The prevalence of hyperuricemia and its correlates in Zhuang nationality, Nanning, Guangxi Province

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Abstract
Background: Hyperuricemia has an increasing incidence in various regions year by year, in this study, we evaluated the prevalence of hyperuricemia in a routine physical examination in Nanning, Guangxi Province, and analyzed the influencing factors of hyperuricemia, aiming to provide evidence for the prevention and treatment of hyperuricemia and related diseases.

Methods: Data were collected from 1957 patients who underwent physical examinations at the First Affiliated Hospital of Guangxi Medical University in China since 2017. Questionnaires were structured, including subjects' demographics, lifestyle, personal history, chronic disease history, medication history, etc. UA (uricase method), TC (cholesterol oxidase method), TG (glycerol phosphate oxidase method), HDL-C (direct method), LDL-C (direct method), BUN (rate method), creatinine (sarine oxidase method), and GLU (oxidase-peroxidase method) were detected. Independent risk factors for hyperuricemia were determined by bivariate non-conditional logistic regression analysis.

Results: The overall prevalence of hyperuricemia was 16.6% (19.5% in males and 14.9% in females). Gender, waist circumference, BMI, the proportion of drinking, hypertension, high education, serum concentrations of TC, TG, LDL-C, BUN, and creatinine were significantly higher and the serum concentration of HDL-C was significantly lower in patients with and without hyperuricemia (all p < 0.05). Waist circumference, BMI, BUN, and creatinine were independent risk factors for hyperuricemia.

Conclusion: The prevalence of hyperuricemia is very high in Guangxi. Public health lectures should be conducted to encourage people to establish a healthy lifestyle and strengthen early intervention for hyperuricemia to reduce the risk of cardio-cerebrovascular and other related diseases.

KEYWORDS
hyperuricemia, influencing factors, prevalence, zhuang nationality

1 INTRODUCTION

Hyperuricemia is a disorder in purine metabolism that results in elevated serum uric acid (SUA) levels. In recent years, with the rapid development of the economy, people's lifestyles have changed greatly, and the spectrum of human diseases has also changed significantly. For example, the incidence of hyperuricemia has increased in various regions year by year. Epidemiological investigation revealed that...
the total prevalence of hyperuricemia was 12.89%, with 19.06% for men and 5.61% among women, in Tianjin.1 Hyperuricemia is not only closely related to the onset of gout but also an independent risk factor for cardiovascular diseases, metabolic syndrome, type 2 diabetes and dyslipidemia, renal diseases, and liver dysfunction.2–8 Ali et al.9 found a strong association between SUA and lipid profile among Bangladeshi adults, and reported that early prevention of hyperuricemia and dyslipidemia can reduce the incidence of associated cardiovascular disease. A cohort study involving 420 participants found that elevated SUA was significantly associated with the prevalence of metabolic syndrome and its components.9

The prevalence of hyperuricemia is influenced by multiple factors, such as genetics, gender, age, lifestyle, food, drink habits, and economic development.1 Zhuang nationality is the largest minority nationality in China. Many Zhuang individuals live in Guangxi Zhuang Autonomous Region, which has a unique diet and distinctive living habits. In this study, we evaluated the prevalence of hyperuricemia in routine physical examinations in Nanning, Guangxi Province, and analyzed the influencing factors of hyperuricemia, aiming to provide evidence for the prevention and treatment of hyperuricemia and related diseases.

2 | PATIENTS AND METHODS

2.1 | Patients

Data from 1957 patients who underwent physical examinations at the First Affiliated Hospital of Guangxi Medical University, China from 2017 were collected. They comprised 740 (37.8%) males and 1217 (62.2%) females. Inclusion criteria: Zhuang residents over 18 years old who have lived or worked in Nanning for a long time. The Zhuang nationality is defined as the nationality listed on the resident identity card of the People’s Republic of China, whose direct relatives in three generations are all Zhuang. Patients with acute illness, information deficit, and not cooperating with the investigation were excluded from this study. The study was approved by the Ethics Committee of the First Affiliated Hospital of Guangxi Medical University, China.

2.2 | Methods

2.2.1 | Detection methods

Structured questionnaires were used for the questionnaire survey, including subjects’ demographics, lifestyle, personal history, chronic disease history, medication history, etc. Height, weight, waist circumference, and blood pressure were measured in all subjects using standardized protocols. Fasting blood samples were collected in the morning, serum UA, lipids (total cholesterol(TC), triglyceride(TG), high-density lipoprotein cholesterol(HDL-C), and low-density lipoprotein cholesterol(LDL-C)), urea nitrogen (BUN), creatinine and fasting blood glucose (GLU) were detected. Among them, UA was detected by uricase method, TC by cholesterol oxidase method, TG by glycerol phosphate oxidase method. HDL-C, and LDL-C by the direct method, BUN by rate method, creatinine by sarine oxidase method and GLU by the oxidase–peroxidase method.

2.2.2 | Diagnostic criteria

The following definitions were used in this study. Hyperuricemia: serum UA concentration of >420 µmol/L in males or >360 µmol/L in females;10 Dyslipidemia is defined as TC ≥6.2 mmol/L, TG ≥2.3 mmol/L, LDL-C ≥4.1 mmol/L, HDC-C <1.0 mmol/L.11 Smokers were defined as current smokers who had accumulated at least 100 cigarettes and were current smokers at the time of the survey.12 Drinkers were defined as those who had been drinking for more than 1 year and consumed >30 grams of alcohol per week.13 According to the Guidelines for Prevention and Treatment of Hypertension in China (2018 Revised Edition), hypertension is defined as systolic blood pressure ≥140 mmHg (1 mmHg = 0.133 kPa) and/or diastolic blood pressure ≥90 mmHg.14 BMI formula is: BMI = weight (kg)/ height (M)2.15 The study divided the educational level into primary school and below, junior middle school, technical secondary school or high school, and junior college and below. Classify the annual household income into 10,000 yuan or less, 10,001-29,999 yuan, and 30,000 yuan or more. Classify high fat diets as little, moderate, and lots.

2.3 | Statistical analysis

All the statistical analyses were performed using SPSS 22.0 software (IBM Corp.). Continuous variables are expressed as mean ± standard deviation, and categorical variables are expressed as numbers and percentages. Differences in gender, age, smoking, drinking, hypertension, annual household income, waist circumference, high fat diet, and educational level were compared by χ2 test. Age, BMI, serum TC, TG, HDL-C, LDL-C, GLU, BUN, and creatinine concentrations were compared between patients with hyperuricemia and those without hyperuricemia using an independent sample T-test. Independent risk factors for hyperuricemia were determined by bivariate non-conditional logistic regression analysis. A p-value of <0.05 was considered statistically significant.

3 | RESULTS

3.1 | Serum UA concentration and prevalence of hyperuricemia

The mean serum UA concentration across all included patients was 317.27 ± 82.84 µmol/L. The total prevalence of hyperuricemia among all included patients was 16.6%; among them, there are 19.5% in males and 14.9% in females; The prevalence of hyperuricemia was significantly higher in males than females (Figure 1). According to the age, they were divided into three groups: less than or equal to
3.2 | Comparisons of each index between patients with and without hyperuricemia

Gender, waist circumference, BMI, drinking, hypertension, high education, serum concentrations of TC, TG, LDL-C, BUN, and creatinine were significantly increased and HDL-C was significantly decreased in patients with and without hyperuricemia (all \( p < 0.05 \)). There were no statistically significant differences in age, smoking, annual household income, high-fat diet, and blood glucose in patients with than without hyperuricemia (all \( p > 0.05 \))(Tables 2–3).

3.3 | Hyperuricemia-related risk factors

Hyperuricemia was used as the dependent variable, and the following possible risk factors were used as independent variables: gender, waist circumference, BMI, drinking, hypertension, and higher education, TC, TG, LDL-C, BUN, creatinine, and HDL-C. All these variables were introduced into the bivariate conditional logistic regression model. The analysis results showed that waist circumference (odds ratio [OR], 1.60; 95% confidence interval [CI], 1.159-2.208), BMI (OR, 1.079; 95% CI, 1.034–1.126), BUN (OR, 1.180; 95% CI, 1.067–1.306), and creatinine (OR, 1.035; 95% CI, 1.026–1.044) were the risk factors for hyperuricemia (Table 4).

4 | DISCUSSION

In humans, UA is the end product of purine metabolism and is mainly excreted via the kidneys. A comprehensive systematic review and meta-analysis showed that an increasing prevalence was reported from 2005–2009 until 2015–2019 in mainland China. Therefore, investigating the prevalence of hyperuricemia in Nanning, Guangxi Province, is of great significance for controlling levels of UA and hyperuricemia risk factors in the population and for formulating effective prevention and treatment measures.

In this study, we analyzed the prevalence of hyperuricemia in 1957 patients undergoing routine physical examination. The total prevalence of hyperuricemia in the healthy population was 16.6% (19.5% in males and 14.9% in females), which was similar to the prevalence of 17.5% in Changsha, Hunan Province, and that of 19.8% in Nanning, Guangxi Province in 2014. However, this prevalence was higher than that in the Eastern Chinese population, for which the reported prevalence of hyperuricemia was 11.3% from January 2014 to December 2015, and the overall prevalence of hyperuricemia of 4.2% in Jinan. In addition, this prevalence was higher than that in Bangladesh, where the reported prevalence of hyperuricemia was 9.3% (8.4% in men and 10.2% in women), and higher than that in Korea, where the reported prevalence of hyperuricemia was 11.4% (17.0% in men and 5.9% in women). Such differences may be due to different geographical environments, demographic backgrounds, and living habits.

A survey showed that the prevalence of hyperuricemia was higher in males than in females. Yang et al. found in a population study in the Lanzhou district that the prevalence of hyperuricemia in males was significantly higher than that in females, which is consistent with our findings. Our results suggest that the prevalence of hyperuricemia is higher in males than in females. This discrepancy may be related to physiological hormones in males and females. Estradiol is negatively correlated with UA. Estradiol decreases after menopause, resulting in a significant increase in UA levels. In addition, the difference in UA levels between males and females may be related to daily living habits, such as males engaging more frequently in entertainment, smoking, and drinking, experiencing greater work pressure, etc. This difference may also be caused by the different gender ratios in the selection of research participants in this study.

Studies have confirmed that drinking is associated with hyperuricemia. The present study shows that the proportion of drinking was significantly higher in patients with and without hyperuricemia. The main reason is that ethanol can promote the nucleotide conversion of adenine and accelerate the synthesis of purine and the formation of UA. At the same time, lactic acid produced by ethanol metabolism can inhibit the excretion of UA by renal tubules and stimulate the reabsorption of proximal renal tubules, thus inhibiting the excretion of UA by the kidneys.

Hyperuricemia is a marker of metabolic abnormalities. Studies have shown that hyperuricemia is associated with traditional cardiovascular risk factors such as lipid abnormality, hypertension, and obesity. Our results also showed that waist circumference, BMI, prevalence of hypertension, TC, TG, and LDL-C were significantly higher and HDL-C was significantly lower in patients with and without hyperuricemia. Liu et al. recruited 14,618 non-hospitalized participants, and the results showed that obesity and dyslipidemia...
**TABLE 1** Prevalence of hyperuricemia

| Age group | All               | Males            | Females           |
|-----------|-------------------|------------------|-------------------|
|           | number of patients | prevalence rate  | number of patients | prevalence rate  | number of patients | prevalence rate  |
| ≤40       | 304 56 18.4       | 121 27 22.3      | 183 29 15.8       |
| 41–60     | 1056 163 15.4     | 380 65 17.1      | 676 98 14.5       |
| ≥60       | 587 106 18.1      | 239 52 21.8      | 358 54 15.1       |
| All       | 1957 325 16.6     | 740 144 19.5     | 1217 181 14.9     |

**TABLE 2** Comparisons of age, sex, smoking, drinking, hypertension, waist circumference, educational level, household income, and high fat diet between patients with and without hyperuricemia

| Factor                        | UA subjects (n = 1632) | Hyperuricemia subjects (n = 325) | $\chi^2$ | $p$  |
|-------------------------------|------------------------|----------------------------------|---------|-----|
| Age (year)                    |                        |                                  | 2.337   | 0.3 |
| ≤40                           | 248 56                 |                                  |         |     |
| 41–60                         | 893 163                |                                  |         |     |
| ≥60                           | 491 106                |                                  |         |     |
| Sex                           |                        |                                  | 6.991   | 0.008|
| males                        | 596 144                |                                  |         |     |
| females                      | 1036 181               |                                  |         |     |
| Smoking                       |                        |                                  | 2.375   | 0.123|
| No                            | 1402 269               |                                  |         |     |
| Yes                           | 230 56                 |                                  |         |     |
| Drinking                      |                        |                                  | 14.168  | 0.000|
| No                            | 1338 237               |                                  |         |     |
| Yes                           | 294 88                 |                                  |         |     |
| Hypertension                  |                        |                                  | 15.906  | 0.000|
| No                            | 827 204                |                                  |         |     |
| Yes                           | 805 121                |                                  |         |     |
| Waist circumference           |                        |                                  | 105.356 | 0.000|
| normal                       | 1258 160               |                                  |         |     |
| obesity                       | 374 165                |                                  |         |     |
| Educational level             |                        |                                  | 27.250  | 0.027|
| Primary School or Below       | 477 93                 |                                  |         |     |
| Junior high school, technical secondary school or senior high school | 1016 189 | | | |
| University or college education | 139 43                |                                  |         |     |
| Household income              |                        |                                  | 2.198   | 0.333|
| 10,000 and below              | 528 96                 |                                  |         |     |
| 10,000 – 30,000               | 847 168                |                                  |         |     |
| More than 30,000              | 257 61                 |                                  |         |     |
| High fat diet                 |                        |                                  | 0.189   | 0.910|
| little                        | 359 68                 |                                  |         |     |
| general                       | 1087 219               |                                  |         |     |
| many                          | 186 38                 |                                  |         |     |
increase the risk of hyperuricemia. Fu et al.\(^{27}\) found that the prevalence of hyperuricemia increased with an increase in BMI, and BMI was positively correlated with UA. Waist circumference is an index used to evaluate abdominal obesity.\(^{28}\) Obesity and hyperuricemia are causative and promote each other in metabolic mechanisms; hyperinsulinemia and IR are common in obese patients. As mentioned, increased UA production and tubular reabsorption lead to hyperuricemia. Hyperuricemia causes increased Ins secretion, inhibits visceral fat decomposition, and promotes the development of obesity.\(^{29}\)

The results of our study confirmed that the prevalence of hyperuricemia was relatively high in residents with high educational attainment. High educational attainment was a risk factor for hyperuricemia. This may be due to the fact that highly educated people are more likely to achieve higher social status and position and thus participate in more social entertainment, combined with the existence of unhealthy living habits.\(^{30}\) It is suggested that high education people should be further increased and the health literacy of residents should be continuously improved.

Research on the correlation between hyperuricemia and hypertension has a history of more than a century. There is increasing evidence that hyperuricemia is an independent risk factor for hypertension.\(^{31}\) A prospective cohort of 539 patients aged 12–17 years with type 2 diabetes also confirmed that high UA increased the risk of hypertension in adolescents.\(^{32}\) A Japanese cohort study involving 3584 adult patients with prehypertension found that the cumulative incidence of hypertension progression within 5 years in hyperuricemic patients was significantly higher than that in non-hyperuricemia patients.\(^{33}\) The present study also shows that hypertension was significantly higher in patients with and without hyperuricemia. The possible mechanisms are as follows: (1) hyperuricemia may induce insulin resistance and thus increase blood pressure in patients;\(^{34}\) (2) hyperuricemia can induce hypertension through the activation of the renin-angiotensin system or indirectly by reducing renal perfusion to transmitting arteriolar smooth muscle cells.\(^{35}\) A study of 59,074 subjects in Lanzhou reported that serum lipids may be independent risk factors for predicting hyperuricemia.\(^{36}\) Studies have also shown that serum concentrations of TC, TG, and LDL-C are significantly higher and that of HDL-C significantly lower in patients with and without hyperuricemia. A possible reason is that the level of TG in serum increases, the levels of free fatty acids generated after decomposition increase, and adenosine triphosphate, which is required for esterification or entering other tissues of the body, increases significantly, leading to the production of UA. The increase in adenosine triphosphate will lead to a significant increase in UA production.\(^{37}\) At the same time, when purine is metabolized into UA, a large number of free radicals will be generated, which will promote LDL-C oxidation and lipid peroxidation in the body, resulting in lipid metabolism disorders. The decrease in HDL-C levels is also a factor leading to dyslipidemia and can also lead to the elevation of blood UA levels.

BUN and creatinine comprise important indices to evaluate renal function. Qin et al.\(^{38}\) found that serum BUN and creatinine

| Group          | Age(y)     | BMI       | TC         | TG         | HDL-C      | LDL-C      | GLU        | BUN       | Creatinine |
|----------------|------------|-----------|------------|------------|------------|------------|------------|-----------|------------|
| Hyperuricemia  | 52.48±11.72| 22.40±3.34| 5.74±1.12  | 1.25±1.27  | 1.86±0.46  | 4.897±1.32 | 5.59±0.87  | 5.58±1.05  | 65.41±15.30|
| Without hyper  | 52.69±12.16| 25.57±3.96| 5.99±1.22  | 2.03±2.69  | 1.67±0.46  | 4.897±1.32 | 5.59±1.05  | 65.41±15.30|

\(^{p}<0.05\) for comparisons between patients with and without hyperuricemia.
levels were also increased in the establishment of a hyperuricemia rat model. Qun et al.\textsuperscript{39} included 9238 participants in their cohort study and found that high levels of BUN and creatinine increased the risk of hyperuricemia. In the present study, serum concentrations of BUN and creatinine were significantly higher in patients with and without hyperuricemia. Our findings also indicate that high BUN and creatinine levels were risk factors for hyperuricemia. Hyperuricemia is closely related to lifestyle and dietary habits. However, smoking and a high-fat diet did not correlate with the prevalence of hyperuricemia in our study.

This study has several limitations. First, this is a cross-sectional survey conducted only in Nanning, Guangxi, and the results may not be generalizable. Second, the findings cannot fully elucidate the causal relationship between serum UA concentration and other risk factors, and studies with more data are needed to further analyze this relationship. Finally, the sample size is small, and larger samples are required for verification.

In summary, the data from this study indicate that the prevalence of hyperuricemia is very high in Guangxi, China. Hyperuricemia can induce metabolic syndrome and cardiovascular disease, which has become an important public health problem in China. Our findings suggest that hyperuricemia is associated with gender, hyperlipidemia, alcohol consumption, and hypertension, all of which can be ameliorated by diet and lifestyle. Therefore, public health lectures should be conducted to encourage people to establish a healthy lifestyle and strengthen early intervention for hyperuricemia to reduce the risk of cardiovascular and related diseases.

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**CONFLICT OF INTEREST**
The authors declare that they have no competing interests.

**DATA AVAILABILITY STATEMENT**
Data are available on request from the authors.

**CONSENT FOR PUBLICATION**
All the participants gave consent for direct quotes from their interviews to be published in this manuscript.

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| Influential factor | OR   | B    | SE   | Wald  | p     | 95%CI   |
|--------------------|------|------|------|-------|-------|---------|
| Sex                | 1.102| 0.097| 0.191| 0.261 | 0.610 | 0.758–1.602 |
| Drinking           | 1.138| 0.130| 0.159| 0.666 | 0.414 | 0.834–1.554 |
| Hypertension       | 1.214| 0.194| 0.189| 1.044 | 0.837 | 0.837–1.759  |
| Waist circumference| 1.60 | 0.47 | 0.164| 0.817 | 0.004 | 1.159–2.208 |
| Educational level  | 1.563| 0.446| 0.229| 3.78  | 0.051 | 0.996–2.453 |
| BMI                | 1.079| 0.076| 0.021| 12.191| 0.000 | 1.034–1.126 |
| TC                 | 1.138| 0.129| 0.231| 0.313 | 0.575 | 0.723–1.792 |
| TG                 | 1.091| 0.087| 0.077| 1.273 | 0.259 | 0.937–1.272 |
| TG                 | 0.991| 0.008| 0.263| 0.001 | 0.974 | 0.592–1.660 |
| HDL-C              | 0.627| 0.466| 0.285| 2.677 | 0.101 | 0.358–1.096 |
| BUN                | 1.180| 0.166| 0.051| 10.40  | 0.001 | 1.067–1.306 |
| creatinine         | 1.035| 0.035| 0.004| 62.781| 0.000 | 1.026–1.044 |

**TABLE 4 Hyperuricemia related risk factors analyzed by bivariate nonconditional logistic regression mode**
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