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Temporal trends in Hyperuricemia among Adults in Wuhan City, China from 2010-2019: a cross-sectional study

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Abstract

Objectives: Hyperuricemia is a risk factor for gout attacks, kidney damage and cardiovascular events. Evidence on the burden of hyperuricemia in Wuhan city, China was limited. The present study aimed to estimate the prevalence of and a decade trend in hyperuricemia in Wuhan city.

Design: Cross-sectional study.

Setting: Health management center of Tongji hospital.

Participants: A total of 732527 adult participants from the general population who took a physical examination in the health management center between 2010 and 2019.

Main outcome measures: Prevalence of and trends in hyperuricemia.

Results: The overall prevalence of hyperuricemia was 25.8% (36.6% in men and 10.8% in women) in 2019. Serum uric acid levels among men and women gradually increased from 363.02 ± 74.32 mmol/L and 255.87 ± 57.58 mmol/L in 2010 to 395.62 ± 83.69 mmol/L and 277.48 ± 64.32 mmol/L in 2019, respectively, *P* values < 0.05. From 2010 through 2019, hyperuricemia prevalence significantly increased in each age category and it increased most sharply among participants aged 20-39 years. The multivariate-adjusted prevalence among men was 25.2% (24.6% - 25.7%) in 2010, 30.3% (29.8% - 30.8%) in 2015, and 34.5% (34.1% - 34.8%) in 2019, while among women it was 5.6% (5.3% - 6.0%) in 2010, 7.1% (6.8% - 7.4%) in 2015, and 10.1% (9.9% - 10.4%) in 2019.

Conclusions: hyperuricemia was highly prevalent among adults in Wuhan city. More attention should be paid to the increasing burden of hyperuricemia, especially for those at higher risks.

Key Words: Hyperuricemia, uric acid, epidemiology, temporal trend

Strengths and limitations of this study

- This study included a large sample size of participants (more than 730000 adults) from the general population, which made our findings more convincible.
- This study firstly estimated the prevalence of and trends in hyperuricemia over the recent decade (2010-2019) among adults in Wuhan city.
- The multivariate logistic model was used to correct selection biases and confounding biases as possible by adjusting for potential confounders.
- Since participants in the present study were recruited from a health management center, selection biases could not be avoided.

Introduction

Serum uric acid (SUA) is the final product of purine nucleotides metabolism. The overproduction or inefficient renal or gut excretion of SUA can consequently lead to hyperuricemia. Hyperuricemia is generally recognized as the major contributor to the onset of gout.[1] Moreover, many studies have demonstrated a positive association of hyperuricemia or a high level of SUA with several chronic diseases such as chronic kidney disease, type 2 diabetes mellitus, hypertension, metabolic syndrome, and cardiovascular events.[2-6] These diseases accounted for a large part of global deaths and disability-adjusted life-year losses,[7 8] resulting in a particular urgency to prevent and control hyperuricemia.

Previous studies have documented an increasing trend of hyperuricemia prevalence in the past few decades across the world, especially in western countries.[9-11] Additionally, hyperuricemia is reported to be more prevalent in developed countries than in developing countries.[12] The prevalence among US adults was substantial (20.2% in men and 20.0% in women) during 2015-2016.[13] In China, the prevalence estimated from national surveys were 8.4% in 2009-2010,[14] 13.0% in 2007-2011,[15] and 6.4% among the middle-aged and elderly in 2011-2012.[16] Besides, a meta-analysis of 38 studies from mainland China reported that the pooled prevalence of hyperuricemia among Chinese adults was 13.3% in 2000-2014.[17] Obviously, the data above were not able to clearly illustrate the trend of hyperuricemia prevalence among Chinese adults.

China is a large developing country with unbalanced economic development and marked regional differences. Hyperuricemia prevalence among Chinese adults varied

greatly by geographical regions, with a report of 18.6% in south China, 12.9% in east China, 13.9% in southwest China, 10.3% in northwest China, 10.1% in northeast China, and 13.2% in north China.[17] Noteworthily, evidence on hyperuricemia prevalence in central China was limited. Wuhan, the capital city of Hubei province in central China, was characterized by rapid economic growth and urbanization in the recent decade. Its gross domestic products (GDP) per capita increased from 50117 yuan in 2009 to 123831 yuan in 2017.[18 19] Studies from developing countries showed that a rapidly growing economy in the short term and subsequently changed lifestyles would increase the risk of several metabolic disorders.[20 21]

To date, few studies have investigated the burden of hyperuricemia in Wuhan city. Therefore, we performed a large cross-sectional study to estimate the sex-specific prevalence of and trends in hyperuricemia among the general adults from 2010 through 2019. This general population-based study used data collected from consecutive healthy adults in a health management center.

Methods

Study population

We conducted a cross-sectional study, of which consecutive participants who had a health check-up in the Health Management Center of Tongji Hospital in Wuhan city, China between January 2010 and December 2019 were included. All the participants came from the general population. Most of them were urban citizens working in government organizations or large enterprises. Each participant completed the basic items of the physical examination including demographic information collection, biochemical tests, and anthropometric measurements. Supplemental Figure 1 shows the procedures for selecting participants in the study. A total of 732527 participants aged ≥ 20 years were recruited. After excluding participants with missing data, we included 676478 participants. As reduced renal function may affect uric acid excretion, we further excluded 5027 participants who had an estimated glomerular filtration rate (eGFR) of less than 60 mL/min/1.73m^2. Finally, 671451 participants were included in the analyses.

We used the STROBE cross sectional reporting guidelines in the present study. [22] The study was conducted in accordance with the Declaration of Helsinki and it was approved by the ethics committee of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology. Written informed consent was obtained from every participant.

Assessment of main variables

Overnight fasting blood samples were collected to test the biochemical variables. SUA concentrations were measured by the enzymatic colorimetry using an automated analyzer (Roche Cobas 8000, Basel, Switzerland). Additionally, the method of SUA measurement did not change during the whole study period. In the current study, hyperuricemia was defined according to the level of SUA: male ≥ 416 mmol/L (7 mg/dL), female ≥ 357 mmol/L (6 mg/dL). Participants were asked to wear light clothes and bare foot before their height and weight were measured. The body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. For Chinese adults, obesity was defined as BMI ≥ 28 Kg/m^2 and overweight was defined as BMI ≥ 24 Kg/m^2. [23] Hypertension was identified if any of the following criteria was satisfied: systolic blood pressure ≥ 140 mmHg, or diastolic blood pressure ≥ 90 mmHg, or use of antihypertensive medication, or self-reported physician diagnosis of hypertension. Information on age and sex was provided by the participants.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research. Patients or the public were not invited to contribute to the writing or editing of this article for readability or accuracy.

Statistical analysis

Due to the marked difference in levels of SUA between males and females, the sex-specific prevalence of and trends in hyperuricemia were estimated. Categorical

variables were expressed in percentages, whereas continuous variables were reported as means ± standard deviation (SD) for normally distributed data or median (interquartile range) for skewed data. We used data collected in 2019 to estimate the SUA level, the hyperuricemia prevalence and their 95% confidence intervals (CIs), stratified by sex (male or female), age (20 - 29, 30 - 39, 40 - 49, 50 - 59, 60 - 69, or ≥ 70 years), BMI (< 24, 24 - 27.9, or ≥ 28 kg/m^2, the cut-off values of overweight and obesity for Asian), and hypertension status (hypertensive or normotensive). In this part, the prevalence of hyperuricemia was compared using the Cochran-Armitage test for trend. The level of SUA was compared using one-way analysis of variance (ANOVA).

Sex- and age- specific trends in hyperuricemia from 2010 through 2019 were then analyzed. We performed tests for trends by including the observation year as a continuous variable in a linear or logistic regression model. The sex-specific multivariate-adjusted prevalence of hyperuricemia from 2010 through 2019 were estimated using logistic regression models after adjustment for age, BMI, eGFR, and hypertension. All statistical analyses were performed using Stata version 12.0 (Stata Corp LP, College Station, TX, USA). Graphs were drawn using an available R package: ggplot2. Two-sided *P* values < 0.05 were considered statistically significant.

Results

The crude prevalence of hyperuricemia in 2019

Table 1 shows the crude prevalence of hyperuricemia and the level of SUA in participants aged ≥ 20 years during the year 2019. A total of 66998 men and 48385 women in 2019 were included, with an average age of 42.0 ± 12.6 years. The overall hyperuricemia prevalence was 25.8%. The crude prevalence of hyperuricemia and level of SUA in men were significantly higher than those in women (36.6% versus 10.8%, 395.62 ± 83.69 mmol/L versus 277.48 ± 64.31 mmol/L; both *P* values < 0.05). Hyperuricemia prevalence was around 9.0% in women aged < 50 years and it rapidly increased with advancing age in women aged ≥ 50 years, with the highest prevalence of 26.1% for women aged ≥ 70 years. The burden of hyperuricemia among men was high across all age groups and it was particularly marked in young men (39.3% for 20-29 years and 40.5% for 30-39 years). Hyperuricemia prevalence and level of SUA dramatically increased with elevating BMI in both sexes (*P* values < 0.05); the prevalence (95% CI) was 55.9% (55.0% - 56.9%) in obese men and 34.6% (32.8% - 36.5%) in obese women. Hypertensive participants had a higher hyperuricemia prevalence and higher levels of SUA than normotensive participants (*P* values < 0.05).

Trends in the crude prevalence of hyperuricemia

A total of 671451 participants were included in the study between 2010 and 2019. As is shown in Table 2, the crude prevalence of hyperuricemia significantly increased over the years in both men and women (*P* values < 0.05). SUA levels among men and women

gradually increased from 363.02 ± 74.32 mmol/L and 255.87 ± 57.58 mmol/L in 2010 to 395.62 ± 83.69 mmol/L and 277.48 ± 64.32 mmol/L in 2019, respectively (*P* values < 0.05). A significantly increasing trend in hyperuricemia prevalence was observed during the observation period in each age category of both sexes (Figure 1 and Figure 2). The prevalence increased most sharply among participants aged 20-39 years. It increased from 22.5% (21.6% - 23.3%) in 2010 to 40.1% (39.6% - 40.6%) in 2019 among young men, whereas among young women it increased from 2.5% (2.1% - 2.9%) in 2010 to 9.0% (8.6% - 9.4%) in 2019.

Trends in multivariate-adjusted prevalence of hyperuricemia

The multivariate-adjusted prevalence of hyperuricemia was calculated using logistic regression models. Figure 3 shows an increasing trend in multivariate-adjusted prevalence of hyperuricemia during the observation years in both sexes (*P* values < 0.05). The prevalence among men was 25.2% (24.6% - 25.7%) in 2010, 30.3% (29.8% - 30.8%) in 2015, and 34.5% (34.1% - 34.8%) in 2019, while among women it was 5.6% (5.3% - 6.0%) in 2010, 7.1% (6.8% - 7.4%) in 2015, and 10.1% (9.9% - 10.4%) in 2019.

Discussion

The present study revealed that hyperuricemia was highly prevalent (36.6% in men and 10.8% in women) among adults in Wuhan city, China during 2019. The burden of hyperuricemia among men was substantial in all age groups. Hyperuricemia prevalence varied distinctly by gender, age, BMI, and hypertension status, with young men, old women, obese adults, and the hypertensives having a significantly higher prevalence.

This study also investigated the trend of hyperuricemia over a decade period (from 2010 to 2019) and revealed a significantly increasing trend in multivariate-adjusted prevalence of hyperuricemia in both sexes. Moreover, it was observed that the prevalence increased most sharply among young adults during the observation period, which meant that hyperuricemia occurred more and more frequently in young adults.

The estimated prevalence in our study (25.8% in 2019) was much higher than those reported in America (20.1% in 2015-2016),[13] Italy (11.9% in 2009),[10] Korea (11.4% in 2016),[24] and a previous national survey in China (13.0% in 2007-2011).[15] A cross-sectional study from Bangkok, Thailand used data of the annual physical examination and reported a prevalence rate of 24.4% in urban residents,[25] which was close to our result. Epidemiological studies demonstrated that urban individuals had a higher prevalence of hyperuricemia than rural residents.[14 16] In the present study, almost all the participants included were urban citizens, which may help explain the high hyperuricemia prevalence. Overweight or obesity was a well-accepted risk factor for hyperuricemia,[26] which was validated in our study. We found that hyperuricemia prevalence increased significantly with elevating BMI in both sexes. Based on

information in Table 1, it could be calculated that nearly 61.0% of men were overweight or obese and 44.5% of them were identified as hyperuricemia. The heavy burden of overweight or obesity may be another reason to explain the highly prevalent hyperuricemia.

The present study found that hyperuricemia prevalence was higher among women aged ≥ 50 years and it further increased with advancing age. Several studies from Asian and European countries revealed a roughly positive association of hyperuricemia prevalence with age among women,[10 11 15 24] which accorded with our results. Given the huge gender difference in hyperuricemia prevalence, we thought that sex hormones may play a key role. One explanation was that female sex hormones had protective effects against hyperuricemia. A cross-sectional study of 58870 South Korean women demonstrated that hyperuricemia prevalence significantly increased with the menopausal stage, after controlling for potential confounders.[27] Postmenopausal women are characterized by materially declined levels of female sex hormones (especially estradiol and progesterone). When they grow older, levels of estradiol and progesterone would decline further. The BioCycle study demonstrated that SUA levels were inversely associated with these two hormones.[28] Until now, how estradiol and progesterone lower SUA levels was not fully understood. They probably effect via promoting renal excretion of uric acid.[29 30]

Data from the National Health and Nutrition Examination Survey demonstrated that hyperuricemia prevalence among American adults significantly increased from 18.2% in 1988-1994 to 21.4% in 2007-2008 and concluded that the increasing trend of

hyperuricemia was likely due to rising prevalence of obesity and hypertension.[9] However, in the present study, we did not observe an increasing trend in obesity and hypertension over the years (Table 2). Thus, it might be some other factors responsible for the increasing prevalence of hyperuricemia among our study participants. We thought that gradually westernized dietary structure and rising consumption of fructose-sweetened soft drinks might be the main causes. Western diets contained much more purine than the traditional Chinese diets, leading to a higher risk of developing hyperuricemia. In addition, accumulating evidence showed that fructose-sweetened drinks, although containing no purines, could induce hyperuricemia.[31-33] Fructose intake per capita has dramatically increased during the past few decades,[34-36] in parallel with the increasing burden of hyperuricemia.

To the best of our knowledge, the present study firstly revealed age-specific trends in hyperuricemia over a decade among Chinese adults and found that hyperuricemia prevalence increased most sharply among young adults during the observation period. A large analysis of 128014 Irish adults revealed an increasing trend in hyperuricemia from 2006 through 2014 across all age groups, with the most increment among young participants aged 18-39 years;[11] a finding that was similar to our result. In addition to hyperuricemia, several hyperuricemia-related diseases such as diabetes and cardiovascular events also occurred more frequently among young adults over the past years,[37 38] posing a serious threat to public health. Based on the trend revealed in our study, hyperuricemia prevalence was much likely to continue rising in the coming years. Policy-makers should pay more attention to the burden of hyperuricemia, especially

among young adults.

The strengths of the present study were distinct. This study included a large sample size of participants (more than 730000 adults) from the general population, which made our findings more convincible. In addition, to the best of our knowledge, this was the first study to estimate the prevalence of and trends in hyperuricemia over the recent decade (2010-2019) among adults in Wuhan city, contributing to the management of hyperuricemia in this area.

The study also had several limitations. First, as the participants in the present study were recruited from a health management center, selection biases could not be avoided. The participants may be not a representative sample of the general population in community. Therefore, it should take caution to interpret the findings of this study. Second, hyperuricemia prevalence may be underestimated in our study. We diagnose hyperuricemia only according to SUA levels. However, participants with hyperuricemia might have normal SUA levels if they were undergoing SUA-lowering therapies. Third, our study did not collect data on diets and lifestyles that were related to hyperuricemia. Changes of these variables such as fructose intake over the years may help explain the trends in hyperuricemia.

Conclusions

In summary, a high burden of hyperuricemia was found among adults in Wuhan city. Moreover, hyperuricemia occurred more and more frequently in young adults. Our study also revealed an significantly increasing trend in multivariate-adjusted prevalence

of hyperuricemia among adults from 2010 through 2019. Effective measures to prevent and control hyperuricemia should be taken urgently, especially among young adults, postmenopausal women, obese adults and the hypertensives, for they were at higher risks.

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Author contributions All authors are in agreement with the content of the manuscript. ZW designed the study and drafted the article. LS, LH, and YL contributed to the conception, analysis, and critically revised the manuscript. XL and YH participated in the data collection and revised the manuscript.

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Competing interests None declared.

Patient consent for publication Not required.

Data availability statement Data are available upon reasonable request.

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Figure legends

Figure 1. Age-specific trends in hyperuricemia prevalence (95% CI) among men, 2010-2019. CI, confidence interval.

Figure 2. Age-specific trends in hyperuricemia prevalence (95% CI) among women, 2010-2019. CI, confidence interval.

Figure 3. Sex-specific trends in multivariate-adjusted hyperuricemia prevalence (95% CI) among participants aged ≥ 20 years, 2010-2019. The prevalence was adjusted for age, BMI, eGFR, and Hypertension. CI, confidence interval; BMI, body mass index; eGFR, estimated glomerular filtration rate.

Table 1. Crude prevalence of hyperuricemia and levels of SUA according to sex, age, BMI, and hypertension status in participants aged ≥ 20 years, 2019

Variables	N	Cases	Hyperuricemia, %		SUA (mmol/L)	
			Prevalence (95% CI)	*P*	Mean ± SD	*P*
Sex				< 0.001		< 0.001
Men	66998	24511	36.6 (36.2-36.9)		395.62±83.69	
Women	48385	5202	10.8 (10.5-11.0)		277.48±64.31	
Men						
Age (years)				< 0.001		< 0.001
20-29	11413	4489	39.3 (38.4-40.2)		402.86±81.58	
30-39	21613	8757	40.5 (39.9-41.2)		404.68±83.96	
40-49	15415	5672	36.8 (36.0-37.6)		396.08±82.91	
50-59	12744	4119	32.3 (31.5-33.1)		385.08±83.15	
60-69	4119	1031	25.0 (23.7-26.4)		369.67±81.57	
≥ 70	1694	443	26.2 (24.1-28.3)		369.34±83.23	
BMI (Kg/m^2)				< 0.001		< 0.001
<24	26072	6309	24.2 (23.7-24.7)		370.61±75.08	
24-27.9	29864	12013	40.2 (39.7-40.8)		403.11±81.94	
≥28	11062	6189	55.9 (55.0-56.9)		434.34±88.76	
Hypertension status				< 0.001		< 0.001
Hypertensive	18905	7991	42.3 (41.6-43.0)		407.10±89.38	
Normotensive	48093	16520	34.4 (33.9-34.8)		391.11±80.90	
Women						
Age (years)				< 0.001		< 0.001
20-29	10003	926	9.3 (8.7-9.8)		275.53±61.07	
30-39	15051	1329	8.8 (8.4-9.3)		272.00±61.34	
40-49	11180	917	8.2 (7.7-8.7)		268.82±61.18	
50-59	7679	1065	13.9 (13.1-14.7)		288.14±67.09	
60-69	3334	668	20.0 (18.7-21.4)		300.11±72.13	
≥ 70	1138	297	26.1 (23.6-28.8)		313.99±78.80	
BMI (Kg/m^2)				< 0.001		< 0.001
<24	35238	2409	6.8 (6.6-7.1)		266.81±57.91	
24-27.9	10529	1886	17.9 (17.2-18.7)		298.92±68.15	
≥28	2618	907	34.6 (32.8-36.5)		334.91±77.14	
Hypertension status				< 0.001		< 0.001
Hypertensive	7461	1625	21.8 (20.8-22.7)		304.94±74.88	
Normotensive	40924	3577	8.7 (8.5-9.0)		272.48±60.88	

SUA, serum uric acid; BMI, body mass index; CI, confidence interval; SD, standard deviation.

Table 2. Sex- specific characteristics of participants aged ≥ 20 years, 2010-2019

Variables	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	*P*
Men											
N	23535	24776	26574	27316	29416	32183	42222	51279	59921	66998	
Age (years)	43.80±13.03	43.35±12.67	42.83±12.72	42.87±12.43	43.39±12.73	43.19±12.40	41.71±12.24	42.01±12.53	42.34±12.44	42.34±12.49	< 0.001
eGFR (mL/min/1.73m^2)	108.48±20.81	107.53±20.01	107.89±19.23	101.62±17.99	104.07±18.92	101.95±18.05	100.49±17.36	99.73±16.86	99.55±16.84	98.97±16.75	< 0.001
Obesity, n (%)	3346 (14.2)	3659 (14.8)	4156 (15.6)	4414 (16.2)	4523 (15.4)	4849 (15.1)	5855 (13.9)	7286 (14.2)	9561 (16.0)	11062 (16.5)	< 0.001
Hypertension, n (%)	7683 (32.6)	7982 (32.2)	8845 (33.3)	9138 (33.5)	9609 (32.7)	9699 (30.1)	11194 (26.5)	14255 (27.9)	15965 (26.6)	18905 (28.2)	< 0.001
SUA (mmol/L)	363.02±74.32	367.28±75.22	366.09±75.39	373.68±77.71	372.13±78.58	381.22±81.80	387.53±82.52	393.09±83.62	393.89±84.11	395.62±83.69	< 0.001
Hyperuricemia, % (95% CI)	21.8 (21.2-22.3)	24.1 (23.6-24.7)	23.1 (22.6-23.7)	26.6 (26.1-27.1)	25.7 (25.2-26.2)	29.9 (29.4-30.4)	32.8 (32.4-33.3)	34.8 (34.4-35.2)	35.9 (35.5-36.3)	36.6 (36.2-37.0)	< 0.001
Women											
N	15759	19212	17867	19544	21643	26816	32552	40247	44606	48385	
Age (years)	42.94±13.44	42.43±13.01	42.10±12.95	41.64±12.88	42.37±13.20	41.42±12.90	39.95±12.65	40.79±12.76	41.15±12.66	41.52±12.62	< 0.001
eGFR (mL/min/1.73m^2)	130.36±28.22	130.69±27.51	130.71±26.16	123.06±25.14	126.08±26.08	123.95±24.54	122.58±23.67	119.46±22.86	120.28±23.03	119.11±22.67	< 0.001
Obesity, n (%)	938 (6.0)	1041 (5.4)	1035 (5.8)	1156 (5.9)	1252 (5.8)	1439 (5.4)	1652 (5.1)	1929 (4.8)	2279 (5.1)	2618 (5.4)	< 0.001
Hypertension, n (%)	2974 (18.9)	3440 (17.9)	3196 (17.9)	3523 (18.0)	3841 (17.7)	4385 (16.4)	4697 (14.4)	6284 (15.6)	6524 (14.6)	7461 (15.4)	< 0.001
SUA (mmol/L)	255.87±57.58	256.43±57.78	256.47±57.40	260.28±57.99	259.99±58.22	264.21±60.38	269.96±61.87	272.26±62.79	275.29±63.43	277.48±64.32	< 0.001
Hyperuricemia, % (95% CI)	5.2 (4.9-5.6)	5.5 (5.2-5.8)	5.3 (5.0-5.6)	5.9 (5.6-6.3)	6.1 (5.8-6.4)	7.1 (6.8-7.4)	8.6 (8.3-8.9)	9.8 (9.5-10.1)	10.1 (9.8-10.4)	10.8 (10.5-11.0)	< 0.001

Data were shown as Mean ± SD or percentages. eGFR, estimated glomerular filtration rate; SUA, serum uric acid; CI, confidence interval.

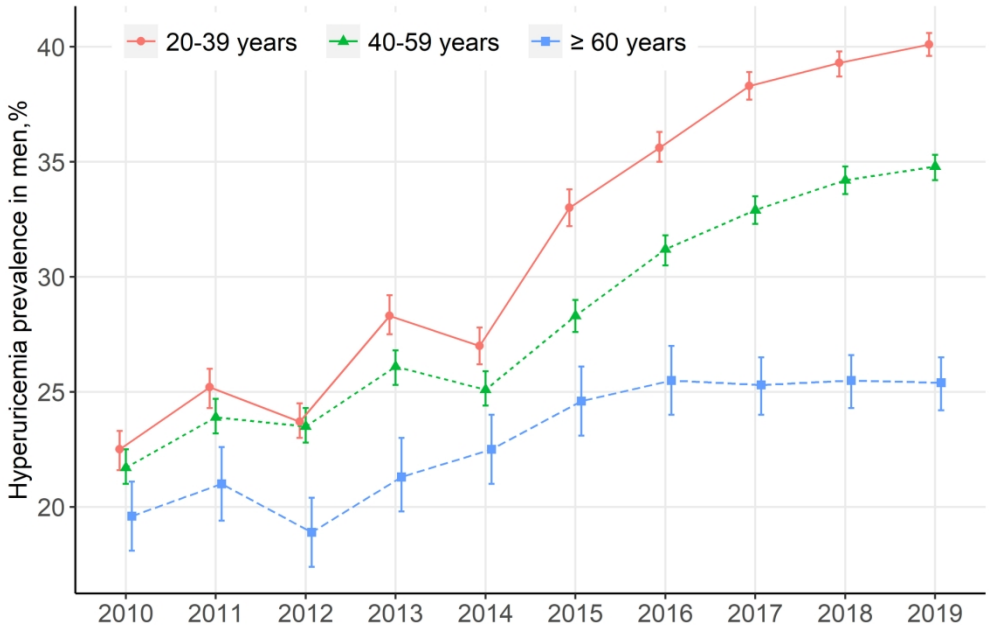


Figure 1. Age-specific trends in hyperuricemia prevalence (95% CI) among men, 2010-2019. CI, confidence interval.

170x114mm (300 x 300 DPI)

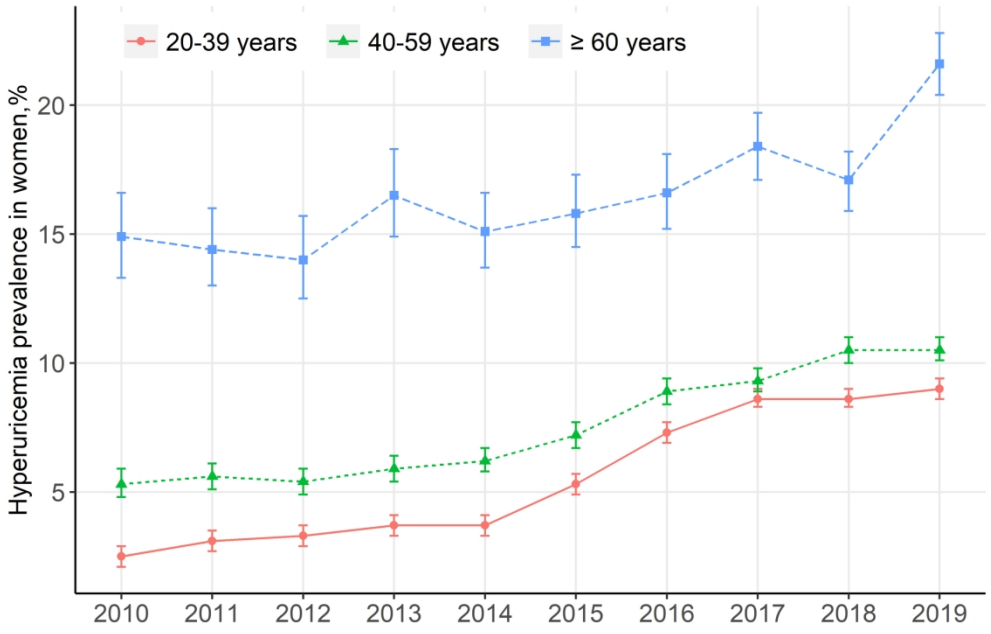


Figure 2. Age-specific trends in hyperuricemia prevalence (95% CI) among women, 2010-2019. CI, confidence interval.

170x114mm (300 x 300 DPI)

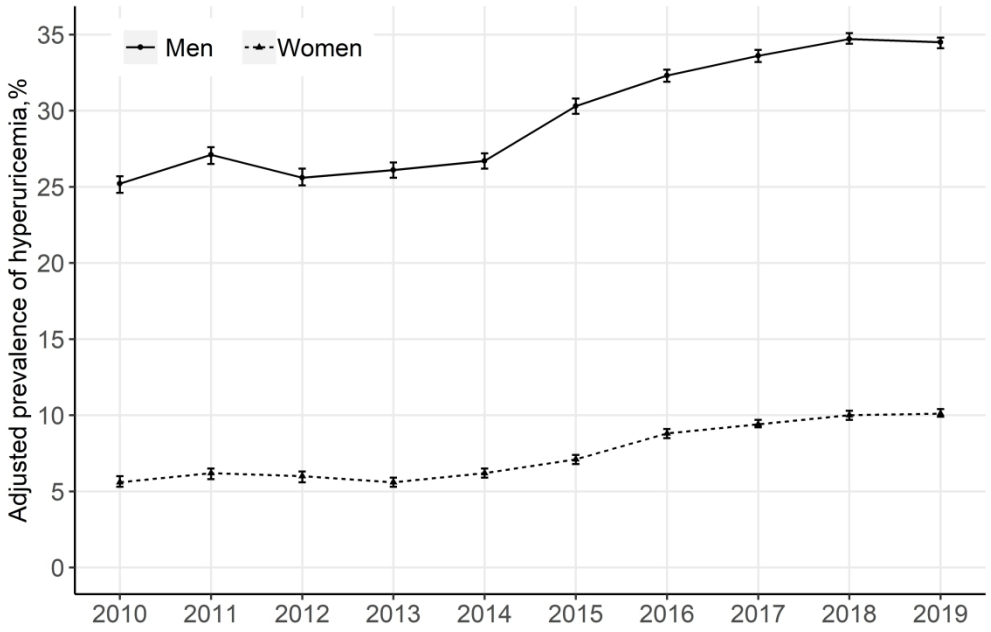
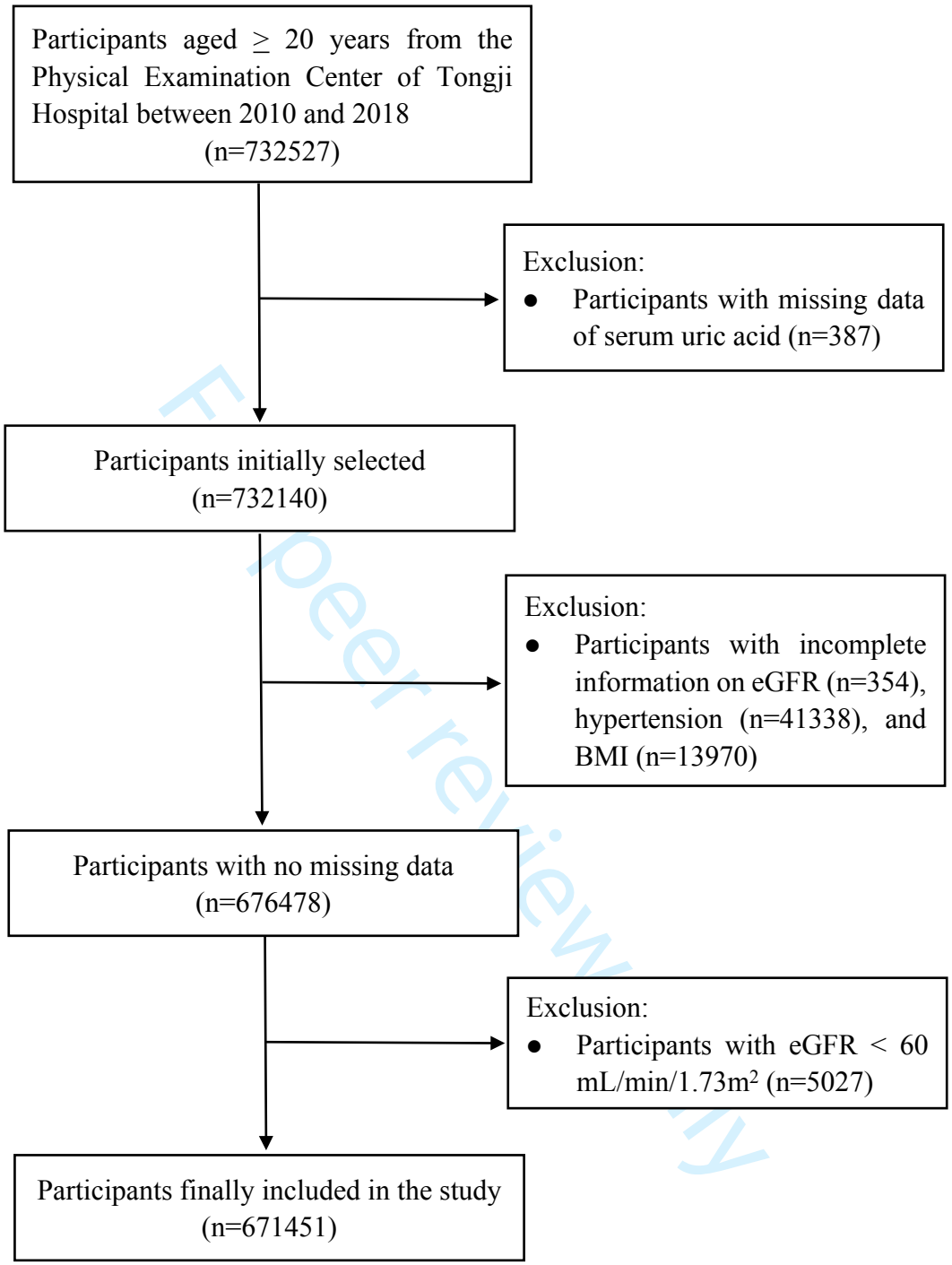


Figure 3. Sex-specific trends in multivariate-adjusted hyperuricemia prevalence (95% CI) among participants aged ≥ 20 years, 2010-2019. The prevalence was adjusted for age, BMI, eGFR, and Hypertension. CI, confidence interval; BMI, body mass index; eGFR, estimated glomerular filtration rate.

170x114mm (600 x 600 DPI)



Supplemental Figure 1. Flow chart for selection of the study participants.

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			4
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	#3	State specific objectives, including any prespecified hypotheses	5
Methods			6
Study design	#4	Present key elements of study design early in the paper	6

Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	6
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	7
Bias	#9	Describe any efforts to address potential sources of bias	3, 8
Study size	#10	Explain how the study size was arrived at	6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	7-8
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	7-8
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	7-8
Statistical methods	#12c	Explain how missing data were addressed	6
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
Statistical methods	#12e	Describe any sensitivity analyses	n/a
Results			9
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility,	9

		confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	
Participants	#13b	Give reasons for non-participation at each stage	6
Participants	#13c	Consider use of a flow diagram	6,supplemental Figure 1.
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9, Tabel 1-2
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	6,supplemental Figure 1.
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	9, Tabel 1-2
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10, Tabel 1-2, Figure 1-3
Main results	#16b	Report category boundaries when continuous variables were categorized	9-10
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	10, Figure 1-2
Discussion			
Key results	#18	Summarise key results with reference to study objectives	11
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14

Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	11-14
Generalisability	#21	Discuss the generalisability (external validity) of the study results	14
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

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Temporal trends in Hyperuricemia among Adults in Wuhan City, China from 2010-2019: a cross-sectional study

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Type of the Paper: Original research

Temporal trends in Hyperuricemia among Adults in Wuhan City, China from 2010-2019: a cross-sectional study

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Abstract

Objectives: Hyperuricemia is a risk factor for gout attacks, kidney damage and cardiovascular events. Evidence on the trends in hyperuricemia burden in Wuhan city, China was limited. The present study aimed to estimate the prevalence of and a decade trend in hyperuricemia in Wuhan city.

Design: Cross-sectional study.

Setting: Health management center of Tongji hospital.

Participants: A total of 732527 adult participants from the general population who took a physical examination in the health management center between 2010 and 2019.

Main outcome measures: Prevalence of and trends in hyperuricemia.

Results: The overall prevalence of hyperuricemia was 25.8% (36.6% in men and 10.8% in women) in 2019. The hyperuricemia prevalence and serum uric acid (SUA) levels were significantly higher in young men, old women, and participants with obesity, hypertension, diabetes, or dyslipidemia ($P < 0.05$). SUA levels among men and women gradually increased from 358.0 (313.0-407.0) mmol/L and 250.0 (217.0-288.0) mmol/L in 2010 to 388.0 (338.0-445.2) mmol/L and 270.0 (233.0-314.0) mmol/L in 2019, respectively, $P < 0.05$. From 2010 through 2019, hyperuricemia prevalence significantly increased in each age category and it increased most sharply among participants aged 20-39 years. The multivariate-adjusted prevalence among men was 26.1% (25.4% - 26.7%) in 2010, 30.9% (30.4% - 31.4%) in 2015, and 34.4% (34.1% - 34.8%) in 2019, while among women it was 5.8% (5.4% - 6.2%) in 2010, 7.2% (6.9% - 7.5%) in 2015, and 10.1% (9.9% - 10.3%) in 2019.

Conclusions: Hyperuricemia was highly prevalent among adults in Wuhan city. More attention should be paid to the increasing burden of hyperuricemia, especially for those at higher risks.

Key Words: Hyperuricemia, uric acid, epidemiology, temporal trend

Strengths and limitations of this study

- This study included a large sample size of participants (more than 730000 adults) from the general population, which made our findings more convincible.
- This study firstly estimated the prevalence of and trends in hyperuricemia over the recent decade (2010-2019) among adults in Wuhan city.
- The multivariate logistic model was used to correct selection biases and confounding biases as possible by adjusting for potential confounders.
- Since participants in the present study were recruited from a health management center, selection biases could not be avoided.

Introduction

Serum uric acid (SUA) is the final product of purine nucleotides metabolism. The overproduction of SUA, as well as its inefficient renal or gut excretion, can consequently lead to hyperuricemia. Hyperuricemia is generally recognized as the major contributor to the onset of gout.[1] Moreover, many studies have demonstrated a positive association of hyperuricemia or a high level of SUA with increased all-cause mortality and several chronic diseases such as chronic kidney disease, cardiovascular events, reduced pulmonary function, obesity, glucose metabolism, dyslipidemia, hypertension, and metabolic syndrome.[2-9] These diseases accounted for a large part of global deaths and disability-adjusted life-year losses,[10 11] resulting in a particular urgency to prevent and control hyperuricemia.

Previous studies have documented an increasing trend of hyperuricemia prevalence in the past few decades across the world, especially in western countries.[12-14] Additionally, hyperuricemia is reported to be more prevalent in developed countries than in developing countries.[15] The prevalence among US adults was substantial (20.2% in men and 20.0% in women) during 2015-2016.[16] In China, the prevalence estimated from national surveys were 8.4% in 2009-2010,[17] 13.0% in 2007-2011,[18] and 6.4% among the middle-aged and elderly in 2011-2012.[19] Besides, a meta-analysis of 38 studies from mainland China reported that the pooled prevalence of hyperuricemia among Chinese adults was 13.3% in 2000-2014.[20] Obviously, the data above were not able to clearly illustrate the trend of hyperuricemia prevalence among Chinese adults.

China is a large developing country with unbalanced economic development and

marked regional differences. Hyperuricemia prevalence among Chinese adults varied greatly by geographical regions, with a report of 18.6% in south China, 12.9% in east China, 13.9% in southwest China, 10.3% in northwest China, 10.1% in northeast China, and 13.2% in north China.[20] Noteworthily, evidence on hyperuricemia burden in central China was limited. Wuhan, the capital city of Hubei province in central China, was characterized by rapid economic growth and urbanization in the recent decade. Its gross domestic products (GDP) per capita increased from 50117 yuan in 2009 to 123831 yuan in 2017.[21 22] Studies from developing countries showed that a rapidly growing economy in the short term and subsequently changed lifestyles would increase the risk of several metabolic disorders.[23 24]

To date, few studies have investigated a decade trend in hyperuricemia burden in Wuhan city. Therefore, we performed a large cross-sectional study to estimate the sex-specific prevalence of and trends in hyperuricemia among the general adults from 2010 through 2019. This general population-based study used data collected from consecutive adults who underwent a health check-up in a health management center.

Methods

Study population

We conducted a cross-sectional study, of which consecutive participants who had a health check-up in the Health Management Center of Tongji Hospital in Wuhan city, China between January 1, 2010 and December 31, 2019 were included. All the participants came from the general population. Most of them were urban citizens working in government organizations or large enterprises. Each participant completed the basic items of the physical examination including demographic information collection, biochemical tests, and anthropometric measurements. Supplemental Figure 1 showed the procedures for selecting participants in the study. A total of 732527 participants aged ≥ 20 years were recruited. This age range was selected in accordance with several previous studies. [12 25] After excluding participants with missing data, we included 676478 participants. As reduced renal function may affect uric acid excretion, we further excluded 5027 participants who had an estimated glomerular filtration rate (eGFR) of less than 60 mL/min/1.73m^2. Finally, 671451 participants were included in the analyses. Due to the lack of information on ID card number, there existed some participants who underwent health check-ups for years during the study period.

We used the STROBE cross sectional reporting guidelines in the present study. [26] The study was conducted in accordance with the Declaration of Helsinki and it was approved by the ethics committee of Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology with a waiver of informed consent. The Institutional Review Board Approval Number was TJ-IRB20200513.

Assessment of main variables

Overnight fasting blood samples were collected to measure the biochemical variables. SUA concentrations were measured by the enzymatic colorimetry using an automated analyzer (Roche Cobas 8000, Basel, Switzerland) according to standard laboratory process of quality control. Additionally, the method of SUA measurement did not change during the whole study period and the laboratory quality assessment was reviewed. The intra-assay and inter-assay coefficients of variation were 4.25% and <5.7% at level 1 (210umol/L), <4.25% and <5.7% at level 2 (572umol/L). In the current study, hyperuricemia was defined according to SUA levels: men ≥ 416 mmol/L (7 mg/dL), women ≥ 357 mmol/L (6 mg/dL). [27 28] Participants were asked to wear light clothes and bare foot before their height and weight were measured. The body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. For Chinese adults, obesity was defined as BMI ≥ 28 Kg/m^2 and overweight was defined as BMI ≥ 24 Kg/m^2. [29] Blood pressure was measured by trained nurses using electronic sphygmomanometers (HBP-9020; OMRON, Dalian, China) in a seated position after participants had rested for at least 5 minutes. Hypertension was identified if any of the following criteria was satisfied: systolic blood pressure ≥ 140 mmHg, or diastolic blood pressure ≥ 90 mmHg, or use of antihypertensive medication, or self-reported physician diagnosis of hypertension. Diabetes was defined as fasting blood glucose ≥ 7.0 mmol/L, or use of antidiabetic medication, or self-reported physician diagnosis of diabetes. Dyslipidemia was diagnosed according to the 2016 Chinese Guideline for the Management of Dyslipidemia in Adults [30] if any of the following criteria was satisfied:

total cholesterol ≥ 6.22 mmol/L, triglyceride ≥ 2.26 mmol/L, LDL-C ≥ 4.14mmol/L, HDL-C < 1.04 mmol/L. Information on age and sex was provided by the participants.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research. Patients or the public were not invited to contribute to the writing or editing of this article for readability or accuracy.

Statistical analysis

Due to the marked difference in SUA levels between men and women, the sex-specific prevalence of and trends in hyperuricemia were estimated. Categorical variables were expressed in percentages, whereas continuous variables were reported as means ± standard deviation (SD) for normally distributed data or median (interquartile range) for skewed data. The normality of data is evaluated by Kolmogorov-Smirnov test. We used data collected in 2019 to estimate SUA levels, the hyperuricemia prevalence and their 95% confidence intervals (CIs), stratified by sex (male or female), age (20 - 29, 30 - 39, 40 - 49, 50 - 59, 60 - 69, or ≥ 70 years), BMI (< 24, 24 - 27.9, or ≥ 28 kg/m^2, the cut-off values of overweight and obesity for Asian), hypertension (yes or no), diabetes (yes or no), and dyslipidemia (yes or no). In this part, the prevalence of hyperuricemia was compared using the Cochran-Armitage test for trend. SUA levels were compared using Kruskal-Wallis test.

Sex- and age- specific trends in hyperuricemia from 2010 through 2019 were then

analyzed. We performed tests for trends by including the observation year as a continuous variable in a linear or logistic regression model. The sex-specific multivariate-adjusted prevalence of hyperuricemia from 2010 through 2019 were estimated using logistic regression models after adjustment for age, BMI, eGFR, hypertension, diabetes, and dyslipidemia. Age, BMI, and eGFR were included in the logistic model as continuous variables, whereas hypertension, diabetes, and dyslipidemia were included as dichotomous variables. The Stata commands used to estimate the adjusted hyperuricemia prevalence were "logit" and "margins" in this study. All statistical analyses were performed using Stata version 12.0 (Stata Corp LP, College Station, TX, USA). Graphs were drawn using R software (version 3.6.1) with an available package: ggplot2. Two-sided $P < 0.05$ was considered statistically significant.

Results

The crude prevalence of hyperuricemia in 2019

Table 1 showed crude prevalence of hyperuricemia and SUA levels in participants aged ≥ 20 years during the year 2019. A total of 66998 men and 48385 women in 2019 were included, with an average age of 42.0 ± 12.6 years. The overall hyperuricemia prevalence was 25.8%. The crude prevalence of hyperuricemia and SUA levels in men were significantly higher than those in women (36.6% versus 10.8%, 388.0 (338.0-445.2) mmol/L versus 270.0 (233.0-314.0) mmol/L; both $P < 0.05$). Hyperuricemia prevalence was around 9.0% in women aged < 50 years and it rapidly increased with advancing age in women aged ≥ 50 years, with the highest prevalence of 26.1% for women aged ≥ 70 years. The burden of hyperuricemia among men was high across all age groups and it was particularly marked in young men (39.3% for 20-29 years and 40.5% for 30-39 years). Hyperuricemia prevalence and l SUA levels dramatically increased with elevating BMI in both sexes ($P < 0.05$); the prevalence (95% CI) was 55.9% (55.0% - 56.9%) in obese men and 34.6% (32.8% - 36.5%) in obese women. In the whole population, participants with hypertension, diabetes, or dyslipidemia had significantly higher hyperuricemia prevalence and SUA levels than the normal groups ($P < 0.05$).

Trends in the crude prevalence of hyperuricemia

A total of 671451 participants were included in the study between 2010 and 2019. As shown in Table 2, the crude prevalence of hyperuricemia significantly increased over

the years in both men and women ($P < 0.05$). SUA levels among men and women gradually increased from 358.0 (313.0-407.0) mmol/L and 250.0 (217.0-288.0) mmol/L in 2010 to 388.0 (338.0-445.2) mmol/L and 270.0 (233.0-314.0) mmol/L in 2019, respectively ($P < 0.05$). A significantly increasing trend in hyperuricemia prevalence was observed during the observation period in each age category of both sexes (Figure 1). The prevalence increased most sharply among participants aged 20-39 years. It increased from 22.5% (21.6% - 23.3%) in 2010 to 40.1% (39.6% - 40.6%) in 2019 among young men, whereas among young women it increased from 2.5% (2.1% - 2.9%) in 2010 to 9.0% (8.6% - 9.4%) in 2019.

Trends in multivariate-adjusted prevalence of hyperuricemia

The multivariate-adjusted prevalence of hyperuricemia was calculated using logistic regression models. Figure 2 showed an increasing trend in multivariate-adjusted prevalence of hyperuricemia during the observation years in both sexes ($P < 0.05$). The prevalence among men was 26.1% (25.4% - 26.7%) in 2010, 30.9% (30.4% - 31.4%) in 2015, and 34.4% (34.1% - 34.8%) in 2019, while among women it was 5.8% (5.4% - 6.2%) in 2010, 7.2% (6.9% - 7.5%) in 2015, and 10.1% (9.9% - 10.3%) in 2019.

Discussion

The present study revealed that hyperuricemia was highly prevalent (36.6% in men and 10.8% in women) among adults in Wuhan city, China during 2019. The burden of hyperuricemia among men was substantial in all age groups. Hyperuricemia prevalence varied distinctly by sex, age, BMI, hypertension, diabetes, and dyslipidemia, with young men, old women, and participants with metabolic disorders having a significantly higher prevalence.

This study also investigated the trend of hyperuricemia over a decade period (from 2010 to 2019) and revealed a significantly increasing trend in multivariate-adjusted prevalence of hyperuricemia in both sexes. Moreover, it was observed that the prevalence increased most sharply among young adults during the observation period, which meant that hyperuricemia occurred more and more frequently in young adults.

The estimated prevalence in our study (25.8% in 2019) was much higher than those reported in America (20.1% in 2015-2016),[16] Italy (11.9% in 2009),[13] Korea (11.4% in 2016),[31] and a previous national survey in China (13.0% in 2007-2011).[18] A cross-sectional study from Bangkok, Thailand used data of the annual physical examination and reported a prevalence rate of 24.4% in urban residents,[32] which was close to our result. Epidemiological studies demonstrated that urban individuals had a higher prevalence of hyperuricemia than rural residents.[17 19] In the present study, almost all the participants included were urban citizens, which may help explain the high hyperuricemia prevalence.

Overweight or obesity was a well-accepted risk factor for hyperuricemia,[33] which

was validated in our study. We found that hyperuricemia prevalence increased significantly with elevating BMI in both sexes. Based on information in Table 1, it could be calculated that nearly 61.0% of men were overweight or obese and 44.5% of them were identified as hyperuricemia. The prevalence of overweight or obesity among men was reported to be 38.6% in a representative sample of Wuhan community residents aged 15-69 years.[34] Compared to this representative sample, the working population in the present study had markedly higher ratios of men, labor force, and overweight or obesity. The heavy burden of overweight or obesity may be another reason to explain the highly prevalent hyperuricemia. It was also observed that hyperuricemia was closely correlated with hypertension, diabetes, and dyslipidemia, which accorded with the previous studies. [6-9] These metabolic disorders were common comorbidities in participants with hyperuricemia, leading to higher risk of renal and cardiovascular diseases.

The present study found that hyperuricemia prevalence was higher among women aged ≥ 50 years and it further increased with advancing age. Several studies from Asian and European countries revealed a roughly positive association of hyperuricemia prevalence with age among women,[13 14 18 31] which accorded with our results. Given the huge sex difference in hyperuricemia prevalence, we thought that sex hormones may play a key role. One explanation was that female sex hormones had protective effects against hyperuricemia. A cross-sectional study of 58870 South Korean women demonstrated that hyperuricemia prevalence significantly increased with the menopausal stage, after controlling for potential confounders.[35] Postmenopausal

women are characterized by materially declined levels of female sex hormones (especially estradiol and progesterone). When they grow older, levels of estradiol and progesterone would decline further. The BioCycle study demonstrated that SUA levels were inversely associated with these two hormones.[36] Until now, how estradiol and progesterone lower SUA levels was not fully understood. They probably effect via promoting renal excretion of uric acid.[37 38] Another two explanations would be the higher prevalence of obesity and alcohol drinking in men than women, [34 39] as obesity and alcohol drinking are well-established risk factors for hyperuricemia.

Data from the National Health and Nutrition Examination Survey demonstrated that hyperuricemia prevalence among American adults significantly increased from 18.2% in 1988-1994 to 21.4% in 2007-2008 and concluded that the increasing trend of hyperuricemia was likely due to rising prevalence of obesity and hypertension.[12] However, in the present study, we did not observe an increasing trend in obesity and hypertension over the years (Table 2). Thus, it might be some other factors responsible for the increasing prevalence of hyperuricemia among our study participants. We thought that gradually westernized dietary structure and rising consumption of fructose-sweetened soft drinks might be the main causes. Western diets contained much more purine than the traditional Chinese diets, leading to a higher risk of developing hyperuricemia. In addition, accumulating evidence showed that fructose-sweetened drinks, although containing no purines, could induce hyperuricemia.[40-42] Fructose intake per capita has dramatically increased during the past few decades,[43-45] in parallel with the increasing burden of hyperuricemia. Alcohol consumption and several lifestyle

habits like inactivity and sedentary behaviors have been established as risk factors for hyperuricemia. There are no studies directly investigating the associations between these risk factors and the increasing trends in hyperuricemia prevalence. However, findings from the China Kadoorie Biobank reported a modest increase in alcohol consumption, drinking frequency and heavy episodic drinking prevalence among men in the past decade, particularly among the young men, [39] which may help explain our results.

To the best of our knowledge, the present study firstly revealed age-specific trends in hyperuricemia over a decade among Chinese adults and found that hyperuricemia prevalence increased most sharply among young adults during the observation period. A large analysis of 128014 Irish adults revealed an increasing trend in hyperuricemia from 2006 through 2014 across all age groups, with the most increment among young participants aged 18-39 years;[14] a finding that was similar to our result. In addition to hyperuricemia, several hyperuricemia-related diseases such as diabetes and cardiovascular events also occurred more frequently among young adults over the past years,[46 47] posing a serious threat to public health. Based on the trend revealed in our study, hyperuricemia prevalence was much likely to continue rising in the coming years. Policy-makers should pay more attention to the burden of hyperuricemia, especially among young adults.

The strengths of the present study were distinct. This study included a large sample size of participants (more than 730000 adults) from the general population, which made our findings more convincible. In addition, to the best of our knowledge, this was the

first study to investigate the trend in hyperuricemia prevalence over the recent decade (2010-2019) among adults in Wuhan city, contributing to the management of hyperuricemia in this area.

The study also had several limitations. First, as the participants in the present study were recruited from a health management center, selection biases could not be avoided. The participants may be not a representative sample of the general population in community. Therefore, it should take caution to interpret the findings of this study. In fact, as almost all the participants were urban citizens working in government organizations or enterprises across every district of Wuhan city, the study participants were more likely a sample of working populations than community residents. Additionally, we estimated the hyperuricemia prevalence after controlling several confounders (shown in Figure 2), which would help reduce the bias through statistical analyses. Second, hyperuricemia prevalence may be underestimated in our study. We diagnose hyperuricemia only according to SUA levels. However, participants with hyperuricemia might have normal SUA levels if they were undergoing SUA-lowering therapies. Third, our study did not collect data on diets and lifestyles that were related to hyperuricemia. Changes of these variables such as fructose intake over the years may help explain the trends in hyperuricemia. Forth, in the study population, there existed participants who underwent health check-ups more than once during the study period. Their multiple medical records were included in the analyses, which may finally influence the accuracy of our results. Fifth, the definition of hyperuricemia highlights the measurement of SUA on two different days under the normal purine diet. However,

SUA was measured only once in the present study, which would affect the screening rate of hyperuricemia.

Conclusions

In summary, a high burden of hyperuricemia was found among adults in Wuhan city. Moreover, hyperuricemia occurred more and more frequently in young adults. Our study also revealed a significant increasing trend in multivariate-adjusted prevalence of hyperuricemia among adults from 2010 through 2019. Promoting dietary change, weight loss and physical activity in community or workplace would be effective measures to prevent and control hyperuricemia. These measures should be taken urgently, especially among young adults, postmenopausal women, and participants with metabolic disorders, for they were at higher risks.

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Patient consent for publication Not required**.**

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Data availability statement Data are available upon reasonable request.

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Figure legends

Figure 1. Sex and age-specific trends in hyperuricemia prevalence (95% CI), 2010-2019. CI, confidence interval.

Figure 2. Sex-specific trends in multivariate-adjusted hyperuricemia prevalence (95% CI) among participants aged ≥ 20 years, 2010-2019. The prevalence was adjusted for age, BMI, eGFR, hypertension, diabetes, and dyslipidemia. CI, confidence interval; BMI, body mass index; eGFR, estimated glomerular filtration rate.

Supplemental Figure 1. Flow chart for selection of the study participants.

Table 1. Crude prevalence of hyperuricemia and levels of SUA in participants aged ≥ 20 years, 2019

Variables	The whole population			Men			Women		
	Cases/ participants	Hyperuricemia, Prevalence (95% CI)	SUA (mmol/L), Median (IQR)	Cases/ participants	Hyperuricemia, Prevalence (95% CI)	SUA (mmol/L), Median (IQR)	Cases/ participants	Hyperuricemia, Prevalence (95% CI)	SUA (mmol/L), Median (IQR)
In total	29713/115383	25.8 (25.5-26.0)	338.3 (274.0-407.3)	24511/66998	36.6 (36.2-36.9)	388.0 (338.0-445.2)	5202/48385	10.8 (10.5-11.0)	270.0 (233.0-314.0)
Age (years)									
20-29	5415/21416	25.3 (24.7-25.9)	335.0 (269.0-405.1)	4489/11413	39.3 (38.4-40.2)	394.8 (347.0-451.0)	926/10003	9.3 (8.7-9.8)	269.0 (234.0-310.0)
30-39	10086/36664	27.5 (27.1-28.0)	343.0 (273.1-415.1)	8757/21613	40.5 (39.9-41.2)	396.1 (346.0-455.0)	1329/15051	8.8 (8.4-9.3)	265.0 (229.6-306.8)
40-49	6589/26595	24.8 (24.3-25.3)	335.0 (268.0-406.0)	5672/15415	36.8 (36.0-37.6)	389.0 (338.0-445.5)	917/11180	8.2 (7.7-8.7)	262.3 (226.8-303.0)
50-59	5184/20423	25.4 (24.8-26.0)	341.0 (283.0-406.0)	4119/12744	32.3 (31.5-33.1)	378.0 (328.0-435.0)	1065/7679	13.9 (13.1-14.7)	280.1 (242.0-327.0)
60-69	1699/7453	22.8 (21.8-23.8)	330.5 (278.4-389.5)	1031/4119	25.0 (23.7-26.4)	363.3 (315.3-416.0)	668/3334	20.0 (18.7-21.4)	292.1 (249.0-342.3)
≥70	740/2832	26.1 (24.5-27.8)	340.8 (288.8-398.0)	443/1694	26.2 (24.1-28.3)	360.0 (312.0-419.9)	297/1138	26.1 (23.6-28.8)	306.5 (258.0-359.0)
BMI (Kg/m^2)									
<24	8718/61310	14.2 (13.9-14.5)	300.0 (249.0-363.0)	6309/26072	24.2 (23.7-24.7)	365.0 (320.0-414.0)	2409/35238	6.8 (6.6-7.1)	260.9 (227.0-300.7)
24-27.9	13899/40393	34.4 (33.9-34.9)	371.8 (312.5-432.8)	12013/29864	40.2 (39.7-40.8)	396.3 (346.9-452.0)	1886/10529	17.9 (17.2-18.7)	292.0 (252.0-338.1)
≥28	7096/13680	51.9 (51.0-52.7)	411.0 (349.6-475.4)	6189/11062	55.9 (55.0-56.9)	428.0 (374.0-489.0)	907/2618	34.6 (32.8-36.5)	327.7 (282.0-377.0)
Hypertension									
Yes	9616/26366	36.5 (35.9-37.1)	372.0 (310.0-439.0)	7991/18905	42.3 (41.6-43.0)	399.0 (345.0-461.0)	1625/7461	21.8 (20.8-22.7)	266.0 (230.6-307.6)
No	20097/89017	22.6 (22.3-22.9)	328.0 (265.0-396.9)	16520/48093	34.4 (33.9-34.8)	384.0 (335.1-439.0)	3577/40924	8.7 (8.5-9.0)	296.6 (252.0-348.8)
Diabetes									
Yes	1496/5339	28.0 (26.8-29.2)	348.0 (294.0-413.7)	1136/4047	28.1 (26.7-29.5)	361.4 (309.0-424.0)	360/1292	27.9 (25.4-30.4)	307.0 (255.0-363.0)
No	28217/110044	25.6 (25.4-25.9)	338.0 (273.0-407.0)	23375/62951	37.1 (36.8-37.5)	389.6 (340.0-446.6)	4842/47093	10.3 (10.0-10.6)	269.0 (232.8-312.5)
Dyslipidemia									
Yes	16294/37925	43.0 (42.5-43.5)	393.0 (334.0-456.0)	14503/30847	47.0 (46.5-47.6)	410.0 (357.3-469.0)	1791/7078	25.3 (24.3-26.3)	306.0 (263.0-357.0)
No	13419/77458	17.3 (17.1-17.6)	311.2 (256.0-376.0)	10008/36151	27.7 (27.2-28.1)	371.1 (325.0-422)	3411/41307	8.3 (8.0-8.5)	264.3 (229.8-306.0)

All *P* for tests < 0.001; SUA, serum uric acid; BMI, body mass index; CI, confidence interval; IQR, interquartile range.

Table 2. Sex- specific characteristics of participants aged ≥ 20 years, 2010-2019

Variables	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	*P* for trend
Men											
N	23535	24776	26574	27316	29416	32183	42222	51879	59921	66998	
Age (years)	43.80±13.03	43.35±12.67	42.83±12.72	42.87±12.43	43.39±12.73	43.19±12.40	41.71±12.24	42.01±12.53	42.34±12.44	42.34±12.49	< 0.001
eGFR (mL/min/1.73m²)	108.48±20.81	107.53±20.01	107.89±19.23	101.62±17.99	104.07±18.92	101.95±18.05	100.49±17.36	99.13±16.86	99.55±16.84	98.97±16.75	< 0.001
Obesity, n (%)	3346 (14.2)	3659 (14.8)	4156 (15.6)	4414 (16.2)	4523 (15.4)	4849 (15.1)	5855 (13.9)	7336 (14.2)	9561 (16.0)	11062 (16.5)	< 0.001
Hypertension, n (%)	7683 (32.6)	7982 (32.2)	8845 (33.3)	9138 (33.5)	9609 (32.7)	9699 (30.1)	11194 (26.5)	14455 (27.9)	15965 (26.6)	18905 (28.2)	< 0.001
Diabetes, n(%)	1426 (6.1)	1611 (6.5)	1567 (5.9)	1653 (6.1)	1876 (6.1)	2145 (6.7)	2602 (6.2)	3251 (6.4)	3718 (6.3)	4047 (6.0)	0.958
Dyslipidemia, n(%)	7265 (39.6)	9299 (40.2)	11116 (41.9)	13391 (49.0)	13713 (46.6)	12952 (40.3)	18497 (44.9)	22549 (43.5)	27350 (46.7)	30847 (46.0)	< 0.001
SUA (mmol/L)	358.0 (313.0-407.0)	362.0 (316.0-413.0)	360.0 (315.0-411.0)	367.9 (320.7-419.9)	365.2 (318.8-417.8)	373.9 (325.7-428.5)	380.0 (331.0-435.5)	388.0 (335.0-440.0)	386.0 (336.0-443.0)	388.0 (338.0-445.2)	< 0.001
Hyperuricemia, % (95% CI)	21.8 (21.2-22.3)	24.1 (23.6-24.7)	23.1 (22.6-23.7)	26.6 (26.1-27.1)	25.7 (25.2-26.2)	29.9 (29.4-30.4)	32.8 (32.4-33.3)	34.8 (34.4-35.2)	35.9 (35.5-36.3)	36.6 (36.2-37.0)	< 0.001
Women											
N	15759	19212	17867	19544	21643	26816	32552	40247	44606	48385	
Age (years)	42.94±13.44	42.43±13.01	42.10±12.95	41.64±12.88	42.37±13.20	41.42±12.90	39.95±12.65	40.79±12.76	41.15±12.66	41.52±12.62	< 0.001
eGFR (mL/min/1.73m²)	130.36±28.22	130.69±27.51	130.71±26.16	123.06±25.14	126.08±26.08	123.95±24.54	122.58±23.67	119.46±22.86	120.28±23.03	119.11±22.67	< 0.001
Obesity, n (%)	938 (6.0)	1041 (5.4)	1035 (5.8)	1156 (5.9)	1252 (5.8)	1439 (5.4)	1652 (5.1)	1949 (4.8)	2279 (5.1)	2618 (5.4)	< 0.001
Hypertension, n (%)	2974 (18.9)	3440 (17.9)	3196 (17.9)	3523 (18.0)	3841 (17.7)	4385 (16.4)	4697 (14.4)	6264 (15.6)	6524 (14.6)	7461 (15.4)	< 0.001
Diabetes, n(%)	501 (3.2)	556 (2.9)	487 (2.7)	500 (2.6)	643 (3.0)	773 (2.9)	830 (2.6)	1080 (2.7)	1157 (2.6)	1292 (2.7)	0.001
Dyslipidemia, n(%)	1719 (14.5)	2290 (13.7)	2573 (14.4)	3260 (16.7)	3361 (15.5)	3692 (13.8)	4523 (14.7)	5617 (14.1)	6319 (14.7)	7078 (14.6)	0.339
SUA (mmol/L)	250.0 (217.0-288.0)	251.0 (216.0-289.0)	250.0 (217.5-289.0)	253.7 (221.2-292.7)	253.7 (220.3-292.2)	257.7 (222.8-297.9)	263.0 (228.0-304.1)	265.2 (232.0-311.0)	268.0 (232.0-311.0)	270.0 (233.0-314.0)	< 0.001
Hyperuricemia, % (95% CI)	5.2 (4.9-5.6)	5.5 (5.2-5.8)	5.3 (5.0-5.6)	5.9 (5.6-6.3)	6.1 (5.8-6.4)	7.1 (6.8-7.4)	8.6 (8.3-8.9)	9.8 (9.5-10.1)	10.1 (9.8-10.4)	10.8 (10.5-11.0)	< 0.001

Data were shown as Mean ± SD, Median (IQR) or percentages. eGFR, estimated glomerular filtration rate; SUA, serum uric acid; CI, confidence interval.

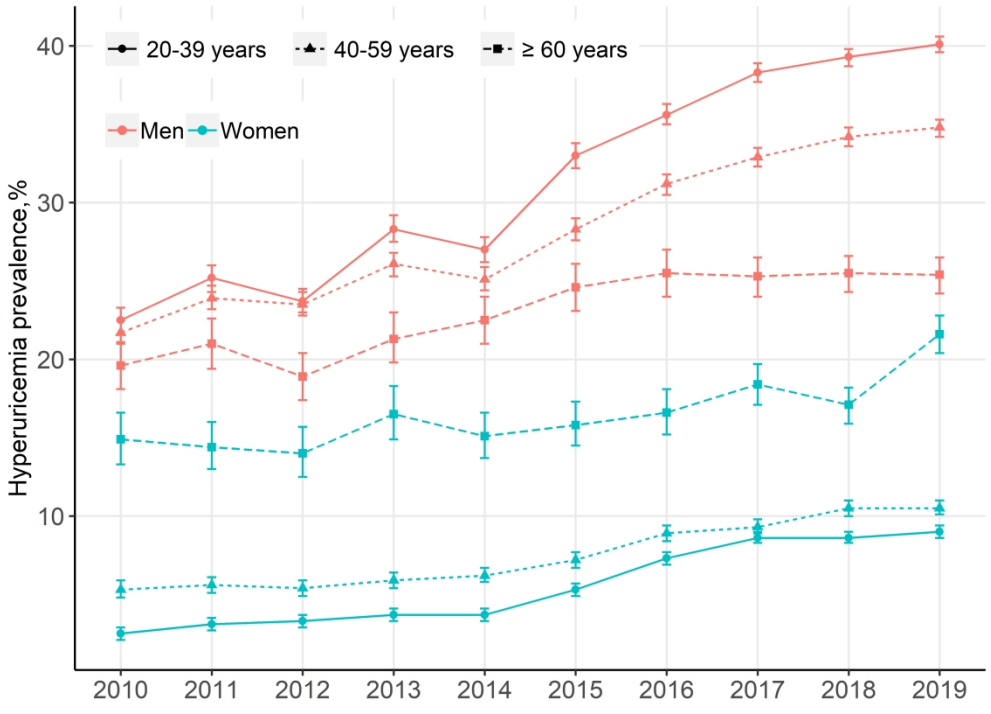

Figure 1. Sex and age-specific trends in hyperuricemia prevalence (95% CI), 2010-2019. CI, confidence interval.

170x127mm (600 x 600 DPI)

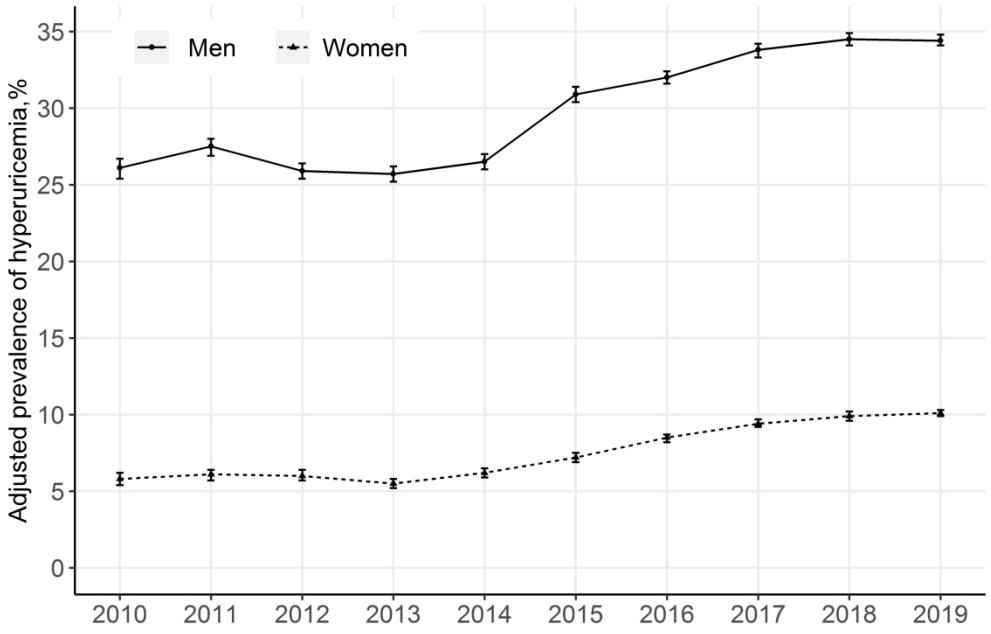

Figure 2. Sex-specific trends in multivariate-adjusted hyperuricemia prevalence (95% CI) among participants aged ≥ 20 years, 2010-2019. The prevalence was adjusted for age, BMI, eGFR, hypertension, diabetes, and dyslipidemia. CI, confidence interval; BMI, body mass index; eGFR, estimated glomerular filtration rate.

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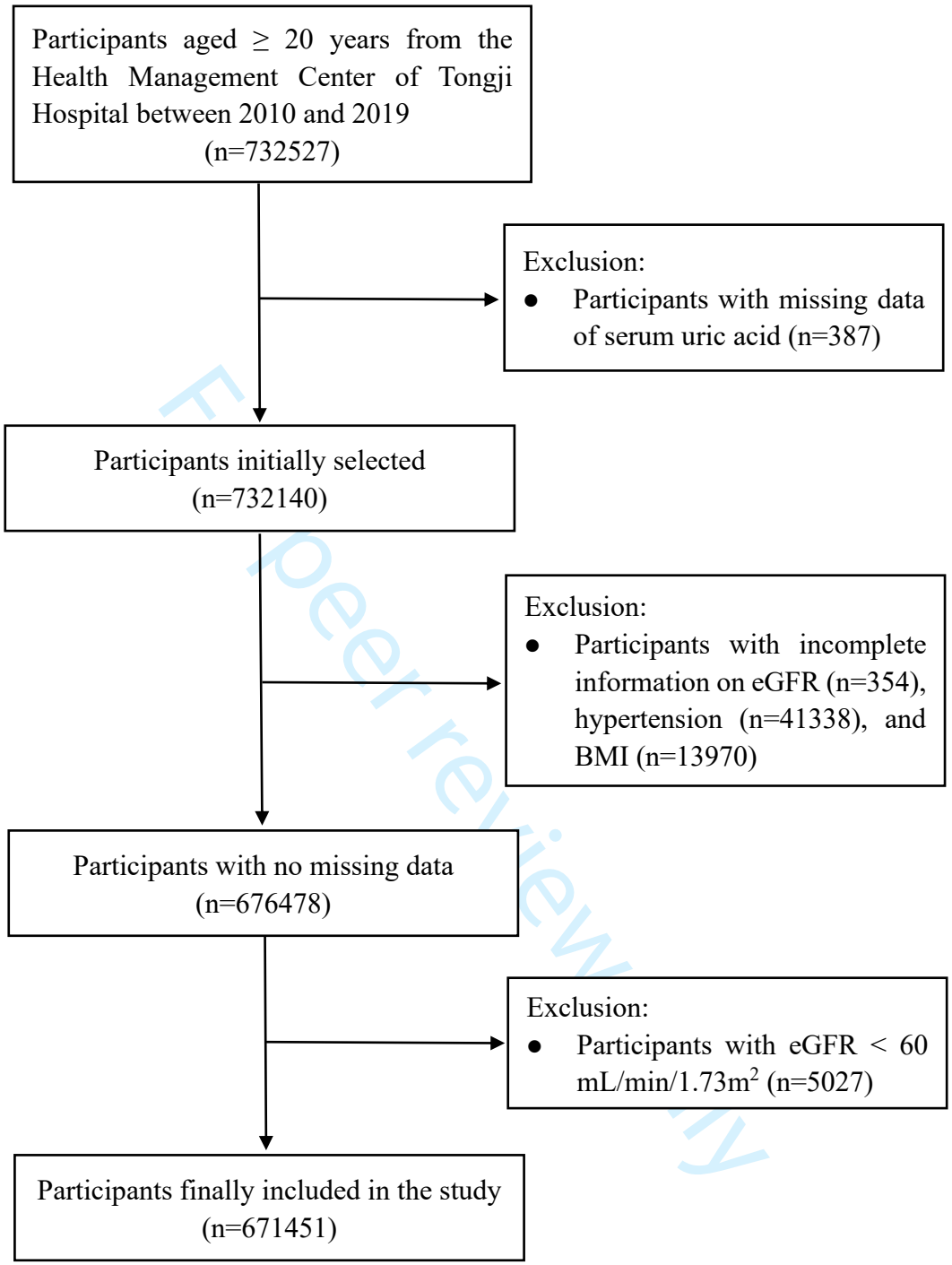

Supplemental Figure 1. Flow chart for selection of the study participants.

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 1 or 3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 3-4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 6
Methods			
Study design	4	Present key elements of study design early in the paper	Page 7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 8
Bias	9	Describe any efforts to address potential sources of bias	Page 7,10
Study size	10	Explain how the study size was arrived at	Page 7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 9-10
		(*b*) Describe any methods used to examine subgroups and interactions	Page 9-10
		(*c*) Explain how missing data were addressed	Page 7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page7, Supplemental Figure 1
		(b) Give reasons for non-participation at each stage	Page7, Supplemental Figure 1
		(c) Consider use of a flow diagram	Page7, Supplemental Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 11-12
		(b) Indicate number of participants with missing data for each variable of interest	Page7, Supplemental Figure 1
Outcome data	15*	Report numbers of outcome events or summary measures	Page 11-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 11-12
		(*b*) Report category boundaries when continuous variables were categorized	Page 11-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Page 11-12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 11-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.