Original Article

Status of Serum Uric Acid and Hyperuricemia among Adults in China: China Nutrition and Health Surveillance (2015)*

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Abstract

Objective The purpose of this study was to determine the serum uric acid levels and the prevalence of hyperuricemia among Chinese adults in 2015 and compare the differences between urban and rural areas, as well as the differences between eastern, central, and western regions.

Methods A national representative sample of 180,208 participants were included using a stratified, multistage, and random sampling method. The demographic characteristics and blood samples were collected to determine the serum uric acid levels and prevalence of hyperuricemia among subgroups using complicated sampling weight. A *t*-test or ANOVA was used for normally-distributed data. The Kruskal-Wallis rank test was used for skewed-distributed data. The Mantel-Haenszel chi-square test was used to compare the difference in categorical variables.

Results The weighted mean uric acid level in Chinese adults was 310.4 μmol/L (317.5 μmol/L in urban areas and 302.9 μmol/L in rural areas). The weighted average values of uric acid in eastern, central, and western China were 315.5 μmol/L, 303.5 μmol/L, and 310.4 μmol/L, respectively. The weighted prevalence of hyperuricemia in Chinese adults was 14.6%, with a prevalence of 16.5% in urban areas and 12.5% in rural areas. The weighted prevalence of hyperuricemia in eastern, central, and western China was 16.0%, 12.5%, and 14.8%, respectively.

Conclusion The uric acid level in Chinese adults is relatively high. Effective actions are warranted to improve this metabolic abnormality.

Key words: Uric acid; Hyperuricemia; Adults; China

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INTRODUCTION

Uric acid (UA) is the final product of purine metabolism in human beings[1]. Due to the lack of activated uricase, UA cannot be degraded to allantoin, a more soluble end-product that exists in lower animals[2]. UA is a poorly soluble substance in the human body. A high concentration of serum UA (SUA) could reach the physiologic limit of its solubility, which may further crystallize as monosodium urate (MSU) and thus cause urate crystal deposition[3]. Urate crystal deposition may lead to an acute inflammatory response, especially in the joints[4]. Hyperuricemia (HUA) is defined as an elevated UA level in the serum and has been recognized as a factor responsible for gout. In addition to gout, many studies have demonstrated that HUA is independently associated with cardiovascular diseases, cancer, hypertension, obesity, type 2

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diabetes mellitus, stroke, urate kidney stones, and trace element concentrations[5-11]. Beset by the consequences above, abnormal SUA status may affect longevity and well-being. To date, as a major cause of disability, HUA has received more attention due to its high prevalence globally as well as in China[12-16].

The results from the National Health and Nutrition Examination Survey (NHANES) suggested that approximately 21.4% of American adults have hyperuricemia[17]. Compared with developed countries, the prevalence of HUA in Asian countries is relatively lower[18,19]. Several previous studies have also investigated the prevalence of HUA in the Chinese population. A meta-analysis showed that the prevalence of hyperuricemia was 13.3% in mainland China between 2000 and 2014[4]. Another study in Beijing showed that the standardized prevalence in postmenopausal women was 9.7% in 2009, and the serum uric acid level was 300.17 μmol/L[20]. According to Yu et al.[18], the levels of SUA in a rural population of northeast China and was 333.7 μmol/L and 255.8 μmol/L in men and women, respectively. Most of the previous studies in China have been limited to only one specific region or focused on a specific population[20,21]. Even though some studies have focused on several provinces in China[22], the power of national and provincial representatives is still not strong enough. Moreover, with the growth of the economy, the SUA levels in the Chinese population were still elevated. Evidence from previous studies suggested that the escalations in SUA were significantly expanded over several decades, and the incidence of HUA was also concerning[4].

The China Nutrition and Health Surveillance (CNHS) was conducted in 2015[23], which aimed to assess nutrition and health status in China, including SUA and HUA. We conducted the current study by using data from a national representative data to describe the characteristics of SUA levels and HUA prevalence among Chinese adults.

METHODS

Data Source and Sampling Method

Data for our study were collected from CNHS (2015). The survey was conducted at 302 survey sites, which were selected based on the systematic monitoring sites of 605 disease surveillance sites from 31 provincial-level administrative divisions (PLADs), including provinces, autonomous regions, and municipalities directly under the central government throughout the mainland of China. The participants were selected using a stratified, multistage, and random sampling method. The study protocol was approved by the Ethical Review Committee of the Chinese Center for Disease Control and Prevention (CCDC [No. 201519-B]). Written informed consent was obtained from all participants.

Data Collection

The participants of this study were Chinese adults ≥ 18 years of age. The demographic characteristics were collected using standard questionnaires designed by the CCDC project team. Face-to-face interviews were conducted in households or at fixed local sites. Urban and rural areas were distinguished according to region codes (100- for urban and 200- for rural), as prescribed by the National Bureau of Statistics. Geographic regions (eastern, central, and western) were defined by the National Bureau of Statistics. Eastern China areas included Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan. Central China areas included Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan. Western China areas included Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. Participants were classified into the following 5 age groups: 18–29 years; 30–39 years; 40–49 years; 50–59 years; and > 60 years. According to the annual household income, participants were divided into 3 groups: low (< 50,000 CNY); middle (50,000–100,000 CNY); and high (> 100,000 CNY). Education level was categorized as low (primary school and below), moderate (junior school), and high (high school and above).

Overnight fasting cubital venous blood samples were collected in blood collection tubes (SSTTM II Advance; Becton, Dickinson and Company, Franklin Lakes, NJ, USA). After collection, the blood samples were permitted to clot for at least 30 min. Sera were separated from the whole blood samples by centrifugation at 3,000 rpm for 15 min at the worksite, then stored at –80 °C until analyzed in the laboratory. SUA levels were measured using the uricase HMMPS method on a Roche analyzer (Cobas 8000-c702; Roche Diagnostics, Switzerland) and expressed as mmol/L. According to the consensus of Chinese experts on the treatment of hyperuricemia and gout, hyperuricemia was defined as a SUA level > 420 μmol/L for males and > 360 μmol/L for females.

Quality Control

All of the face-to-face interviews and laboratory measurements were conducted under strict quality control. The investigators were trained and passed a qualification assessment by the China CDC project team. The questionnaires were administered by qualified investigators, then checked and verified by inspectors. The blood samples were measured in the designated laboratories using a standard protocol according to the manufacturer's instructions and reference samples. Participants with incomplete data were excluded from this study.

Data Analysis

Descriptive statistics were performed on all variables and all calculations in our study were weighted. The continuous variables are described using mean values and standard errors, and percentiles (P25, median, and P75). The prevalence of HUA was presented as ratios and 95% confidence intervals. A *t*-test or one-way analysis of variance (ANOVA) was used to compare the differences between or among groups for normally-distributed data. The Kruskal-Wallis rank test was used for skewed-distributed data. The Mantel-Haenszel chi-square test was used to compare the difference for categorical variables. SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA) was used for all statistical analyses. All statistical tests were two-sided. A *P*-value < 0.05 was considered statistically significant.

RESULTS

The characteristics of the included participants are described in Table 1. A total of 180,208 participants from CNHS (2015) were included in this study, with 84,449 (46.9%) males and 95,759 (53.1%) females. Among the participants, 73,818 lived in an urban area and 106,390 participants lived in a rural area. The number of participants from eastern, central, and western China was similar. Approximately one-third of the participants were ≥ 60 years of age. The majority of households (72.9%) sampled had an annual income > 100,000 CNY. Approximately 50% of the participants were in the low education group.

Table 2 shows the overall status of SUA levels in the different subgroups. The national SUA level of China in 2015 was 310.4 μmol/L. The levels of SUA in males were higher than females. Participants living in urban areas had slightly higher levels of SUV than participants living in rural areas. When considering the regional differences, the SUA levels of participants in central China were the lowest. Moreover, the highest SUA levels were observed in participants 18–29 years of age and in the highest education group. In addition, the SUA level increased as the household annual income increased.

Table 3 compares the differences in SUA levels between urban and rural participants. The mean and median levels of SUA in each subgroup were all significantly higher in the urban population than the rural population, with the exception of the high education group. The trends in SUA levels in each urban and rural subgroup were also consistent. Table 4 presents the status of SUA levels among the three regions. Significant differences in SUA levels were observed in all subgroups among the eastern,

Table 1. Demographic characteristics of the participants

Characteristics	*N*	%
National	180,208	100.0
Gender		
Male	84,449	46.9
Female	95,759	53.1
Residence		
Urban	73,818	41.0
Rural	106,390	59.0
Area		
East	67,732	37.6
Central	51,978	28.8
West	60,498	33.6
Age (years)		
18–29	15,580	8.7
30–39	21,541	12.0
40–49	39,850	22.1
50–59	44,137	24.5
60–	59,100	32.8
Household Income		
Low	13,264	7.4
Middle	35,605	19.8
High	131,339	72.9
Education		
Low	88,034	48.9
Moderate	55,293	30.7
High	36,881	20.5

Table 2. The levels of SUA in Chinese adults in 2015 (μmol/L)

Characteristics	Mean	SE	P25	P50	P75	*P*
National	310.4	2.0	246.5	299.9	364.3	
Gender						
Male	351.8	2.4	291.9	344.3	404.2	< 0.0001
Female	268.4	1.6	220.8	260.0	307.0	
Residence						
Urban	317.5	2.9	251.9	306.5	373.0	< 0.0001
Rural	302.9	2.1	240.8	292.6	353.9	
Region						
East	315.5	3.7	250.0	305.0	370.8	< 0.0001
Central	303.5	2.3	241.7	292.5	354.1	
West	310.4	2.7	246.0	300.8	363.5	
Age (years)						
18–29	319.2	2.7	252.0	308.3	376.4	< 0.0001
30–39	309.5	1.9	243.0	298.9	365.8	
40–49	304.2	2.5	239.6	293.0	357.7	
50–59	306.3	1.8	246.1	295.9	356.0	
60–	311.0	1.9	250.6	301.2	360.2	
Household Income						
Low	306.3	1.7	243.0	296.2	358.9	< 0.0001
Middle	316.8	3.0	250.8	305.9	371.7	
High	322.4	2.8	257.2	312.9	377.8	
Education						
Low	298.1	1.9	236.9	286.9	348.3	< 0.0001
Moderate	311.2	1.8	247.1	301.9	364.4	
High	323.2	2.6	257.4	312.5	380.0	

Table 3. The levels of SUA in city and rural in 2015 (μmol/L)

Characteristics	Urban					Rural					*P*
	Mean	SE	P25	P50	P75	Mean	SE	P25	P50	P75	
Gender											
Male	361.3	3.5	301.3	355.2	413.2	341.6	2.4	283.0	333.1	391.5	< 0.0001
Female	272.6	2.3	225.9	264.1	310.1	264.1	1.8	215.9	255.2	303.7	< 0.0001
Age (years)											
18–29	323.4	4.1	253.1	311.6	383.1	314.0	2.7	250.7	305.2	367.7	0.0046
30–39	316.0	2.5	249.0	304.9	373.9	301.2	2.2	237.9	292.0	353.9	< 0.0001
40–49	312.9	3.9	246.2	302.9	369.0	295.1	2.3	232.0	284.1	345.0	< 0.0001
50–59	314.3	2.5	253.2	304.7	365.6	298.9	2.2	240.3	288.6	346.5	< 0.0001
60–	319.4	2.5	259.8	309.9	368.9	304.3	2.6	244.1	294.2	353.0	< 0.0001
Household Income											
Low	314.0	2.5	249.0	303.8	368.5	300.6	2.1	239.0	290.5	351.4	< 0.0001
Middle	320.8	3.9	253.8	309.1	377.9	308.4	2.4	246.0	297.2	357.5	< 0.0001
High	323.4	3.6	260.1	313.2	379.8	319.6	3.5	252.4	311.9	372.0	< 0.0001
Education											
Low	304.9	3.0	243.0	294.0	357.2	294.7	2.3	234.0	283.9	343.9	< 0.0001
Moderate	316.1	2.6	250.1	305.7	370.7	307.0	2.4	244.5	298.8	358.3	< 0.0001
High	324.4	3.3	257.9	313.7	382.0	319.2	2.8	255.9	309.9	371.3	0.7826

central, and western China regions. The SUA levels in the central China region were lower than the other regions, and this trend was detected in each subgroup.

Table 5 shows the prevalence of HUA in Chinese adults during 2015. The overall prevalence of HUA was 14.6%. The gender-specific prevalence of HUA was 19.5% in males and 9.6% in females. The lowest prevalence of HUA was observed in the central China region (12.5%). The highest prevalence of HUA was observed in participants 18–29 years of age (16.9%), followed by participants ≥ 60 years of age (15.2%). In the high-income family group, the prevalence of HUA was 17.4%, which was the highest among all family income groups. The high education group had a higher HUA prevalence; the trends were consistent with the SUA levels.

In the comparison between urban and rural areas shown in Table 6, significant differences in the prevalence of HUA were observed in gender, age, and household income subgroups; however, there were no statistically significant differences in the prevalence of HUA between urban and rural women, the 18–29-year age group, and the high household income subgroup. Furthermore, we also compared the differences in prevalence of HUA among the eastern, central, and western regions of China (Table 7). Among the three regions, no significant differences in HUA prevalence were observed in the female subgroups. Although there were significant differences in SUA levels across age groups, the significant differences in HUA prevalence among age groups disappeared with increasing age. Interestingly, in the 18–29-year age group, the highest prevalence of HUA (19.03%) occurred in the western China region, while in the 30–39-year age group, the highest prevalence of HUA was observed in the eastern China region. Among the eastern, central, and western China regions, only the low-income family group showed significant differences, and the prevalence of HUA in the eastern China region of this subgroup was 14.9%. There was a significant difference in the prevalence of HUA between the low- and intermediate-level groups; however, no significant difference existed in the higher education subgroup.

DISCUSSION

Based on the CNHS cross-section study (2015), we determined the SUA levels and the prevalence of HUA in representative Chinese adults. We found

Table 4. The levels of SUA in east, middle, and west regions in 2015 (μmol/L)

Characteristics	East					Central					West					*P*
	Mean	SE	P25	P50	P75	Mean	SE	P25	P50	P75	Mean	SE	P25	P50	P75	
Gender																
Male	358.8	4.5	298.4	352.5	411.5	343.4	2.9	285.2	335.0	393.9	350.3	3.0	290.5	342.1	402.9	< 0.0001
Female	271.5	2.7	224.7	262.8	310.9	263.8	2.1	217.0	256.2	301.6	268.9	2.7	220.3	260.3	308.9	< 0.0001
Age (years)																
18–29	325.2	4.6	255.7	314.2	385.8	309.3	3.5	245.7	298.1	360.0	320.6	4.0	251.1	311.6	379.5	< 0.0001
30–39	314.9	3.4	246.2	304.9	370.0	302.4	2.5	239.1	290.9	357.6	309.3	2.7	244.0	301.0	365.0	< 0.0001
40–49	310.0	5.1	243.0	299.0	367.3	297.2	2.6	233.9	285.6	346.8	303.6	2.8	240.2	293.6	354.0	< 0.0001
50–59	309.6	3.3	249.1	299.9	361.0	302.3	2.6	243.4	291.4	350.4	305.7	2.7	245.3	295.4	354.0	< 0.0001
60–	314.5	3.6	253.5	305.0	366.5	306.6	3.0	247.5	297.0	353.4	310.7	3.0	250.0	300.9	360.1	< 0.0001
Household Income																
Low	310.1	3.4	245.4	299.4	364.8	300.4	2.3	239.4	290.0	349.7	308.0	2.8	244.6	299.0	361.2	< 0.0001
Middle	321.7	5.0	253.4	311.0	378.7	308.3	3.2	246.0	296.1	361.3	317.8	3.2	252.0	306.6	370.4	< 0.0001
High	324.1	3.9	260.7	316.5	379.9	317.8	3.5	255.2	307.0	370.6	321.6	5.7	251.0	310.3	377.0	< 0.0001
Education																
Low	301.8	3.9	239.1	291.0	355.0	292.2	2.4	233.2	281.4	338.5	299.9	2.9	239.0	288.9	350.6	< 0.0001
Moderate	314.6	3.3	249.0	304.0	369.1	305.1	2.4	243.6	295.8	355.0	313.8	3.0	250.0	305.5	366.7	< 0.0001
High	326.3	4.4	259.2	316.9	384.9	315.8	3.2	253.9	304.4	370.9	325.9	3.4	257.9	316.0	381.4	< 0.0001

Table 5. The prevalence of HUA in Chinese adults in 2015*

Characteristics	*N*	%	95% *CI*	χ^2	*P*
National	24,524	14.6	13.4–15.8		
Gender					
Male	14,705	19.5	17.9–21.1	577.2078	< 0.0001
Female	9,819	9.6	8.7–10.5		
Residence					
Urban	11,300	16.5	14.6–18.4	17.6736	< 0.0001
Rural	13,224	12.5	11.5–13.6		
Region					
East	10,426	16.0	13.7–18.3	8.9343	0.0115
Central	6,262	12.5	11.2–13.8		
West	7,836	14.8	13.2–16.4		
Age (years)					
18–29	2,404	16.9	15.1–18.6	46.1217	< 0.0001
30–39	2,770	14.1	12.9–15.3		
40–49	4,568	13.2	11.4–15.1		
50–59	5,643	13.0	12.0–14.0		
60–	9,139	15.2	14.1–16.3		
Household Income					
Low	2,171	13.6	12.6–14.6	48.9419	< 0.0001
Middle	5,378	16.2	14.4–18.0		
High	16,975	17.4	15.5–19.2		
Education					
Low	11,439	12.7	11.7–13.7	102.7242	< 0.0001
Moderate	7,421	14.2	12.9–15.5		
High	5,664	17.1	15.5–18.7		

Note. *The prevalence of HUA was weighted.

Table 6. The prevalence of HUA in city and rural in 2015*

Characteristics	Urban		Rural		χ^2	*P*
	%	95% *CI*	%	95% *CI*		
Gender						
Male	22.5	20.0–24.9	16.3	14.9–17.6	27.4594	< 0.0001
Female	10.4	8.9–11.9	8.8	7.9–9.7	3.6450	0.0562
Age (years)						
18–29	17.7	15.0–20.4	15.8	14.0–17.6	1.4492	0.2287
30–39	16.2	14.7–17.8	11.3	10.2–12.4	41.3067	< 0.0001
40–49	15.7	12.5–18.9	10.7	9.5–11.9	12.1952	0.0005
50–59	15.0	13.5–16.6	11.2	10.0–12.3	18.4398	< 0.0001
60–	17.5	15.9–19.1	13.3	11.9–14.7	15.3478	< 0.0001
Household Income						
Low	15.7	13.9–17.5	12.1	11.0–13.1	0.1971	0.0002
Middle	17.4	15.0–19.8	13.5	12.1–14.9	10.5816	0.0011
High	17.6	15.3–19.8	16.8	14.2–19.4	13.5363	0.6571
Education						
Low	14.3	12.3–16.3	11.9	10.8–13.0	4.8211	0.0281
Moderate	16.2	14.0–18.5	12.5	11.2–13.7	10.3297	0.0013
High	17.8	15.9–19.7	14.9	13.0–16.7	5.1428	0.0233

Note. *The prevalence of HUA was weighted.

differences in the SUA levels and HUA prevalence between urban and rural areas, and among different geographic regions. Indeed, this is the largest cross-sectional study investigating the SUA status in China. Although some previous studies[4,20-21] were conducted in Chinese populations, the results were limited by the relatively small sample sizes, limited areas, or specific populations. Due to these limitations, previous studies did not specifically describe the complete picture of SUA levels and HUA prevalence in China. In our study we focused on significant differences in SUA levels and HUA prevalence between urban and rural areas or among different geographic regions.

High SUA levels may lead to HUA and result in gout or other related diseases, such as metabolic syndrome or cardiovascular disease[19,24]. In this study the overall level of SUA was 310.4 μmol/L (351.8 μmol/L in males and 268.4 μmol/L in females), which was significantly higher than the domestic findings reported by Song et al.[12] (the overall SUA level was 271.9 μmol/L) and Huang et al.[21] (the overall SUA level was 289.8 μmol/L), which was also higher than the SUA levels in neighboring countries; specifically, the overall SUA level in the Korean population was 303.5 μmol/L[18] and 294.0 μmol/L in Bangladeshi adults[25]. In agreement with previous studies, the SUA levels in urban participants were higher than rural participants[26]. In our study the SUA levels in urban and rural areas were 317.5 μmol/L and 302.9 μmol/L, respectively, which were higher than the SUA levels reported by Yang et al.[27], but the trends in both studies were consistent. The overall prevalence of HUA in our study was 14.6% (19.5% in males and 9.6% in females), which was consistent with the findings of Liu et al.[4], and higher than the results of Maloberti et al.[27]. Data from the China National Survey of Chronic Kidney Disease in 2009–2010 and the China Health and Retirement Longitudinal Study in 2011 showed that the prevalence of HUA among Chinese adults was 8.4%[26] and 6.4%[12], respectively. Differences in the prevalence of HUA may be due to different socioeconomic characteristics and age groups of the participants. Of note, the prevalence of HUA in Chinese males was 19.5%, which was similar to the results of the NHANES 2007–2008[17]. Previous studies in different populations and countries have also shown that the male population had a higher SUA level and prevalence of HUA than

Table 7. The prevalence of HUA in east, middle, and west regions in 2015*

Characteristics	East		Central		West		χ^2	*P*
	%	95% *CI*	%	95% *CI*	%	95% *CI*		
Gender								
Male	21.4	18.5–24.4	16.8	14.8–18.8	19.5	17.5–21.6	8.6436	0.0133
Female	10.5	8.7–12.2	8.3	7.3–9.2	9.9	8.4–11.3	5.7156	0.0574
Age (years)								
18–29	17.9	15.0–20.8	13.5	11.3–15.7	19.0	16.1–22.0	8.8743	0.0118
30–39	15.8	13.9–17.7	12.2	10.3–14.2	13.6	11.9–15.3	8.3471	0.0154
40–49	15.3	11.2–19.3	11.3	9.7–12.8	12.5	11.0–14.0	5.9851	0.0502
50–59	13.9	12.1–15.7	12.0	10.5–13.4	12.9	11.2–14.5	3.0044	0.2226
60–	16.3	14.3–18.4	13.7	11.9–15.4	15.2	13.4–17.0	4.4096	0.1103
Household Income								
Low	14.9	12.7–17.1	11.7	10.5–12.9	14.1	12.5–15.7	8.1885	0.0167
Middle	17.3	14.3–20.3	14.0	11.7–16.3	16.7	14.8–18.7	4.6098	0.0998
High	17.6	15.0–20.1	15.9	13.3–18.5	18.8	14.8–22.8	1.3901	0.4990
Education								
Low	14.1	11.8–16.3	11.2	10.0–12.3	12.7	11.2–14.2	6.0618	0.0483
Moderate	15.6	13.0–18.1	12.1	10.6–13.5	14.8	13.0–16.6	7.4313	0.0243
High	17.8	15.2–20.3	14.7	12.6–16.9	18.8	16.4–21.2	5.3781	0.0679

Note. *The prevalence of HUA was weighted.

the female population[28,29]. These gender differences could be explained by the influence of sex hormones[29,30].

Because the SUA level or HUA prevalence fluctuated with age, a "U-shaped" curve was observed, which was consistent with previous studies[17,31]. The SUA levels and HUA prevalence were highest in the 18–29-year age group and lowest in the 40–49-year age group. The potential biological mechanism underlying the differences among age groups might be due to fluctuation in estrogen levels. A study conducted in post-menopausal women in Beijing showed that the SUA levels and HUA prevalence increased significantly as age increased[20]. Similar results were also observed in the western China population; the SUA level increased in postmenopausal women[32,33]. It was concluded from previous studies that the uricosuric effect of estrogen is significantly associated with the prevalence of HUA, which may be partly responsible for the age-related differences[31,34]. It should be noted that although the differences in SUA levels were observed in each age group among the eastern, central, and western China regions, the discrepancies in HUA prevalence were not present in the elderly age groups. There was no significant difference in the 18–29-year age group with the highest HUA prevalence between urban and rural participants. Our findings suggested that the high prevalence of HUA in the 18–29-year age group is a serious issue that needs more attention.

Lifestyle changes are the result of an interaction between household income and education[35]. Our findings suggested that SUA levels and HUA prevalence increased as the household income increased. A similar trend was observed in the education group. A previous study suggested that people in economically-developed regions, such as urban or eastern China regions, tend to have unhealthy lifestyles habits[36]. Among unhealthy lifestyle habits, dietary habits are among the most important. In developing country, adults with higher household incomes are at a higher risk for chronic disease, partly due to earlier westernization of their lifestyles and eating habits, as well as in China[37,38]. There was no significant difference in SUA levels between urban and rural participants in the high education group. With respect to the HUA prevalence, no significant difference was observed between urban and rural participants in the high household income subgroup. And among eastern, central, and western China regions, the negative results were detected in moderate and high household income subgroups, and the high education subgroup as well. A previous study considered that the better health services available in eastern China could provide more health education to the residents that might affect the prevalence of HUA[22]; however, this viewpoint was not corroborated in our study. In general, higher education corresponds to higher income. In China, a higher income with lifestyle changes might lead to excessive intake of animal foods with a high purine content, alcohol consumption, and longer sedentary time, all of which might increase the SUA level and the risk of HUA[39]. It was noted that the differences in SUA level and HUA prevalence did not exist in higher household income and education subgroups between urban and rural or among eastern, central, and western China regions. This finding suggested that compared with the geographic regions, economics might have a more potent effect on SUA conditions.

Although some demographics were analyzed preliminarily, other risk factors for a higher SUA level or HUA prevalence should be further investigated. Diuretics, as one of the basic medications in the treatment of hypertension, are recommended in older populations, and the effect on increasing SUA was also confirmed[40]. The functions of genetic loci (SLC2A9 and ABCG2) were shown to have an effect on UA metabolism in humans, and the single nucleotide polymorphisms (SNPs) are associated with SUA levels in Chinese population[41]. These findings should be conducted in further factor analyses.

Two limitations in this study should be acknowledged. First, this study only focused on the different levels of SUA and the prevalence of HUA in urban and rural, and geographic regions in China; the potential influencing factors need to be further investigated. Second, the geographic divisions in our study might be rough, and our findings may not describe some specific areas, such as ethnic minority areas. Despite these limitations, the overall pictures of SUA levels and HUA prevalence in the Chinese population could enable us to understand the relative health status of Chinese adults in 2015.

CONCLUSIONS

Overall, the SUA levels and HUA prevalence are higher in urban and eastern China areas. More attention should focus on the male groups with a high household income living in urban and eastern China areas. Health education could be one of the

effective measures to ameliorate the high HUA prevalence *via* lifestyle changes. Our findings provide up-to-date information on SUA levels and prevalence of HUA in Chinese adults and demonstrate the distributions of SUA and HUA prevalence in different regions of China.

AUTHOR'S CONTRIBUTIONS

The authors' contributions are as follows: PIAO Wei and YU Dong Mei conceived and designed the study; YU Dong Mei, PIAO Wei, and ZHAO Li Yun conducted the research and collected and supervised the samples; PIAO Wei and BO Ya Cong analyzed the data and wrote the manuscript; YU Dong Mei and ZHAO Li Yun supervised the study. All authors have read and approved the final manuscript.

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CONFLICTS OF INTEREST STATEMENT

None of the researchers or technicians have conflicts of interest to declare.

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