

# Knowledge, attitude, and practice toward hyperuricemia among healthcare workers in Shandong, China

Honghai Peng<sup>1</sup>, Ke Zhang<sup>2</sup>, Chunxue Zhang<sup>3</sup> and Jun Gao<sup>1</sup>

<sup>1</sup> Department of Neurosurgery, Central Hospital Affiliated to Shandong First Medical University, Jinan, Shandong, China

<sup>2</sup> Department of Anesthesia, Central Hospital Affiliated to Shandong First Medical University, Jinan, Shandong, China

<sup>3</sup> Shandong International Talent Exchange & Service Center, Jinan, Shandong, China

## ABSTRACT

**Background:** Hyperuricemia is a relatively common condition, with a prevalence of over 20% among the general population. Also, most patients initially present no symptoms. This study aimed to investigate the knowledge, attitude, and practice (KAP) toward hyperuricemia among healthcare workers in Shandong, China.

**Methods:** Healthcare workers were recruited in this cross-sectional study conducted in Shandong in December 2022. A self-designed questionnaire was used to collect demographic information and KAP data.

**Results:** A total of 372 questionnaires were distributed, and 216 (58.06%) valid questionnaires were collected from 131 physicians, 80 nurses, and five other healthcare workers. The participants had a mean score of  $10.76 \pm 2.53$  (possible range: 0–14, 76.9%) and  $31.94 \pm 2.58$  (possible range: 0–40, 79.9%) in knowledge and attitude, respectively. The physicians' and nurses' practice scores were  $47.57 \pm 5.34$  (possible range: 0–55, 86.5%) and  $30.06 \pm 4.11$  (possible range: 0–35, 85.9%), respectively. The attitude scores were independently associated with proactive practice in both physicians ( $P < 0.001$ ) and nurses ( $P = 0.046$ ).

**Conclusion:** This study found that healthcare workers in Shandong had adequate knowledge, positive attitudes, and proactive practices towards hyperuricemia. However, there is room for improvement in the attitudes of both physicians and nurses to achieve better practice.

Submitted 16 December 2023  
Accepted 24 July 2024  
Published 1 October 2024

Corresponding author  
Jun Gao, gaoj1666@126.com

Academic editor  
Yoshinori Marunaka

Additional Information and  
Declarations can be found on  
page 10

DOI 10.7717/peerj.17926

© Copyright  
2024 Peng et al.

Distributed under  
Creative Commons CC-BY 4.0

## OPEN ACCESS

**Subjects** Internal Medicine, Nephrology, Metabolic Sciences

**Keywords** Knowledge, Attitudes, Practice, Hyperuricemia, Cross-sectional study, Gout

## INTRODUCTION

Serum uric acid (SUA) is the end-product of purine metabolism in humans, excreted primarily through the kidneys (>70%) (Ashiq *et al.*, 2021; Schlesinger, 2005).

Hyperuricemia is defined as SUA levels of >6 mg/dL (360 μmol/L) and >7 mg/dL (420 μmol/L) in women and men, respectively (Li *et al.*, 2019; von Lueder *et al.*, 2015). The prevalence in the general population is 21% vs. 25% in hospitalized individuals. Also, most patients with hyperuricemia are asymptomatic (George & Minter, 2022). According to The Global Burden of Disease (GBD) 2019 database, the global age-standardized prevalence is

652.2 per 100,000 individuals, varying from 183.8 in Central Latin America to 1,722.4 in high-income North America (Han *et al.*, 2024). In China, the prevalence of hyperuricemia from 2000 to 2014 was 13.3% (Liu *et al.*, 2015). People of Asian ancestry are at a three-fold higher risk of hyperuricemia and gout than Caucasians (Butler, Alghubayshi & Roman, 2021). Following the sustained elevation of SUA, one-third of patients with hyperuricemia are affected by gout, characterized by the formation and deposition of monosodium urate crystals around joints (Chen-Xu *et al.*, 2019; Dalbeth *et al.*, 2015). Gout is the most common form of inflammatory arthritis worldwide, affecting 1–6.8% of the population (Dehlin, Jacobsson & Roddy, 2020). This condition imposes a significant economic burden on the patients and the healthcare systems due to treatments, consultations, complications, hospitalizations, and mortality (Degli Esposti *et al.*, 2016; Rai *et al.*, 2015). Gout and hyperuricemia are often treated with urate-lowering therapy (ULT) such as xanthine oxidase inhibitors, uricosuric drugs, uricolytic enzymes, losartan, and sodium-glucose cotransporter-2 inhibitors (Dalbeth, Merriman & Stamp, 2016; FitzGerald *et al.*, 2020; Richette *et al.*, 2017), although the recent guidelines advise against the routine treatment of asymptomatic hyperuricemia in the absence of related symptoms or conditions (FitzGerald *et al.*, 2020). Lifestyle modifications such as weight loss, regular exercise, and dietary changes can also reduce SUA levels and the risk of gout (Choi, 2010). However, whether asymptomatic hyperuricemia should be treated and the appropriate threshold for initiating ULT are still debatable (Skoczynska *et al.*, 2020).

Recently, the role of SUA in various health conditions has gained increasing interest. Despite most asymptomatic patients tend not to develop changes caused by the accumulation of urate crystals, elevated SUA levels have been found to cause silent tissue damage, leading to several diseases such as hypertension, dyslipidemia, obesity, metabolic syndrome, type 2 diabetes, cardiovascular disease, and chronic kidney disease (CKD) (Benn *et al.*, 2018; Chen, Lu & Yao, 2016), but such evidence was not considered enough to recommend drug treatments in asymptomatic hyperuricemia (FitzGerald *et al.*, 2020). On the other hand, impaired renal excretion is responsible for 90% of hyperuricemia, and approximately 50% of CKD patients already have hyperuricemia before undergoing hemodialysis treatment (Hyndman, Liu & Miner, 2016; Johnson *et al.*, 2013; Maiuolo *et al.*, 2016; Ohno, 2011). Furthermore, hyperuricemia has been associated with increased mortality in patients with coronary artery disease, chronic obstructive pulmonary disease, or cancer (Shin *et al.*, 2006; Zhang *et al.*, 2015). In China, hyperuricemia has become the second most common metabolic disease, following diabetes mellitus (Multidisciplinary Expert Task Force on Hyperuricemia and Related Diseases, 2017). The prevalence of hyperuricemia in the Chinese adult population was 11.1% in 2015–16 and 14.0% in 2018–19, indicating an alarming trend (Zhang *et al.*, 2021).

Knowledge, attitude, and practice (KAP) surveys are commonly used in the health sciences to examine what people know, believe, and do about a topic of interest (Andrade *et al.*, 2020). Healthcare workers have a critical role in diagnosing and treating hyperuricemia, and their ability to react systematically to the disease is influenced by their knowledge, attitude, and practice. Since the KAP is influenced by local culture, policies, education, healthcare services available, and guidelines, it is highly variable among

countries and even provinces within a given country. Thus, there is a need to assess the understanding of hyperuricemia and its management by healthcare workers in China, as no such study has yet been conducted. Therefore, this study aimed to explore the knowledge, attitude, and practice of hyperuricemia among healthcare workers managing hyperuricemia patients in Shandong, China. We hypothesized that this study might identify knowledge gaps in hyperuricemia diagnosis and treatment, providing insights into improving hyperuricemia management in China.

## MATERIALS AND METHODS

### Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

### Study design and participants

The cross-sectional study was conducted in seven hospitals in Shandong, China, in December 2022 among healthcare. The inclusion criteria were: (1) Healthcare workers who may treat, care, or communicate with patients with hyperuricemia; (2) with a qualification certificate. Those on leave, in training or education, or refusing to participate were excluded.

This study was approved by the Ethics Committee of Jinan Central Hospital (approval No. 2022-234-01). All participants signed informed consent forms.

### Questionnaire

A self-designed questionnaire was created according to a previous study and guidelines for diagnosing and treating hyperuricemia ([Chinese Society of Endocrinology, 2020](#); [Tiwaskar & Sholapuri, 2021](#)). A small-scale pilot test with 30 physicians and 44 other medical workers was conducted, reaching Cronbach's  $\alpha$  coefficients of 0.859 and 0.897, respectively.

The questionnaire contained four dimensions: demographic characteristics (e.g., age, sex, residency, ethnicity, education, job title, etc.), knowledge, attitude, and practice. The knowledge dimension contained 15 questions and was scored between 0 and 14, with one point for each correct answer and 0 points for each incorrect or unclear answer from K1 to K14. K15 was used for testing questionnaire validity. The attitude category contained eight items evaluated on a five-point Likert scale. Besides items A4 and A6 that were reverse scored, all other items were evaluated from "strongly agree" (five points) to "strongly disagree" (one point). The total scores ranged from 8 to 40. The practice dimension consisted of 11 questions evaluated on a five-point Likert scale, from "always" to "never", i.e., 5–1. P1 to P11 applied to physicians with scores ranging from 11 to 55, while P5 to P11 applied to nurses and other healthcare workers with scores ranging from 7 to 35. The knowledge (>9), attitude (>27), and practice (>38 for physicians and >24 for nurses) scores were considered adequate, positive, and proactive according to the cutoff of 70% of the total score.

Electronic questionnaires were distributed *via* Wechat (Tencent, China) using a QR code created by “Sojump” (Changsha Ranxing Information Technology Co., Ltd) ([Guo et al., 2021](#)). A QR code and link to the electronic questionnaire were generated and distributed to the leaders of the seven participating hospitals *via* WeChat, who would then send them to potential participants by WeChat group of their hospital to invite the healthcare workers to participate in the study. The leaders ensured they sent the questionnaire to eligible participants based on the eligibility criteria. Since the potential study population at the seven hospitals was about 4,000, convenience sampling was performed. As the QR code and link were distributed by leaders, those who had access to the questionnaire met the criteria. Informed consent was on the first page of the questionnaire. The participants had to sign the informed consent page to access the questionnaire. The website provided instructions on how to complete the questionnaire. The investigators could be reached through WeChat if needed. The participants could complete the questionnaire at any time during the study period, but only once. If the participant did not complete the questionnaire, a reminder was sent 15 days after the first one. Each IP address could only be used once to submit a questionnaire, and all items had to be completed to ensure the quality and integrity of the questionnaire results.

### Sample size

The sample size was estimated based on the sample size determination method for quantitative surveys, *i.e.*, 5–10 participants for each KAP item ([Ni, Chen & Liu, 2010](#)). This study had 33 KAP items. Therefore, the minimal sample size was 165–330.

### Statistical analysis

Stata 17.0 was used for the statistical analysis (Stata Corporation, College Station, TX, USA). All continuous variables were normally distributed, expressed as mean  $\pm$  standard deviation (SD), and compared by one-way analysis of variance or t-test. Categorical data were expressed as frequency (percentage). Multivariable logistic regression analysis was performed to identify the factors associated with the proactive practice of physicians and nurses respectively. A structural equation modeling (SEM) analysis was used to examine how the KAP dimensions influenced each other. A two-sided  $P < 0.05$  was considered statistically significant.

## RESULTS

A total of 372 questionnaires were distributed, and 156 questionnaires were excluded because of incomplete responses, inconsistencies in questionnaire responses, and duplicate IP addresses, resulting in 216 valid questionnaires from 131 physicians, 80 nurses, and five other healthcare workers. [Table S1](#) shows the demographic characteristics and KAP scores of the 216 respondents. The knowledge and attitude scores were  $10.76 \pm 2.53$  (76.9%) and  $31.94 \pm 2.58$  (79.9%), respectively. The physicians’ and nurses’ practice scores were  $47.57 \pm 5.34$  (86.5%) and  $30.06 \pm 4.11$  (85.9%), respectively.

Knowledge scores significantly differed by job title ( $P = 0.008$ ), experience in managing hyperuricemia patients ( $P = 0.001$ ), and occupation ( $P < 0.001$ , [Table S1](#)). Participants

**Table 1** Multivariate logistic regression analysis on the practice of the physicians ( $n = 131$ ).

Characteristics	Multivariate logistic regression	
	OR (95% CI)	P
<b>Knowledge score</b>	1.212 [0.941–1.562]	0.137
<b>Attitude score</b>	1.432 [1.173–1.748]	<0.001
<b>Sex</b>		
Male	Ref.	
Female	1.520 [0.649–3.560]	0.335
<b>Age (years)</b>		
<30	Ref.	
30–40	2.151 [0.263–17.572]	0.475
<40	1.930 [0.160–23.355]	0.605
<b>Residency</b>		
Non-urban	Ref.	
Urban	0.922 [0.340–2.504]	0.874
<b>Education</b>		
Bachelor's degree	1.356 [0.516–3.565]	0.537
Master's degree and higher	Ref.	
<b>Job title</b>		
None and junior	Ref.	
Intermediate	0.882 [0.146–5.329]	0.891
Senior	2.359 [0.295–18.862]	0.418
<b>Work experience (years)</b>		
<10	Ref.	
10–20	0.711 [0.145–3.488]	0.674
>20	1.285 [0.175–9.417]	0.805
<b>Treated patients with hyperuricemia</b>		
Yes	0.819 [0.315–2.130]	0.683
No or unclear	Ref.	

scored the lowest on the threshold level of SUA (correct rates <70%, [Table S2](#)). Only experience managing hyperuricemia patients was associated with a more positive attitude ( $P < 0.001$ , [Table S1](#)). It appears that participants placed too much emphasis on the patient's responsibility to control SUA levels, as the positive attitude rate was only 40.7% (34.7% + 6%; [Table S3](#)). Physicians with a Bachelor's degree or higher ( $P = 0.008$ ), senior job titles ( $P = 0.007$ ), and experience with hyperuricemia patients ( $P = 0.001$ ) had better practice than their counterparts ([Table S1](#)). Most participants encouraged patients to have regular checkups, make lifestyle changes, and participate in educational programs, while 54.7% considered drug therapy or sodium bicarbonate therapy an option ([Table S4](#)). Compared with nurses, physicians demonstrated better knowledge ( $11.33 \pm 52.24$  vs.  $9.85 \pm 2.69$ ,  $P < 0.001$ ) and comparable attitudes ( $32.12 \pm 2.49$  vs.  $31.60 \pm 2.69$ ,  $P = 0.306$ ) ([Table S1](#)).

**Table 2** Multivariate logistic regression analysis on the practice of the nurses ( $n = 80$ ).

Characteristics	Multivariate logistic regression	
	OR (95%CI)	P
<b>Knowledge score</b>	1.212 [0.943–1.556]	0.133
<b>Attitude score</b>	1.289 [1.004–1.655]	0.046
<b>Sex</b>		
Male	Ref.	
Female	0.499 [0.061–4.067]	0.516
<b>Age (years)</b>		
<30	Ref.	
30–40	0.268 [0.033–2.197]	0.475
<40	–	0.999
<b>Residency</b>		
Non-urban	Ref.	
Urban	0.814 [0.227–2.915]	0.752
<b>Job title</b>		
None and junior	Ref.	
Intermediate	0.611 [0.119–3.145]	0.556
Senior	2.359 [0.076–9.244]	0.886
<b>Work experience (years)</b>		
<10	Ref.	
10–20	2.721 [0.420–17.629]	0.294
>20	–	0.999
<b>Treated patients with hyperuricemia</b>		
Yes	0.815 [0.245–2.713]	0.739
No or unclear	Ref.	

Multivariable logistic regression analysis showed that the attitude scores were independently associated with proactive practice in both physicians (OR (95%CI) = 1.432 [1.173–1.748],  $P < 0.001$ ) and nurses (OR (95%CI) = 1.289 [1.004–1.655],  $P = 0.046$ ] (Tables 1 and 2).

SEM analyses were performed to examine the interrelationships among the KAP dimensions among physicians (Fig. 1) and nurses (Fig. 2). Among physicians, knowledge positively influenced attitude ( $\beta = 0.772$ ,  $P < 0.001$ ) but not practice ( $\beta = 0.071$ ,  $P = 0.726$ ), while attitude positively influenced practice ( $\beta = 1.011$ ,  $P < 0.001$ ) (Table 3). Among nurses, knowledge positively influenced attitude ( $\beta = 1.591$ ,  $P < 0.001$ ) but not practice ( $\beta = -0.723$ ,  $P = 0.232$ ), while attitude positively influenced practice ( $\beta = 0.793$ ,  $P = 0.013$ ) (Table 3).

## DISCUSSION

The present study found that healthcare workers had adequate knowledge, positive attitudes, and proactive practice regarding hyperuricemia. Furthermore, a positive attitude

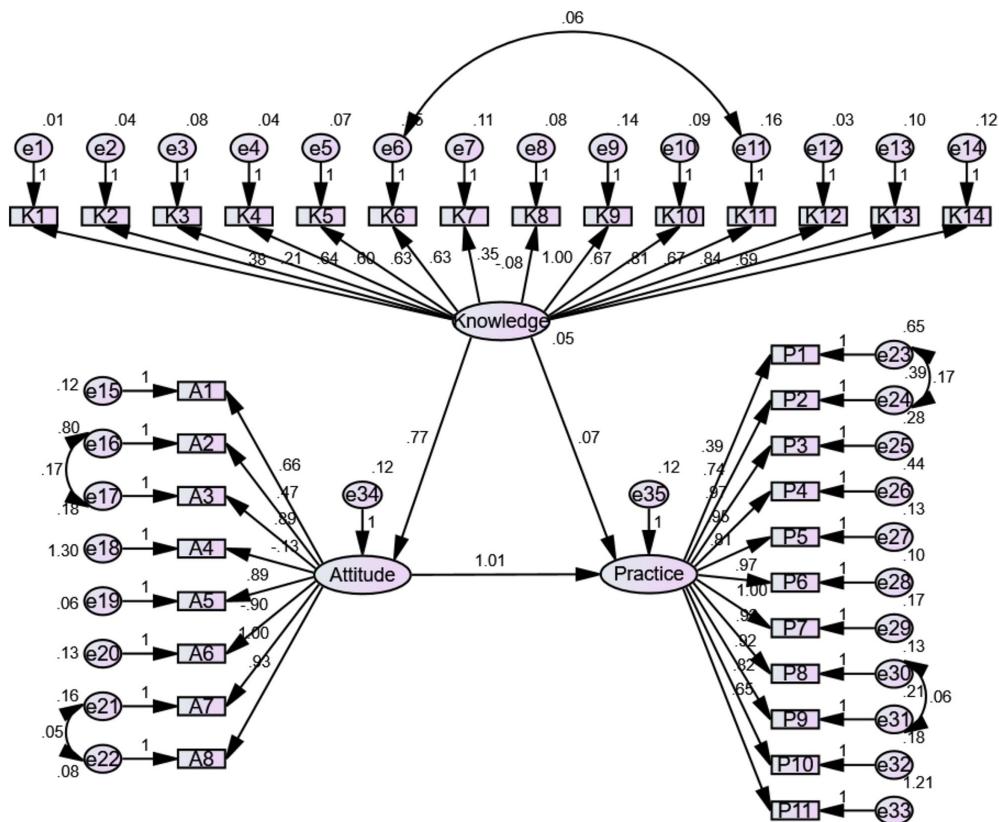


Figure 1 The SEM for physician.

Full-size DOI: 10.7717/peerj.17926/fig-1

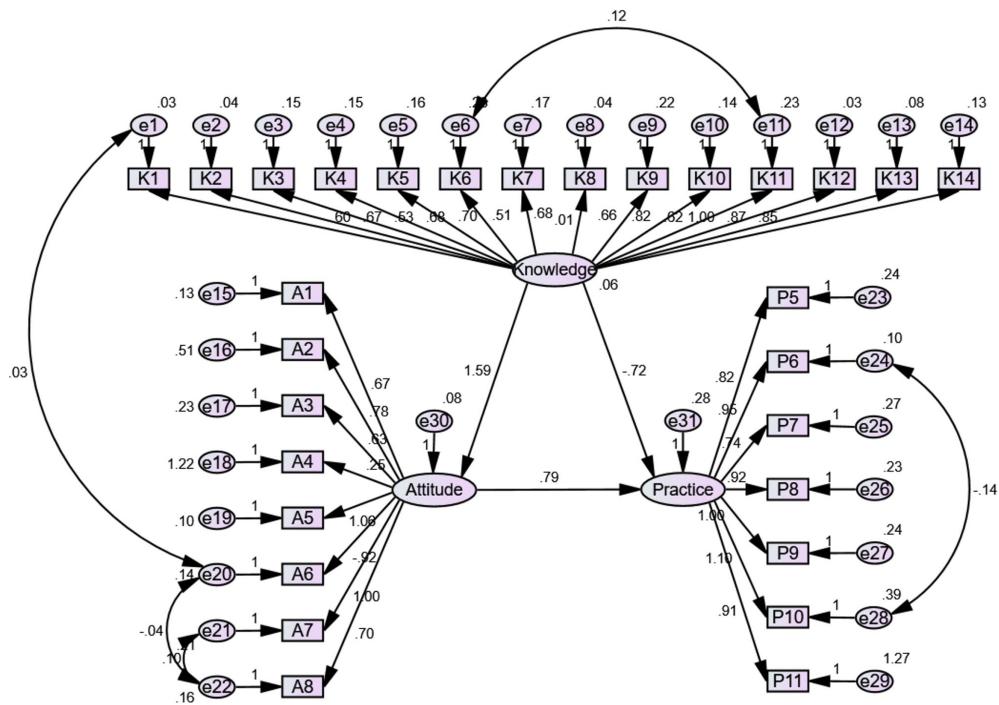


Figure 2 The SEM for nurses.

Full-size DOI: 10.7717/peerj.17926/fig-2

**Table 3** The structural equation modeling (SEM).

			$\beta$	P
Physicians				
Attitude	<—	Knowledge	0.772	<0.001
Practice	<—	Attitude	1.011	<0.001
Practice	<—	Knowledge	0.071	0.726
Nurses				
Attitude	<—	Knowledge	0.772	<0.001
Practice	<—	Attitude	1.011	<0.001
Practice	<—	Knowledge	0.071	0.726

was an independent predictor of good practice among physicians and nurses. These findings provide insight into new ways to improve hyperuricemia management in China.

Physicians who treated hyperuricemia patients before were likely to have better KAP than other participants. Consistent with our findings, greater experience contributed to a better understanding of hyperuricemia management and higher practice scores among primary healthcare providers in the Qassim region of Saudi Arabia ([Alraqibah et al., 2022](#)). However, these comparisons must be made with caution, considering the differences in the healthcare systems among countries. Unlike our results, knowledge and practice levels regarding hyperuricemia among primary health providers in Saudi Arabia were very low (45.9% and 23.3%, respectively), which could be due to limited experience resulting from fewer patients or the different dimensions of knowledge involved in the questionnaire ([Alqarni & Hassan, 2018](#); [Alraqibah et al., 2022](#)).

Despite positive attitudes towards hyperuricemia management, 97.2% of participants believed that patients must take more responsibility than healthcare workers to control SUA levels. Unfortunately, [Huang et al. \(2020\)](#) identified a lack of education regarding clinical guidelines and disease knowledge and highlighted the importance of cooperation with physicians in diagnosing and treating hyperuricemia in China. [Chia \(2016\)](#) demonstrated that barriers to poorly controlled gout include patient factors such as lack of understanding of the disease and nonadherence to treatment, as well as physical factors such as knowledge gaps and inadequate use of ULT. To bridge the gap, physicians must do more to educate patients, identify treatment targets, and disseminate treatment guidelines ([Chia, 2016](#)). Thus, healthcare workers should take a greater role in guiding hyperuricemia diagnosis and treatment than the patients themselves.

Participants scored the least regarding the threshold level of SUA with correct rates <70%. Similarly, only 32.8% of primary health care physicians in Jeddah, Western Region of Saudi Arabia, showed adequate knowledge about asymptomatic hyperuricemia by consideration of the used cutoffs ([Alqarni & Hassan, 2018](#)). Medical students from Croatia's two largest universities also struggled with defining asymptomatic hyperuricemia and treatment goals ([Zuzic Furlan et al., 2021](#)), which could be due to the lack of agreement

on the definition of hyperuricemia. SUA concentrations  $>405 \mu\text{mol/L}$  are a practical value as this represents the urate's solubility point as measured by automated enzymatic methods in laboratories (Mallat *et al.*, 2016). A few researchers suggest that the values for healthy individuals should be reduced to  $300 \mu\text{mol/L}$ , while others suggest different values for men and women due to the uricosuric effect of estrogenic compounds (Bardin & Richette, 2014; Ferri, 2017; Ramirez & Bargman, 2017). The latest recommendations by the British Society for Rheumatology (BSR) and the European Alliance of Associations for Rheumatology (EULAR) suggest  $360 \text{ mol/L}$  ( $6 \text{ mg/dL}$ ) as the target value when using ULT (Russell *et al.*, 2022). A consensus on hyperuricemia is urgently required to improve healthcare workers' understanding of this condition.

A retrospective cross-sectional study in Japan showed that ULT was prescribed to 80.7% of gout patients and 72.4% of asymptomatic hyperuricemia patients. However, most patients were given low-dose ULT, and fewer than half of them reached the SUA target ( $\leq 420 \mu\text{mol/L}$ ), which may contribute to the 47.8% incidence of gout flares (Koto *et al.*, 2021). According to Chinese guidelines, asymptomatic hyperuricemia should be treated with ULT when SUA reaches 540 or  $480 \mu\text{mol/L}$  in combination with the following comorbidities: hypertension, abnormal lipid metabolism, diabetes, obesity, stroke, coronary heart disease, cardiac insufficiency, urinary acid nephrosis, or damaged renal function ( $\geq \text{CKD stage 2}$ ) (Chinese Society of Endocrinology, 2020). A real-world retrospective study at a dedicated gout clinic in China showed that 92.70% of gout patients accepted ULT (Bai *et al.*, 2021); however, the rate of ULT treatment in patients with asymptomatic hyperuricemia remained unclear. In the practice assessment, we found that most healthcare workers encouraged patients' self-management, such as changing their lifestyles and receiving regular medical examinations. Only about half of the physicians were actively engaged in drug treatment, possibly due to controversy related to the use of ULT in patients with asymptomatic hyperuricemia (Sapankaew *et al.*, 2022).

The SEM analysis showed that knowledge directly influenced attitudes, which in turn directly influenced practice; knowledge had no direct influence on practice, and its influence was, therefore, indirect through attitude. According to the KAP theory, knowledge is the basis underlying practice, but attitude is the force driving practice (Andrade *et al.*, 2020; World Health Organization, 2008). Hence, interventions aiming at improving the knowledge of physicians and nurses toward hyperuricemia should also improve attitude and practice.

Based on our findings, we speculated that hyperuricemia management is suboptimal in Shandong, China. Guidelines and consensus on the diagnosis and management of gout and hyperuricemia should be improved, and stricter compliance with guidelines should be practiced among physicians. Still, to be able to apply guidelines, they must be familiar with the guidelines and their content. Continuing education activities (e.g., lectures, online modules, *etc.*) should be designed to improve the knowledge and attitude of the healthcare workers in Shandong, China, which should translate into better practice, *i.e.*, better patient care. A better understanding of SUA thresholds and therapies for hyperuricemia is especially needed.

This study has some limitations. It was performed in Shandong, a coastal province in East China. Shandong is a well-established economic center, China's second most populous province, and the third-largest provincial economy ([National Bureau of Statistics of China, 2021](#)). Therefore, the generalizability of the results must be taken with caution, especially in the poorer areas. Indeed, such poorer areas tend to have less accessible healthcare services, which could lead to discrepancies in care received and prognosis ([Guo et al., 2020](#); [Zheng et al., 2022](#)). Furthermore, we did not compare the practice between physicians and nurses. In addition, although some pharmacists participated in the study, their KAP was not specifically examined since hospital pharmacists rarely manage patients in the Chinese medical system, especially for hyperuricemia. Since the practice scores of physicians and nurses were independently and positively correlated with attitude scores, and both groups had comparable attitudes toward hyperuricemia, we speculated that their practice levels would also be comparable. The department findings should be interpreted with caution, as the number of participants in each department was small, and some specific professionals could not be identified due to the structure of the medical system. Because this is a cross-sectional study, it is difficult to draw causal conclusions. A SEM was performed as a surrogate of causality, but such results must be taken with caution since causality is statistically inferred rather than observed ([Beran & Violato, 2010](#); [Fan, Chen & Shirkey, 2016](#); [Kline, 2023](#)). The questionnaire did not cover some areas, e.g., side effects associated with ULT. Considering self-reporting bias, our data may be less reliable than medical records and laboratory measurements. In addition, there is a risk of social desirability bias ([Bergen & Labonte, 2020](#); [Latkin et al., 2017](#)). Statistical bias is also possible, but multivariable regression analyses were performed to mitigate confounding. More studies in other areas with larger sample sizes are required to further improve the understanding of the KAP of hyperuricemia.

## CONCLUSIONS

Healthcare workers in Shandong, China, demonstrated adequate knowledge, positive attitudes, and proactive practice toward hyperuricemia. A better understanding of SUA thresholds and hyperuricemia drug therapy is needed. Proactive practice can be achieved by improving the attitudes of both physicians and nurses. Future studies could examine the impact of educational activities on the participants' KAP. The KAP of rheumatologists and pharmacists could also be examined.

## ADDITIONAL INFORMATION AND DECLARATIONS

### Funding

The authors received no financial support for the research, authorship, and publication of this article.

### Competing Interests

The authors declare that they have no competing interests.

## Author Contributions

- Honghai Peng conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the article, and approved the final draft.
- Ke Zhang conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the article, and approved the final draft.
- Chunxue Zhang conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the article, and approved the final draft.
- Jun Gao conceived and designed the experiments, performed the experiments, authored or reviewed drafts of the article, and approved the final draft.

## Human Ethics

The following information was supplied relating to ethical approvals (i.e., approving body and any reference numbers):

The Ethics Committee of Jinan Central Hospital approved the study (No. 2022-234-01).

## Data Availability

The following information was supplied regarding data availability:

Raw data are available in the [Supplemental Files](#).

## Supplemental Information

Supplemental information for this article can be found online at <http://dx.doi.org/10.7717/peerj.17926#supplemental-information>.

## REFERENCES

- Alqarni NA, Hassan AH. 2018. Knowledge and practice in the management of asymptomatic hyperuricemia among primary health care physicians in Jeddah, Western Region of Saudi Arabia. *Saudi Medical Journal* 39(12):1218–1225 DOI [10.15537/smj.2018.12.23715](https://doi.org/10.15537/smj.2018.12.23715).
- Alraqibah EA, Alharbi FM, Alharbi NS, Aldekhail MI, Alahmadi KM, Alresheedi MA, AlKhattaf MI. 2022. Knowledge and practice of primary health care providers in the management of asymptomatic hyperuricemia and gout in the Qassim Region of Saudi Arabia. *Cureus* 14:e30976 DOI [10.7759/cureus.30976](https://doi.org/10.7759/cureus.30976).
- Andrade C, Menon V, Ameen S, Kumar Praharaj S. 2020. Designing and conducting knowledge, attitude, and practice surveys in psychiatry: practical guidance. *Indian Journal of Psychological Medicine* 42(5):478–481 DOI [10.1177/0253717620946111](https://doi.org/10.1177/0253717620946111).
- Ashiq K, Bajwa MA, Tanveer S, Qayyum M, Ashiq S, Khokhar R, Abid F. 2021. A comprehensive review on gout: the epidemiological trends, pathophysiology, clinical presentation, diagnosis and treatment. *Journal of the Pakistan Medical Association* 71:1234–1238 DOI [10.47391/JPMA.313](https://doi.org/10.47391/JPMA.313).
- Bai XS, Wang M, Zhao XD, Cui LL, He YW, Wang C, Li XD, Qu XJ, Sun MS, Li CG. 2021. Treat-to-target urate-lowering therapy in primary gout patients: a real-world retrospective study at a dedicated gout clinic in China. *Technology and Health Care* 29(1):121–131 DOI [10.3233/THC-191951](https://doi.org/10.3233/THC-191951).

- Bardin T, Richette P.** 2014. Definition of hyperuricemia and gouty conditions. *Current Opinion in Rheumatology* 26(2):186–191 DOI 10.1097/BOR.0000000000000028.
- Benn CL, Dua P, Gurrell R, Loudon P, Pike A, Storer RI, Vangjeli C.** 2018. Physiology of hyperuricemia and urate-lowering treatments. *Frontiers in Medicine* 5:160 DOI 10.3389/fmed.2018.00160.
- Beran TN, Violato C.** 2010. Structural equation modeling in medical research: a primer. *BMC Research Notes* 3(1):267 DOI 10.1186/1756-0500-3-267.
- Bergen N, Labonte R.** 2020. “Everything is perfect, and we have no problems”: detecting and limiting social desirability bias in qualitative research. *Qualitative Health Research* 30(5):783–792 DOI 10.1177/1049732319889354.
- Butler F, Alghubayshi A, Roman Y.** 2021. The epidemiology and genetics of hyperuricemia and gout across major racial groups: a literature review and population genetics secondary database analysis. *Journal of Personalized Medicine* 11(3):231 DOI 10.3390/jpm11030231.
- Chen C, Lu JM, Yao Q.** 2016. Hyperuricemia-related diseases and xanthine oxidoreductase (XOR) inhibitors: an overview. *Medical Science Monitor* 22:2501–2512 DOI 10.12659/MSM.899852.
- Chen-Xu M, Yokose C, Rai SK, Pillinger MH, Choi HK.** 2019. Contemporary prevalence of gout and hyperuricemia in the United States and decadal trends: the national health and nutrition examination survey, 2007–2016. *Arthritis & Rheumatology* 71(6):991–999 DOI 10.1002/art.40807.
- Chia FL.** 2016. Poorly controlled gout: who is doing poorly? *Singapore Medical Journal* 57(8):412–414 DOI 10.11622/smedj.2016129.
- Chinese Society of Endocrinology.** 2020. Guideline for the diagnosis and management of hyperuricemia and gout in China (2019). *Chinese Journal of Endocrinology and Metabolism* 36(1):1–13 DOI 10.3760/cma.j.issn.1000-6699.2020.01.001.
- Choi HK.** 2010. A prescription for lifestyle change in patients with hyperuricemia and gout. *Current Opinion in Rheumatology* 22(2):165–172 DOI 10.1097/BOR.0b013e328335ef38.
- Dalbeth N, House ME, Aati O, Tan P, Franklin C, Horne A, Gamble GD, Stamp LK, Doyle AJ, McQueen FM.** 2015. Urate crystal deposition in asymptomatic hyperuricaemia and symptomatic gout: a dual energy CT study. *Annals of the Rheumatic Diseases* 74(5):908–911 DOI 10.1136/annrheumdis-2014-206397.
- Dalbeth N, Merriman TR, Stamp LK.** 2016. Gout. *The Lancet* 388(10055):2039–2052 DOI 10.1016/S0140-6736(16)00346-9.
- Degli Esposti L, Desideri G, Saragoni S, Buda S, Pontremoli R, Borghi C.** 2016. Hyperuricemia is associated with increased hospitalization risk and healthcare costs: Evidence from an administrative database in Italy. *Nutrition, Metabolism and Cardiovascular Diseases* 26(10):951–961 DOI 10.1016/j.numecd.2016.06.008.
- Dehlin M, Jacobsson L, Roddy E.** 2020. Global epidemiology of gout: prevalence, incidence, treatment patterns and risk factors. *Nature Reviews Rheumatology* 16(7):380–390 DOI 10.1038/s41584-020-0441-1.
- Fan Y, Chen J, Shirkey G.** 2016. Applications of structural equation modeling (SEM) in ecological studies: an updated review. *Ecological Processes* 5(1):19 DOI 10.1186/s13717-016-0063-3.
- Ferri C.** 2017. The problem of cardio-renal diseases in patients with gout. *Current Medical Research and Opinion* 33(sup3):9–13 DOI 10.1080/03007995.2017.1378518.
- FitzGerald JD, Dalbeth N, Mikuls T, Brignardello-Petersen R, Guyatt G, Abeles AM, Gelber AC, Harrold LR, Khanna D, King C, Levy G, Libbey C, Mount D, Pillinger MH, Rosenthal A, Singh JA, Sims JE, Smith BJ, Wenger NS, Bae SS, Danve A, Khanna PP, Kim SC, Lenert A, Poon S, Qasim A, Sehra ST, Sharma TSK, Toprover M, Turgunbaev M,**

- Zeng L, Zhang MA, Turner AS, Neogi T. 2020.** 2020 American college of rheumatology guideline for the management of gout. *Arthritis & Rheumatology* **72**(6):879–895 DOI [10.1002/art.41247](https://doi.org/10.1002/art.41247).
- George C, Minter DA. 2022.** *Hyperuricemia*. Treasure Island (FL): StatPearls Publishing. Available at <https://www.ncbi.nlm.nih.gov/books/NBK459218/>.
- Guo C, Hu B, Guo C, Meng X, Kuang Y, Huang L, Wang D, Xu K, Zhao Y, Yang G, Cai W, Shu Y. 2021.** A survey of pharmacogenomics testing among physicians, pharmacists, and researchers from China. *Frontiers in Pharmacology* **12**:682020 DOI [10.3389/fphar.2021.682020](https://doi.org/10.3389/fphar.2021.682020).
- Guo B, Xie X, Wu Q, Zhang X, Cheng H, Tao S, Quan H. 2020.** Inequality in the health services utilization in rural and urban china: a horizontal inequality analysis. *Medicine (Baltimore)* **99**(2):e18625 DOI [10.1097/MD.00000000000018625](https://doi.org/10.1097/MD.00000000000018625).
- Han T, Chen W, Qiu X, Wang W. 2024.** Epidemiology of gout-global burden of disease research from 1990 to 2019 and future trend predictions. *Therapeutic Advances in Endocrinology and Metabolism* **15**:20420188241227295 DOI [10.1177/20420188241227295](https://doi.org/10.1177/20420188241227295).
- Huang YF, Yang KH, Chen SH, Xie Y, Huang CB, Qing YF, He DY, Wu LJ, Zhan F, Wang XQ, Zhou YQ, Kong QC, Wang K, Schlesinger N, Xu DT, Ma XJ, Gu JR. 2020.** [Practice guideline for patients with hyperuricemia/gout]. *Zhonghua Nei Ke Za Zhi* **59**(7):519–527 DOI [10.3760/cma.j.cn112138-20200505-00449](https://doi.org/10.3760/cma.j.cn112138-20200505-00449).
- Hyndman D, Liu S, Miner JN. 2016.** Urate handling in the human body. *Current Rheumatology Reports* **18**(6):34 DOI [10.1007/s11926-016-0587-7](https://doi.org/10.1007/s11926-016-0587-7).
- Johnson RJ, Nakagawa T, Jalal D, Sanchez-Lozada LG, Kang DH, Ritz E. 2013.** Uric acid and chronic kidney disease: which is chasing which? *Nephrology Dialysis Transplantation* **28**(9):2221–2228 DOI [10.1093/ndt/gft029](https://doi.org/10.1093/ndt/gft029).
- Kline RB. 2023.** *Principles and practice of structural equation modeling*. Fifth Edition. New York: The Guilford Press.
- Koto R, Nakajima A, Horiuchi H, Yamanaka H. 2021.** Real-world treatment of gout and asymptomatic hyperuricemia: a cross-sectional study of Japanese health insurance claims data. *Modern Rheumatology* **31**(1):261–269 DOI [10.1080/14397595.2020.1784556](https://doi.org/10.1080/14397595.2020.1784556).
- Latkin CA, Edwards C, Davey-Rothwell MA, Tobin KE. 2017.** The relationship between social desirability bias and self-reports of health, substance use, and social network factors among urban substance users in Baltimore, Maryland. *Addictive Behaviors* **73**(3):133–136 DOI [10.1016/j.addbeh.2017.05.005](https://doi.org/10.1016/j.addbeh.2017.05.005).
- Li Q, Li X, Wang J, Liu H, Kwong JS, Chen H, Li L, Chung SC, Shah A, Chen Y, An Z, Sun X, Hemingway H, Tian H, Li S. 2019.** Diagnosis and treatment for hyperuricemia and gout: a systematic review of clinical practice guidelines and consensus statements. *BMJ Open* **9**(8):e026677 DOI [10.1136/bmjopen-2018-026677](https://doi.org/10.1136/bmjopen-2018-026677).
- Liu R, Han C, Wu D, Xia X, Gu J, Guan H, Shan Z, Teng W. 2015.** Prevalence of hyperuricemia and gout in Mainland China from 2000 to 2014: a systematic review and meta-analysis. *Biomed Research International* **2015**:762820 DOI [10.1155/2015/762820](https://doi.org/10.1155/2015/762820).
- Maiuolo J, Oppedisano F, Gratteri S, Muscoli C, Mollace V. 2016.** Regulation of uric acid metabolism and excretion. *International Journal of Cardiology* **213**:8–14 DOI [10.1016/j.ijcard.2015.08.109](https://doi.org/10.1016/j.ijcard.2015.08.109).
- Mallat SG, Al Kattar S, Tanios BY, Jurjus A. 2016.** Hyperuricemia, hypertension, and chronic kidney disease: an emerging association. *Current Hypertension Reports* **18**(10):74 DOI [10.1007/s11906-016-0684-z](https://doi.org/10.1007/s11906-016-0684-z).

- Multidisciplinary Expert Task Force on Hyperuricemia and Related Diseases.** 2017. [Chinese multi-disciplinary consensus on the diagnosis and treatment of hyperuricemia and its related diseases]. *Zhonghua Nei Ke Za Zhi* **56**:235–248 DOI [10.3760/cma.j.issn.0578-1426.2017.03.021](https://doi.org/10.3760/cma.j.issn.0578-1426.2017.03.021).
- National Bureau of Statistics of China.** 2021. Main data of the seventh national population census. 11 May 2021. Available at [https://www.stats.gov.cn/english/PressRelease/202105/t20210510\\_1817185.html](https://www.stats.gov.cn/english/PressRelease/202105/t20210510_1817185.html).
- Ni P, Chen JL, Liu N.** 2010. Sample size estimation for quantitative studies in nursing research. *Chinese Journal of Nursing* **45**:378–380.
- Ohno I.** 2011. Relationship between hyperuricemia and chronic kidney disease. *Nucleosides, Nucleotides and Nucleic Acids* **30**(12):1039–1044 DOI [10.1080/15257770.2011.611484](https://doi.org/10.1080/15257770.2011.611484).
- Rai SK, Burns LC, De Vera MA, Haji A, Giustini D, Choi HK.** 2015. The economic burden of gout: a systematic review. *Seminars in Arthritis and Rheumatism* **45**(1):75–80 DOI [10.1016/j.semarthrit.2015.02.004](https://doi.org/10.1016/j.semarthrit.2015.02.004).
- Ramirez MEG, Bargman JM.** 2017. Treatment of asymptomatic hyperuricemia in chronic kidney disease: a new target in an old enemy—a review. *Journal of Advanced Research* **8**(5):551–554 DOI [10.1016/j.jare.2017.04.006](https://doi.org/10.1016/j.jare.2017.04.006).
- Richette P, Doherty M, Pascual E, Barskova V, Becce F, Castaneda-Sanabria J, Coyfish M, Guillot S, Jansen TL, Janssens H, Liote F, Mallen C, Nuki G, Perez-Ruiz F, Pimentao J, Punzi L, Pywell T, So A, Tausche AK, Uhlig T, Zavada J, Zhang W, Tubach F, Bardin T.** 2017. 2016 updated EULAR evidence-based recommendations for the management of gout. *Annals of the Rheumatic Diseases* **76**(1):29–42 DOI [10.1136/annrheumdis-2016-209707](https://doi.org/10.1136/annrheumdis-2016-209707).
- Russell MD, Rutherford AI, Ellis B, Norton S, Douiri A, Gulliford MC, Cope AP, Galloway JB.** 2022. Management of gout following 2016/2017 European (EULAR) and British (BSR) guidelines: an interrupted time-series analysis in the United Kingdom. *The Lancet Regional Health-Europe* **18**(4):100416 DOI [10.1016/j.lanepe.2022.100416](https://doi.org/10.1016/j.lanepe.2022.100416).
- Sapankaew T, Thadanipon K, Ruenroengbun N, Chaiyakittisopon K, Ingsathit A, Numthavaj P, Chaiyakunapruk N, McKay G, Attia J, Thakkinstian A.** 2022. Efficacy and safety of urate-lowering agents in asymptomatic hyperuricemia: systematic review and network meta-analysis of randomized controlled trials. *BMC Nephrology* **23**:223 DOI [10.1186/s12882-022-02850-3](https://doi.org/10.1186/s12882-022-02850-3).
- Schlesinger N.** 2005. Dietary factors and hyperuricaemia. *Current Pharmaceutical Design* **11**(32):4133–4138 DOI [10.2174/138161205774913273](https://doi.org/10.2174/138161205774913273).
- Shin HS, Lee HR, Lee DC, Shim JY, Cho KH, Suh SY.** 2006. Uric acid as a prognostic factor for survival time: a prospective cohort study of terminally ill cancer patients. *Journal of Pain and Symptom Management* **31**(6):493–501 DOI [10.1016/j.jpainsympman.2005.11.014](https://doi.org/10.1016/j.jpainsympman.2005.11.014).
- Skoczynska M, Chowaniec M, Szymczak A, Langner-Hetmanczuk A, Maciazek-Chyra B, Wiland P.** 2020. Pathophysiology of hyperuricemia and its clinical significance—a narrative review. *Rheumatology* **58**(5):312–323 DOI [10.1093/reum/2020.100140](https://doi.org/10.1093/reum/2020.100140).
- Tiawaskar M, Sholapuri D.** 2021. An assessment of knowledge, attitude, and practices of physicians in the management of hyperuricemia in India: a questionnaire-based study. *Journal of the Association of Physicians of India* **69**:11–12.
- von Lueder TG, Girerd N, Atar D, Agewall S, Lamiral Z, Kanbay M, Pitt B, Dickstein K, Zannad F, Rossignol P, High-Risk Myocardial Infarction Database Initiative Investigators.** 2015. Serum uric acid is associated with mortality and heart failure hospitalizations in patients with complicated myocardial infarction: findings from the high-risk myocardial infarction database initiative. *European Journal of Heart Failure* **17**(11):1144–1151 DOI [10.1002/ejhf.419](https://doi.org/10.1002/ejhf.419).

- World Health Organization.** 2008. Advocacy, communication and social mobilization for TB control: a guide to developing knowledge, attitude and practice surveys. Available at [http://whqlibdoc.who.int/publications/2008/9789241596176\\_eng.pdf](http://whqlibdoc.who.int/publications/2008/9789241596176_eng.pdf). (accessed November 22, 2022).
- Zhang X, Liu L, Liang R, Jin S.** 2015. Hyperuricemia is a biomarker of early mortality in patients with chronic obstructive pulmonary disease. *International Journal of Chronic Obstructive Pulmonary Disease* **10**:2519–2523 DOI [10.2147/COPD.S87202](https://doi.org/10.2147/COPD.S87202).
- Zhang M, Zhu X, Wu J, Huang Z, Zhao Z, Zhang X, Xue Y, Wan W, Li C, Zhang W, Wang L, Zhou M, Zou H, Wang L.** 2021. Prevalence of hyperuricemia among Chinese adults: findings from two nationally representative cross-sectional surveys in 2015–16 and 2018–19. *Frontiers in Immunology* **12**:791983 DOI [10.3389/fimmu.2021.791983](https://doi.org/10.3389/fimmu.2021.791983).
- Zheng L, Zhang L, Chen K, He Q.** 2022. Unmasking unexpected health care inequalities in China using urban big data: Service-rich and service-poor communities. *PLOS ONE* **17**(2):e0263577 DOI [10.1371/journal.pone.0263577](https://doi.org/10.1371/journal.pone.0263577).
- Zuzic Furlan S, Rusic D, Kumric M, Bozic J, Vilovic M, Vilovic T, Rada M, Cerovecki V, Tomicic M.** 2021. Medical students' perspective and knowledge of asymptomatic hyperuricemia and gout management: a cross-sectional study. *Healthcare* **9**(12):1639 DOI [10.3390/healthcare9121639](https://doi.org/10.3390/healthcare9121639).