	1.000
Marital status		
Married	1.000	1.000
Divorced/separated	1.209 (0.868–1.686)	0.908 (0.589–1.402)
Widowed	1.006 (0.622–1.627)	1.031 (0.767–1.386)
Single	0.777 (0.620–0.973)	0.777 (0.471–1.282)
Occupation		
Farmer, worker, and business	1.000	1.000
Leader, clerk, and technical	1.237 (1.070–1.430)	0.989 (0.782–1.251)
Others	0.979 (0.818–1.171)	0.782 (0.610–1.002)
Unemployment, student, retirement	1.155 (0.984–1.356)	1.074 (0.906–1.273)
Residence		
Urban	1.000	1.000
Suburban	1.081 (0.963–1.214)	1.380 (1.195–1.593)
Outer suburbs	1.186 (1.037–1.357)	1.825 (1.535–2.170)
Smoke		
Never smoke	1.000	1.000
Smoke	1.270 (1.150–1.402)	1.283 (0.935–1.761)
Alcohol use		
Never drink	1.000	1.000
Drink	1.124 (1.009–1.252)	0.951 (0.687–1.317)

Abbreviations: MetS=Metabolic syndrome; CIs=confidence intervals, BMI=body mass index.

\*Adjusted for age, study cohort, residential area, sex, education levels, income levels, smoking, and drinking.

increased compared to 2010 (24.5% and 11.0%, respectively) (10).

Prevalence of MetS varied significantly by gender.

Males had a higher prevalence than females, which was different from the previous study. The prevalence was 27.0% among females and 19.2% among males in a

recent Chinese study (2). The main reason was survivor bias, as young males who survived the disparities of resources period were more likely to receive sufficient nutrition than young females in their early life. Malnutrition during the critical growth stages may lead to early adaptations in body structure and function, such as the establishment of a thrifty phenotype. Another reason may be biological differences in sex hormones, body composition, and glucose metabolism. The gender disparity in the risk for MetS requires further investigation. In addition, the pattern of risk factors is sex-specific. Alcohol drinking was identified as the main risk factor for MetS among males, while low household income and less education increased the risk for MetS among females (11).

A significant increasing trend was observed in different age groups, as metabolic syndrome increased significantly with age (2). Developmental origins of health and disease well explained the origins of MetS in later life. Early-life malnutrition and later-life overnutrition were shown to be critical for metabolic disorders in adult life. Low birth weight, low socioeconomic status in early life increased the likelihood of adulthood metabolic disorders and chronic diseases.

Studies observed an association between a lower socioeconomic status and MetS prevalence; the ORs for MetS prevalence for residents in outer suburbs were higher than residents in urban. Dietary and lifestyle factors may contribute to the difference. Although it's reported that the prevalence of MetS was higher in urban residents than in rural areas, the study was conducted on northwest Chinese adults who had different diets and lifestyles from Beijing adults (12). Smoking and drinking were related to higher risks of MetS, and the correlation between unhealthy lifestyle factors and lower socioeconomic status was also verified (8).

The study had several strengths. First, our study included a random representative and large sample of adults in Beijing. Second, all interviews were conducted face to face by trained health workers, and the anthropometric parameters were measured on-site, which allowed for rigorous quality control. Third, the sample constituted of both urban, suburban, and outer suburbs residents, which was representative of the diversity of environments in China. Fourth, this study used the new version of MetS criteria for Chinese adults, 2017 CDS, which would be more suitable since a previous study revealed that CDS definition was

superior to The Adult Treatment Panel III of the National Cholesterol Education Program criteria and International Diabetes Federation when predicting factors and MetS among Chinese (9).

This study was subject to some limitations. First, this was a cross-sectional study, so the causal relation between factors and MetS risk could not be inferred. Second, lack of environmental exposure prevented us from exploring its effect on MetS.

In conclusion, MetS was prevalent among residents in Beijing. The findings suggested males, especially those living in the rural areas, who smoked, had lower education, higher BMI and were of older age were associated with an increased risk of MetS.

**Conflicts of Interest:** No conflicts of interest.

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