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Dietary risk factors and trends of kidney stones in north Karnataka patients attending a urology clinic at tertiary care center-hospital-based study

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ABSTRACT

Introduction: The incidence of renal stones is estimated to be 13% - 15% in the past few decades and is constantly on the rise. The present study aims to find dietary risk factors and modify them as per the need, which is appealing to physicians and patients to prevent the reoccurrence of kidney stones as it is relatively safe and economical. *Methodology:* Patients of all age groups presenting with kidney stones for surgical management at our tertiary care center were recruited for the study. A detailed history of these KSD (kidney disease) patients was recorded, including their age, sex, residential address, details of diet, source of water, previous history of kidney stones, and any other metabolic syndromes. *Results:* The study involves 240 renal stone patients presenting to the urology clinic at the tertiary care center. 152 were male patients (63.3%) with an average age of 48.23±16.93, and 88 were females (36.6%) with an average age of 44.755±14.30. Other dietary risk factors have been assessed and details have been mentioned in the article. *Conclusion:* The present study's findings highlight the critical role of lifestyle risk factors in the reoccurrence of kidney stones within the north Karnataka population. The prominent findings of the study indicate that inadequate water intake, frequent red meat diet, and elevated levels of BMI become paramount. Hence, including a balanced healthy diet rich in vegetables and adequate water intake emerges as a practical approach to mitigate the risk of stone formation.

Keywords: Dietary, risk factors, Urolithiasis, kidney stones, North Karnataka population

1. INTRODUCTION

Urolithiasis is considered to be one of the highly prevalent diseases in most industrialized countries with an estimated prevalence of 13%-15% from the past few decades (Romero et al., 2010; Sorokin et al., 2017). The increased rate of the disease has shown its close relation with obesity and other metabolic disorders which are mainly contributed by changes in lifestyle and modern dietary habits (Taylor et al., 2005). Urolithiasis is initiated by mineral precipitation secondary to decreased fluid intake and over-saturation of urine. This is followed by the nucleation of crystals, aggregation, and growth of crystals measuring a few hundred microns. Further, these crystals agglomerate into small calculi and increase their size in the renal collecting system at different rates based on the underlying cause (Ang et al., 2020). The stone formation may lead to chronic kidney injury or end-stage kidney damage because of obstructive nephropathy (Shoag et al., 2014; Dhondup et al., 2018).

There are several types of kidney stones among which the most common one is calcium oxalate (60-65%) followed by calcium phosphate (10-20%), uric acid (6-8%), struvite (1-2%), and cystine (0.5-0.8%) (Lieske et al., 2014). Urolithiasis is a multifactorial process where genetic factors, anatomical, and functional abnormalities, and metabolic derangements may contribute as a risk factor amidst which diet plays a crucial role (Siener and Hesse, 2002). Literature search of various sorts from epidemiology to urinary chemistry states that diet is the main factor contributing to the prevalence of stone formation. Thus, finding dietary risk factors and modifying it as per the need is an appealing way for physicians as well as patients to prevent the reoccurrence of kidney stones as it is relatively safe and also economical (Borghi et al., 1996; Sangolli et al., 2021). The human diet is mainly composed of three major macronutrients, those are carbohydrates (4 kcal/gm), Lipids (9 kcal/gm), and proteins (4 kcal/gm).

The recommended composition of these nutrients is 40–50%, 10–30%, and 25–35% respectively which accounts for around 30-35 Kcal/Kg per day (Savarino et al., 2021). Calcium stones, representing the majority of kidney stones may be associated with oxalate or phosphate content of urine. Excessive dietary intake or presence of intestinal malabsorption syndromes or an increase in urinary calcium because of parathyroid disease influences the formation of calcium stones. On the other hand, a high dietary intake of proteins and purine-rich products or metabolic acidosis as a secondary cause of diabetes mellitus saturates urine with uric acid crystals and leads to the formation of uric acid stones which has become the second most common type of stone in the recent decades (Ang et al., 2020).

So, considering above mentioned facts, it's clear that Specific dietary intake guidelines based on the dietary assessment and metabolic evaluation can be considered to be more effective for the prevention of kidney stones. A reliable kidney stone analysis is also an essential predominant along with dietary assessment as urinary risk factors vary with each type of kidney stone. Dietary and lifestyle habits change vastly from one demographic region to another, and there has beenan increased prevalence of urolithiasis in recent years. There is a lack of evidence for risk factors and trends of kidney stones in the north Karnataka region. Hence considering these as a need for the study, the present study is focused on the assessment of various dietary intakes along with their brief medical history and lifestyle habits in kidney stone patients attending a tertiary care center in north Karnataka.

2. PATIENTS AND METHODS

The present cross-sectional study was conducted following the ethical clearance obtained from the University/Institutional ethical committee (KAHER/EC/20-21/001). Patients with all age groups presenting with kidney stones for the surgical management at our tertiary care center were recruited for the study. The number of subjects has been calculated at 95% CI considering an average 15% error in the estimate with 10% attrition for lost cases. A detailed history of these KSD (kidney disease) patients was recorded which included their age, sex, residential address, details of diet, source of water, previous history of kidney stones, and any other metabolic syndromes. Body mass index (BMI) was calculated by taking the patients' height and weight.

All the patients underwent surgical treatment for the removal of kidney stones, including percutaneous nephrolithotomy, open surgery, and retrograde intrarenal surgery. The surgically extracted stones/ stone fragments were analyzed for their chemical composition using FTIR spectroscopy. To determine the determinants associated with Urolithiasis, a Questionnaire (in three languages: English Marathi, and Kannada) was provided to all the study subjects. The Questionnaire was divided into three main categories: I) Sociodemographic characteristics, II) Clinical characteristics, and III) Detailed Dietary habits.

The questionnaire was prepared with multiple choices such as never, very less (less than one time in a month), less (1-2 times /month), moderate(1-2time/week), and more (2-3 times a day) and further these options were coded accordingly for analysis. After the complete collection of data, descriptive statistics were calculated by using IBM SPSS (Version 22.0 Armonk NY, Chicago USA) software for analyzing patients' questionnaire responses. Categorical variables were analysed by calculating their frequencies, and continuous variables were analysed by calculating mean, standard deviation, median, and range.

3. RESULTS

A total of 240 kidney stone patients attending a urology clinic of our tertiary care center participated in the study. Out of 240 cases,152 were male patients (63.3%) with an average age of 48.23±16.93 and 88 were females (36.6%) with an average age of 44.755±14.30. The overall average age of cases is the ratio of male and female cases was found to be 1.7: 1. The Body Mass Index (BMI) was calculated using the height and weight of individuals. The average BMI of males was26.07±3.14. The average BMI of females was 25.98±4.02 and overall was found to be 26.04±3.48. The details are mentioned in the (Table 1).

Table 1 Male and female ratio and BMI of kidney stone patients.

Gender	n	%	Age (mean)	BMI (Mean)
Male	152	63.3	48.23±16.93	26.07±3.14
Female	88	36.6	44.755±14.30	25.98±4.02
Total	240	100	46.83±16.16	26.04±3.48
Male: Female Ratio	1.7: 1			

We analyzed the distribution of cases among various age groups and found that the highest number of cases in both males and females were found in the age group above 50 with a total percentage of 43.33%. The second highest was found in the age group of 41-50 with a total percentage of 21.7%. In the study, 2 male cases and 2 female cases were found to be podiatric cases falling in the age group interval of 1-10. The details of the same are mentioned in the (Table 2).

Table 2 Distribution of cases among various age groups of kidney stone patients.

Age distribution				
Age group	**Male 'n'**	**Female 'n'**	**Total 'n'**	**Total Percentage**
0-10	2	2	4	1.7
11-20	6	4	10	4.2
21-30	20	12	32	13.3
31-40	26	12	38	15.8
41-50	32	20	52	21.7
Above 50	66	38	104	43.3
Total	152	88	240	100.0

In the present study when we analyzed dietary habits among all kidney stone patients, we found that 64% of the cases used to consume both vegetarian and non -vegetarian. Whereas 33.5% were pure vegetarians and around 2.91% of the cases used to consume a vegetarian diet with egg on their daily routine. The details are shown in (Table 3).

Table 3 Dietary habits in kidney stone patients.

	'n'	Percentage
Veg	80	33.5
Both (Veg and Non-veg)	153	64
Veg and egg	7	2.91

Total	240	100

Further, we analyzed in detail red meat eaters and white meat consumers among non-vegetarian cases and found that around 49.6% of the non-vegetarians consume red meat (Pork/beef/mutton) more than twice a week, which is the main contributor to the accumulation of more uric acid. Along with this around 60.1% of non-vegetarians consume white meat (Fish and chicken) more than twice a week. The details are given in (Table 4).

Table 4 Red meat and white meat consumption among non-vegetarian consumers.

Non-vegetarian	More than twice a week	Less consumption	Total
Red meat consumption (Pork/beef/mutton)	76 (49.6%)	77 (50.3%)	153
White meat consumption (Fish and chicken)	92 (60.1%)	61 (39.8%)	153

Among these cases, we further analyzed their detailed food habits, and we found that around 61.5% of the cases' staple diet was rice and Jawar (Figure 1). 15.86% used to consume mixed cereals, and the other 15% used to consume only rice as their staple diet. Around 2.08% of the cases used to consume Maida on a daily basis, and their staple diet was bread (mostly in Goan cases). Occasional dietary habits were also analysed (Figure 2).

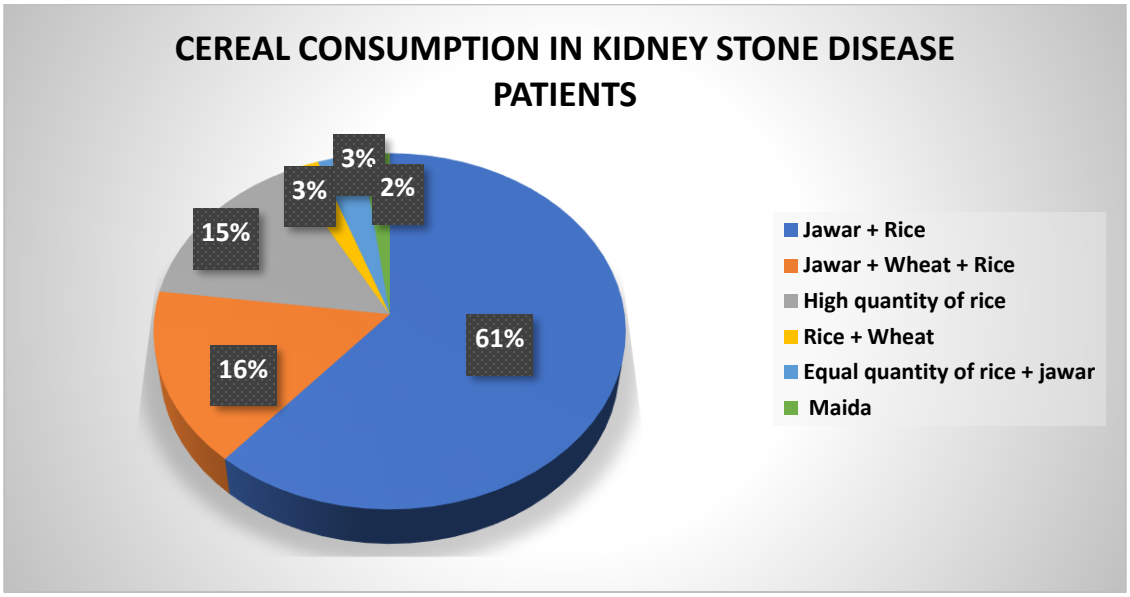

Figure 1 Cereal consumption in kidney stone disease patients.

With this brief history, we correlated risk factors such as age, gender, and BMI with a reoccurrence of kidney stone disease. We applied logistic regression for the age and reoccurrence of kidney stone disease, we found a significant association between these two variables, Chi-square (d.f =5) =14.17, P = 0.015(>0.05) which suggests that as age advances the risk of reoccurrence of kidney stones will also increase. BMI also was significantly correlating with reoccurrence, P = 0.10 (>0.05). Correlation of gender and reoccurrence showed p p-value greater than 0.05 (P=0.507). It suggests that gender is an independent factor in the reoccurrence of kidney stones. Details are mentioned in (Table 5).

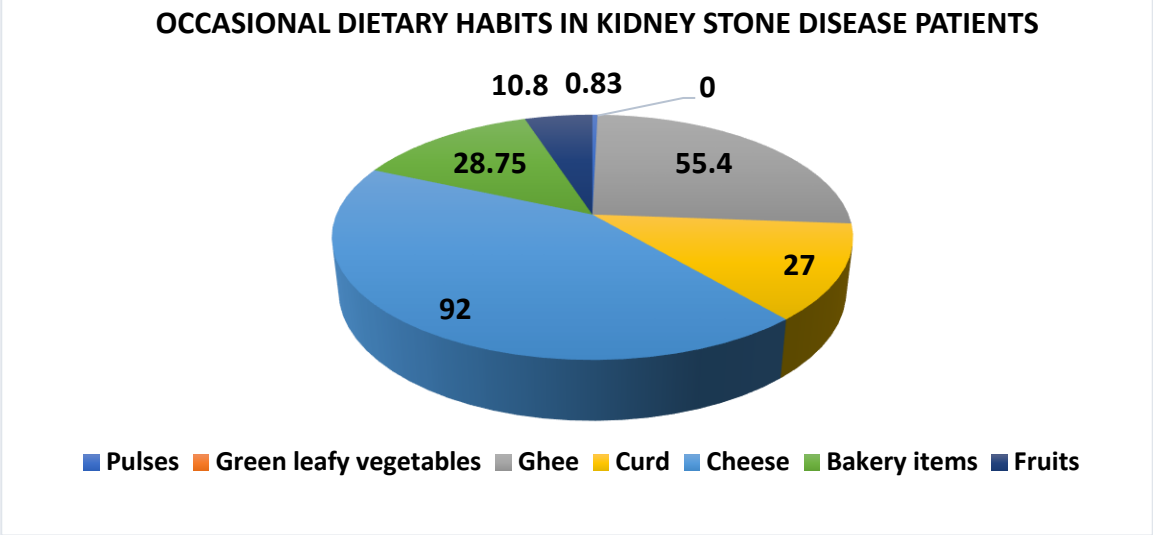

Figure 2 Occasional dietary habits in kidney stone disease patients

Table 5 Pearson Chi-Square Tests (Correlation of age, gender, BMI with reoccurrence of kidney stones.

Reoccurrence of kidney stone disease	Age	BMI	Gender
Chi-square	14.172	11.440	0.441
Df	5	3	1
Sig.	0.015*	0.010*	0.507
	(d.f =5) =14.17, p<0.015(>0.05)	(d.f=5)=14.17, p<0.015(>0.05)	p<0.507(<0.05)

*. The Chi-square statistic is significant at the p<0.05 level

Further, we calculated the association of dietary habits and intake of water with the reoccurrence, and we found that dietary habits (P = 0.032(>0.05)), red meat consumption (P = 0.017(>0.05), and quantity of water intake (P = 0.023 (>0.05)) showed significant correlation with the reoccurrence of kidney stones with P value less than 0.05. Intake of white meat did not show a significant association with a reoccurrence of kidney stones with a p-value = 0.358. The Details are mentioned in the (Table 6).

Table 6 Pearson Chi-Square Tests (Correlation of dietary habits with reoccurrence of kidney stones.

Reoccurrence of kidney stone disease	Diet (Veg/non-veg)	White meat	Red meat	Quantity of water intake
Chi-square	6.876	4.372	13.847	11.363
Df	2	4	5	4
Sig.	.032*	.358	.017*	.023*
	(d.f =2) =6.876, p<0.032 (>0.05)	(d.f=4)=4.372, p<0.358 (<0.05)	(d.f=5) =13.847, p< 0.017 (>0.05)	(d.f =4) =11.363, p< 0.023 (>0.05)

*. The Chi-square statistic is significant at the p<0.05 level.

The collected kidney stones samples from 240 patients were dried and pulverized and 0.1g of collected kidney stones sample from 240 patients were dried and pulverized and 0.1g of each sample was subjected to FTIR (Fourier transform infra-red spectroscopy) analysis. Based on the results of FTIR, kidney stone samples were classified based on their chemical composition. The stone samples were also categorized according to the patient's residence.

The results of the chemical composition of kidney stones, according to the residents, showed that the highest number of patients were from Karnataka (84.16%). And most common type of the stone was calcium oxalate (58.32%). The second most common type of kidney stone was uric acid stone (16.65%). The least common type was struvite stone and mixed stones (0.82%) and cysteine stone were not seen. The total number of cases from Maharashtra and Goa was 32 (13.33%) and 6 (2.5%) respectively. As the total number of cases from Maharashtra and Goa was on the lesser side, the most common type of kidney stone cannot be justified significantly. The details are mentioned in (Table 7).

Table 7 Chemical composition of kidney stones with the residence of KSD patients.

Residence	Pure Calcium oxalate		Pure uric acid +Calcium oxalate with uric acid		Calcium oxalate + phosphate		Calcium oxalate +phosphate +carbonate		Calcium oxalate+ carbonate		Struvite Stones		Mixed Stones		Total	
	N	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Karnataka	120	59.9	30	14.8	24	11.8	22	10.8	2	0.99	2	0.99	2	0.99	202	84.1
Maharashtra	16	50	8	25	2	6.25	2	6.25	4	12.5	0	0	0	0	32	13.3
Goa	4	66.6	2	33.3	0	0	0	0	0	0	0	0	0	0	6	2.5
Total	140	58.3	40	16.6	26	10.8	24	24	6	2.5	2	0.82	2	0.82	240	

Classification of kidney stones following dietary habits showed that higher concentrations of all kinds of stones were observed in non-vegetarian dietary habits. Of the total 140 calcium oxalate stones, 88(62%) cases were non-vegetarian eaters; among 56 uric acid stones, 22(55%) were non-vegetarians. Struvite and mixed stone cases were only 2 and both were non-vegetarians (Figure 3).

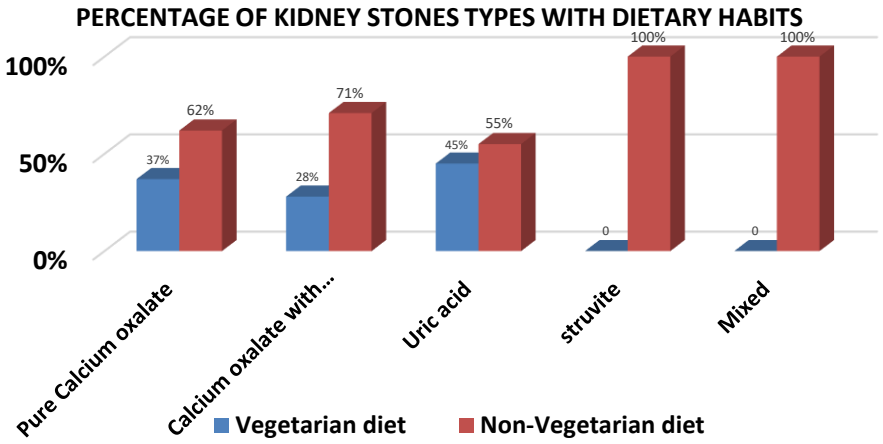

Figure 3 Classification of kidney stones with dietary habits.

4. DISCUSSION

The earlier literature states that the male gender was more prone to have kidney stones compared to females (Chen et al., 2019). In recent years, there has been a significant expansion in the number of females compared to males. Although in our present study males were more affected compared to females, we evidenced a decrease in the male-to-female ratio among kidney stone patients which was around 1.7:1. The mechanism behind the difference in the risk profile of males and females is not fully elucidated, but diet and lifestyle habits can partially explain the change of risk profile in male and female (Ferraro et al., 2022). A prospective study conducted by

Prochaska et al., (2018) states that the post-menopausal status of a female was associated with an increased risk of an incident renal stone, indirectly suggesting the hormonal role in increasing the risk of urolithiasis.

In contrast to these findings, a prior study in the distinct NHS I cohort did not show any association between natural menopause and incident kidney stones (Mattix-Kramer et al., 2003). In our present study, a maximum number of female cases were above the age of 50 which supports the results of Prochaska et al., (2018) considering menopausal age as one of the risk factors for urolithiasis. So, detailed studies have to be conducted on the menopausal age group to understand the mechanism behind the menopausal age group as a risk factor. Irrespective of gender, age alone can also be considered to be one of the risk factors in causing kidney stone diseases as in our study highest number of male cases have been observed above the age of 50, and age factor has shown a significant association with reoccurrence of kidney stones, which suggests that as age advances the risk of urolithiasis increases in both genders.

Many studies indicated that kidney stone disease is a systematic disease and is related to metabolic syndrome (Wong et al., 2015). Increased prevalence of urinary stones is found in people with higher BMI (Takeuchi and Aoyagi, 2019). Certain cross-sectional studies have reported that increased body weight is associated with lowering the urinary PH and increasing the uric acid levels, causing an increase in the risk of urolithiasis (Maalouf et al., 2004). Another cohort study conducted in the United States observed that increased BMI values were associated with a higher risk of urolithiasis in a dose-response relationship in men and women. The relative risk of developing renal stones was 1.33 times higher (95% CI, 1.088-1.62) in cases with a BMI of ≥30.0 than in those individuals with a BMI of 21.01-22.92 (Taylor et al., 2005).

In our study considering normal (BMI < 25), overweight (BMI 25–29.9), and obese (BMI > 30), we found significantly higher average BMI in both male (26.07±3.14) and female (25.98±4.02) cases, and BMI showed a significant association with a reoccurrence of urolithiasis. Considering our results and previous study proofs, BMI can be considered one of the major risk factors for kidney stone disease, and it is also having an impact on reoccurrence. So, managing body weight can be considered an important tool in preventive measures of urolithiasis. Nutrition is one of the important modifiable risk factors associated with the increased prevalence of urolithiasis in the general population. Nowadays, nutritional treatment and dietary modification are important fundamental tools in reducing the risk of urolithiasis (Skolarikos et al., 2015).

Studies have reported that a diet rich in vegetables and fruits has an alkalizing potential and can neutralize the acid load generated by the metabolism of ingested protein. These vegetarian foods increase the urinary pH and excrete citrate content and help in the reduction of supersaturation of urine with calcium and uric acid (Meschi et al., 2004). On the other hand, decreased urine pH and citrate excretion caused by an increased animal protein diet results in high dietary proton and high acidity, leading to several types of kidney stones, particularly the most prevalent ones, i.e., calcium and uric acid stones (Moe and Huang, 2006). The dietary evaluation of the current study reveals that the frequency of consumption of animal protein (meat, fish, poultry and eggs) was high among most of the kidney stone patients.

With these preliminary dietary details, we categorized non-vegetarians into red meat eaters (beef/pork/mutton) and white meat eaters (fish/poultry) and observed a significant number of cases of consuming high amounts of red meat more than twice a week. Though white meat consumption among the population was higher than that of red meat, we found a significant association with the reoccurrence of kidney stones in red meat eaters. This states that increased intake of red meat results in more acid load and reduced excretion of citrate, which may lead to an increased risk of kidney stone formation. So, our study results suggest that there should be restrictions on the consumption of animal protein, particularly red meat, and the intake of more vegetables and fruits has to be encouraged, which helps to neutralize the proton load.

These dietary modifications help to reduce the risk of reoccurrence of urolithiasis. Further, we analyzed in detail other dietary habits such as intake of pulses, cereals, oil, ghee, and bakery items and found that an equal quantity of jawar and rice was the staple diet among most of the patients. Though the consumption of fruits and vegetables was not in adequate amounts, it did not find any significant association with reoccurrence. Apart from detailed dietary habits we also analysed intake of various fluids and their impact on urolithiasis. Details of the intake of various fluids in kidney stone patients have been published in our previous article (Sangolli et al., 2022). We found that intake of aerated drinks and alcohol was considerably higher among male kidney stone patients who had reoccurrence than the first-time stone formers.

In the present study, we analyzed the relation between intake of less water and the reoccurrence of kidney stones and found a significant association between these variables, which suggests that less water intake will eventually saturate the urine with minerals and also decrease the urinary pH. which gradually increases the risk of stone formation. Hence, the existing literature and evidence of

the present study recommends drinking enough water to have urine excretion between 2 to 2.5 liters per day to reduce the risk of reoccurrence (Gamage et al., 2020). There is less evidence available on types of prominent kidney stones occurring among the north Karnataka population. So, in the present study along with analysis of various risk factors, we also collected patient's kidney stones to identify their chemical composition. In our tertiary care hospital, patients from three different states come for their treatment, e. Karnataka, Maharashtra and Goa.

But the Majority number will be coming from Karnataka, precisely from North Karnataka. In our population, we found the highest number of cases (60%) with calcium oxalate stones. Though the findings were similar to most of the other studies done in different geographical areas, the percentage of the cases significantly varied from one population to another. A study conducted by Halinski et al., (2021) in different global regions reports that calcium-rich stones are most prevalent in all countries, yet the frequency of various types of kidney stones differs from country to country. Another review study conducted in the Indian continent by Guha et al., (2019) reports that 80-90% of kidney stones will be made up of calcium combined with oxalates or phosphates or mixtures. The study also reports that in the Indian population, 5-10% of stones will be composed of uric acids (Guha et al., 2019).

Our study has shown contradictory results for these previous statements, as we found around 16% of stones were composed of uric acid. This was the second-highest type of stone found in this North Karnataka region of India. Urinary pH decreases because of the acid load given by the diet, and low urinary pH is one of the main reasons for uric acid stone formation. Hyperuricosuria is also caused by a purine-rich diet, especially animal protein such as poultry and meat (Villegas et al., 2012). In the present study high animal diet consumption can be considered to be one of the main causes for increased prevalence of uric acid stones. We found less than 1% of mixed stones and struvite stones in the population. The above finding strongly suggests that there is a diversity in the composition of kidney stones across different geographical regions based on food, culture, climate, and various lifestyle habits. So, more studies have to be conducted in various regions to find risk factors for urolithiasis.

5. CONCLUSION

In recent years urolithiasis has been a highly prevalent disease, and identifying modifiable risk factors is prime essential to reducing the reoccurrence rate of urolithiasis. The findings of the present study highlight the critical role of lifestyle risk factors in the reoccurrence of kidney stones within the North Karnataka population. Addressing risk factors such as inadequate water intake, excessive red meat consumption, and elevated BMI becomes paramount. Hence by fostering awareness and implementing proactive measures, individuals can take significant strides towards reducing the risk of reoccurrence of urolithiasis. Further studies have to be conducted considering higher populations in different geographical areas to identify risk factors in different zones to take preventive measures to reduce the burden of urolithiasis.

Limitations

The number of participants was less as it was a hospital-based study. The same study can be conducted in different communities to create awareness about the preventive measures of kidney stone disease.

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Authors' Contributions

RBN developed the concept designed, AS collected the data, wrote the manuscript and executed the study, SCG edited the manuscript, performed the statistical analysis. All the authors reviewed and approved the manuscript.

Ethical approval

The study was approved by the Medical Ethics Committee of KAHER Ethics Committee on Human Subjects (Ethical approval code: KAHER/EC/20-21/001).

Informed consent

Written & Oral informed consent was obtained from all individual participants included in the study.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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