

# Impact Of Hydration Status And Dietary Patterns On Ureteral And Renal Stone Formation: A Comparative Study Of Vegetarians And Non-Vegetarians

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## ABSTRACT

**Background:** The disease of stones in the kidneys (urolithiasis) is increasingly becoming a global health issue, particularly renal stone formation, which is influenced by several factors such as hydration and nutrition.

**Objectives:** This research aimed at assessing the impact of dietary patterns classified as vegetarian and non-vegetarian on dehydration.

**Methods:** A cross-sectional study was conducted with 100 patients diagnosed with kidney stones from the JSS Hospital in Karnataka, India. Participants completed a survey with questions regarding personal information related to age, hydration practices, nutrition and diet to collect pertinent data. Descriptive analysis along with bivariate analysis and multiple regression were analyzed on SPSS after controlling for age, sex, body mass index, and history of chronic renal disease.

**Results:** According to the findings of this study, people classified as dehydrated had non-vegetarian diets while having untreated chronic kidney disease suggestive that they have higher stone burden disorder than slender fit persons not doing any work physically. Chronic kidney diseases are defined by grade lower than one percent or functioning kidneys that progressively leads towards failure over a period greater than three months.

**Keywords:** Renal stone, urolithiasis, dietary patterns, dehydration

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## INTRODUCTION

Urolithiasis is the formation of stones within the urinary tract. It is a growing global health concern that affects millions of individuals and places a significant burden on healthcare systems [1]. The most common sites for stone formations are ureters and kidneys. The stone formation can lead to several urinary obstructions, infections, and pain, and in chronic cases, it may impair the renal functioning [2]. Stone formation is a multifactorial process which involves various factors. It happens due to supersaturation of urine with lithogenic substances such as calcium, oxalate, phosphate, and uric acid [3]. When these substances are too concentrated it leads to nucleation, crystal growth, aggregation, and retention within the renal tubules or urinary tract [4]. There are various factors that contribute to stone formation such as dehydration, dietary habits, poor water quality, climate, genetics etc. According to the Global Burden of Disease (GBD) 2019 report, it highlights the number of people developing stones has increased by more than 48% between 1990 and 2019[5]. Factors such as low urine volume, alterations in urinary pH, and the presence or absence of inhibitors (e.g., citrate, magnesium) and promoters (e.g., uric acid, oxalate) of crystallization play critical roles in this process [3]. There are several reasons and factors which contribute to the formation of Stone. Some can be changed and some cannot be changed, it can be changed through diet and water intake and some which cannot be changed which is genetics. One of the major cause of renal stone is not drinking enough water which can lead to dehydration and which makes the Urine too concentrated, which makes it easier to form crystals [4] This occurs due to the concentration of certain minerals like calcium oxalate, Calcium phosphate, uric acid and Cystine which forms crystals in the kidney [3]. Once the crystals are formed they grow in size and bind together through a process called crystal aggression, creating large clusters [3]. However,

for these clusters to eventually form stones, they must be retained within the kidney or urinary tract, rather than being flushed out through normal urine flow [3]. Factors that contribute to the retention of crystals or low urine volume, slow urine flow, anatomical abnormalities and damage to the lining of the urinary tract, which may provide sites where crystals can adhere [3]. Once retained, these aggregates serve as a core around which further mineral layers and organic matter such as protein and all debris can accumulate. This gradual build up over time, leads to the development of mature kidney stones, which can vary in size, composition and clinical impact depending on the individual's diet, hydration, genetic predisposition, and urinary chemistry [4]. Dehydration is characterized by reduced fluid intake or excessive fluid loss, which leads to concentrated urine with elevated levels of lithogenic substances such as calcium, oxalate, and uric acid [4]. This creates an ideal environment for crystallization and stone formation [3]. In dietary choices specifically, the consumption of vegetarian versus non-vegetarian diets. It plays a significant role in stone composition and recurrence [3]. Vegetarian diets, which are often rich in plant-based foods such as green leafy vegetables, nuts, seeds, legumes, and whole grains, are typically high in oxalate compounds, which bind with calcium in the urine to form calcium oxalate stones [4]. It is the most common type of renal calculi. Foods such as spinach, beans, sweet potatoes, and chocolate are particularly high in oxalates [4]. However, these are low in purines, which are broken down into uric acid in the body. As a result, vegetarian foods have a low risk of uric acid stone formation due to reduced uric acid excretion in urine [3]. Non-vegetarian diets are typically high in animal protein sources such as meat, poultry, and fish. These are rich in purine, which can lead to increased production of uric acid [3]. High intake of proteins also lowers the urinary pH, creating a more acidic environment, which can favor uric acid stone formation [3]. However, animal protein reduces the urinary excretion of citrate, which is a natural inhibitor of stone formation, and increases calcium and oxalate excretion, further contributing to the risk of calcium oxalate and calcium phosphate stones [4]. A comprehensive understanding of the relationship between hydration and dietary habits is crucial in developing effective, evidence-based nutritional and lifestyle strategies for the prevention and control of ureteral and renal stone formation [1] [3]. The amount and quality of fluid intake play a crucial role in determining the urinary volume and solute concentration. The two key elements influencing the risk of crystal formation [4]. When fluid consumption is insufficient, urine becomes more concentrated, which leads to a higher concentration of lithogenic substances such as calcium, oxalate, phosphate, and uric acid. This biochemical environment encourages the development of crystals, which can eventually aggregate into the formation of stones [3]

## RESEARCH METHODOLOGY

**Research Design:** This study adopts a comparative cross-sectional design. Data was collected from individuals who were diagnosed with renal or ureteral stones at a single point in time, using a structured questionnaire administered in a hospital setting. Rationale for choosing the design. A cross-sectional study, which is appropriate for identifying associations between dietary patterns, hydration practices, and the presence of kidney stones without manipulating any variables. Based on their report, dietary practices and fluid intake allow a comparison between groups such as vegetarian and non-vegetarian. The hospital-based setting enabled access to the relevant population to collect data within the given timing.

**Study Population:** This study targets individuals of all age groups and both genders (male and female) residing in Mysore, Karnataka, India. Inclusion criteria are those diagnosed with a renal or ureteral stone and exclusion criteria with other complications or not willing to participate in the study.

### Sample Size and Sampling Technique

The sample size for the study was determined based on the data availability from the patients diagnosed with ureteral and renal stones in came for the investigation at JSS Medical College & Hospital, Mysuru. Since this is a cross-observational study using patients' records and dietary surveys, a power analysis was not carried out hence, a total of 100 patients who were willing to enroll based on the inclusion criteria were included in the study. The sample size was considered adequate to provide a representative overview of the dietary and hydration patterns related to kidney stone formation in the local population. A purposive sample technique was employed where participants were selected based on certain criteria, such as those diagnosed with ureteral and renal stones with available dietary, hydration, and lifestyle information. This non probability sampling method was chosen because it is allowed for the selection of the individual who could provide relevant insights

into the research questions.

Purposive sampling was ideal for this study as it focuses on a targeted group with a known medical condition that is, urethral and renal stone and ensures that collected data are specific to research aim, a sample size of 100 patient’s, representing different age groups, gender and dietary vegetarian habitats such as vegetarian and non- vegetarian.

**Data collection tools**

To ensure comprehensive data capture a combination of structure, tools and patients record was used. These tools were designed to access various factors, contributing to urethral and renal stone formation. Especially focusing on dietary and hydration patterns. A validated structured questionnaire was developed and given to all the patients having urethral and renal Stone. It includes both closed and frequency based questions to ensure clarity and consistency. The questionnaire contains the following questions such as; Personal and demographic information, Dietary pattern using a food frequency questionnaire, Fluid consumption habits and Medical history related to kidney disorders

Demographic detail: Data such as age, gender, height, weight, and BMI were obtained. This information aids in classifying patients into age groups and BMI categories, which provide information on the physical status regarding the development of stones. History and diagnosis: Questions were raised regarding whether there was a history of renal or ureteral stones earlier or not. Family history of stone disease whether other kidney pathology such as urinary tract infection or CKD and its stages were present or not. Dietary assessment: To determine the dietary intake and pattern, a food frequency questionnaire was employed to assess the frequency of intake of particular foods. Participants were inquired regarding the amount of fluid intake daily, i.e., the amount of water intake in terms of less than one liter, one to two liters, or greater than two liters on a daily basis. This information was used to calculate the level of dehydration and its relation with the stone development.

The Institutional ethical committee has provided the ethical clearance before the study had begun. The patient's medical information was kept private and voluntarily participated in this research. The participants could leave the study at any time without consequences. The patient's identity was protected.

**Statistical analysis:**

In the study, the data collected were analyzed with the Statistical Package for the Social Sciences (SPSS). Descriptive statistics in the form of frequencies and percentages were employed to describe demographic, lifestyle, and clinical features of the subjects. Bivariate analysis was carried out using Chi-square tests and odds ratios (OR) at 95% confidence intervals to evaluate correlations between kidney stone formation and factors such as age, gender, BMI, hydration status, type of diet, and medical history. For the control of possible confounding variables, multivariate logistic regression analysis was used. The Mantel-Haenszel test was further used to test the interaction effects of diet and hydration status on the risk of kidney stones. A p-value of < 0.05 was regarded as statistically significant. The data were analyzed by using descriptive analysis, ANOVA (Analysis of Variance), Mantel-Haenszel chi-square statistic, multivariate logistic regression model.

**RESULTS AND DISCUSSION**

**Table-1 Categorical Distribution of Demographic, Lifestyle, and Health Characteristics of Study Participants**

Variables	Categories	Count	Percent
Age Group	18-25	9	9.0%
	26-35	22	22.0%
	36-45	18	18.0%
	46-55	24	24.0%
	≥56	27	27.0%
Gender	Male	67	67.0%
	Female	33	33.0%
	Underweight	14	14.0%
	Normal	15	15.0%
	Overweight	14	14.0%

<b>BMI</b>	Obese	57	57.0%
<b>Kidney Stones</b>	Yes	29	29.0%
	No	71	71.0%
<b>Hydration Status</b>	Dehydrated	62	62.0%
	Adequate Hydrated	38	38.0%
<b>Diet Type</b>	Vegetarian	34	34.0%
	Non-Vegetarian	66	66.0%

The descriptive summary of the study population (N=100) reveals key demographic and health-related patterns. Age-wise, participants are fairly distributed, with the largest group (27%) being 56 years or older, followed by 24% aged 46–55 years, indicating that over half of the sample is middle-aged or older. The gender distribution shows a male predominance, with 67% of participants being male. BMI, categorized into standard groups, shows a high prevalence of obesity (57%), while only 15% fall within the normal BMI range, and 14% each are classified as underweight or overweight— highlighting a significant imbalance in healthy weight status. In terms of kidney health, 29% of participants reported having kidney stones, a notable proportion that may warrant further investigation into associated risk factors. Hydration status shows that a majority (62%) of individuals were dehydrated, which is concerning given its known association with kidney stone formation and other renal issues. Dietary patterns, after grouping into vegetarian and non-vegetarian categories, reveal that two-thirds of the participants (66%) follow a non-vegetarian diet. This demographic and lifestyle profile provide a foundational understanding of the sample and suggest potential areas for targeted health interventions, particularly around weight management, hydration, and diet in relation to kidney health.

**Table-2 Bivariate Analysis of Demographic, Clinical, and Lifestyle Factors Associated with Kidney Stone Formation**

Variables	Category	Kidney stones						p-value
		Present		Absent		Total		
		n	%	n	%	N	%	
<b>Gender</b>	Female	18	62.07	49	69.01	67	67.00	0.503
	Male	11	37.93	22	30.99	33	33.00	
<b>Age</b>	18-25	3	10.34	6	8.45	9	9.00	0.08
	26-35	7	24.14	15	21.13	22	22.00	
	36-45	5	17.24	13	18.31	18	18.00	
	46-55	7	24.14	17	23.94	24	24.00	
	≥56	7	24.14	20	28.17	27	27.00	
<b>BMI</b>	underweight	5	17.24	9	12.68	14	14.00	0.17
	normal	2	6.90	13	18.31	15	15.00	
	overweight	1	3.45	13	18.31	14	14.00	
	obese	21	72.41	36	50.70	57	57.00	
<b>Family history of Kidney Stone</b>	Yes	6	20.69	20	28.17	26	26.00	0.44
	No	23	79.31	51	71.83	74	74.00	
<b>Other Kidney conditions</b>	No	18	62.07	52	73.24	70	70.00	0.778
	Yes (UTI)	5	17.24	17	23.94	22	22.00	
	Yes (CKD)	3	10.34	1	1.41	4	4.00	
	Yes(CKD Stage 1)	3	10.34	1	1.41	4	4.00	
<b>Hydration Status</b>	Adequate Hydrate	12	41.38	26	36.62	38	38.00	0.657
	Dehydrate	17	58.62	45	63.38	62	62.00	
<b>Diet Type</b>	Non-Vegetarian	22	75.86	44	61.97	66	66.00	0.187
	Vegetarian	7	24.14	27	38.03	34	34.00	
<b>Other Kidney conditions</b>	No	18	62.07	52	73.24	70	70.00	0.271
	Yes	11	37.93	19	26.76	30	30.00	
	<b>Total</b>	<b>29</b>	<b>29</b>	<b>71</b>	<b>71</b>	<b>100</b>		

This table presents a bivariate analysis examining the association between kidney stone formation and various demographic, clinical, and lifestyle variables using odds ratios (OR) and p-values. Although none of the associations reached statistical significance ( $p > 0.05$ ), some notable trends were observed. Males had higher, though not statistically significant, odds of developing kidney stones compared to females (OR = 1.36,  $p = 0.503$ ). Individuals following a vegetarian diet showed higher odds of stone formation (OR = 1.93,  $p = 0.187$ ), and those classified as dehydrated had a modestly elevated risk (OR = 1.22,  $p = 0.657$ ). Among BMI categories, overweight individuals demonstrated the highest odds (OR = 7.22), although the wide confidence interval suggests the estimate is unstable due to a small subgroup size. Variability was also observed among individuals with other kidney-related conditions, with some subgroups showing elevated or reduced odds, reflecting complex clinical interactions. Overall, while no variable demonstrated a statistically significant association, the observed patterns highlight potential risk trends that merit further investigation in larger, more powered studies.

**Table-3 Association Between Hydration Status and Kidney Stone Formation**

Hydration Status	Number of Patients with Kidney stones	Total Number of Patients	Chi-Square	
Dehydrated	17 (27.4%)	62	0.198	0.656
Adequate Hydrated	12 (31.6%)	38		

This table examines the association between hydration status and the occurrence of kidney stones among participants. Of the 62 individuals classified as dehydrated, 27.4% (17 patients) had kidney stones, whereas 31.6% (12 out of 38) in the adequately hydrated group were affected. The Chi-square test results ( $\chi^2 = 0.198$ ,  $p = 0.656$ ) indicate no statistically significant difference in kidney stone prevalence between the two hydration groups. Therefore, within this study sample, hydration status does not appear to have a significant impact on the risk of developing kidney stones.

**Table-4 Association Between Diet Type and Kidney Stone Formation**

Diet Status	Number of Patients with Kidney stones	Total Number of Patients	Chi-Square	P-value
Vegetarian	7 (20.6%)	34	1.7703	0.183
Non-Vegetarian	22 (33.3%)	66		

This table summarizes the relationship between diet type and the occurrence of kidney stones among study participants. Among vegetarians, 7 out of 34 individuals (20.6%) had kidney stones, whereas the prevalence was higher among non-vegetarians, with 22 out of 66 individuals (33.3%) affected. A Chi-square test was performed to assess the association, resulting in a value of 1.7703 with a p-value of 0.183. Although the proportion of kidney stones was higher in the non-vegetarian group, the difference was **not statistically significant**, suggesting that diet type, in this sample, does not have a clear association with kidney stone formation.

**Table-5 Association Between Diet Type, Hydration Status, and Kidney Stone Risk: Mantel-Haenszel Analysis**

Hydration Status	Diet Type	Kidney Stones	Total Number of patients	Risk (%)	Mantel-Haenszel chi-square	OR	
Dehydrated	Veg	6	28	21.4			
	Non-Veg	11	34	32.4			

Adequate Hydrated	Veg	1	6	16.7	1.0158	0.519	0.314
	Non- Veg	11	32	34.4			

This table shows the risk of kidney stone formation across different diet types (vegetarian vs. non-vegetarian) stratified by hydration status, along with results from the Mantel-Haenszel test. Among dehydrated participants, 21.4% of vegetarians and 32.4% of non-vegetarians had kidney stones, while among adequately hydrated individuals, these risks were 16.7% and 34.4%, respectively. The Mantel-Haenszel chi-square statistic of 1.016 ( $p = 0.314$ ) with an odds ratio of 0.519 indicates that, after adjusting for hydration status, there is no statistically significant association between diet type and kidney stone formation. Thus, diet type does not appear to significantly affect kidney stone risk when considering hydration status in this sample.

**Table-6 Association of Demographic and Clinical Factors with Kidney Stone Formation**

Variables	Categories	Number of Patients with Kidney stones	Total Number of Patients	Chi-Square	P-value
Age	18-25	3 (33.3%)	9		0.99
	26-35	7 (31.8%)	22		
	36-45	5 (27.8%)	18		
	46-55	7 (29.2%)	24		
	≥56	7 (25.9%)	27		
BMI	Underweight	5 (35.7%)	14		0.07
	Normal	2 (13.3%)	15		
	Overweight	1 (7.1%)	14		
	Obese	21 (36.8%)	57		
Family history of kidney stones	No	23 (31.1%)	74		0.439
	Yes	6 (23.1%)	26		
Other Kidney Conditions	No	18 (25.7%)	70	9.01	0.029
	Yes (UTI)	5 (22.7%)	22		
	Yes (CKD)	3 (75%)	4		
	Yes (CKD Stage 1)	3 (75%)	4		
Gender	Male	18 (26.9%)	67	0.449	0.503
	Female	11 (33.3%)	33		

This table explores the relationship between several demographic and clinical variables and the occurrence of kidney stones. No statistically significant association was found between kidney stone formation and age ( $p = 0.99$ ), gender ( $p = 0.503$ ), or family history of kidney stones ( $p = 0.439$ ). BMI approached statistical significance ( $p = 0.07$ ), with the highest prevalence observed in the obese (36.8%) and underweight (35.7%) categories. Notably, a significant association was found between other kidney conditions and kidney stone occurrence ( $p = 0.029$ ), with individuals having CKD or CKD Stage 1 showing a particularly high prevalence (75%) of stones. These findings suggest that while demographic factors alone may not strongly predict kidney stone risk, the presence of underlying kidney conditions may play a more critical role.

**Table-7 Adjusted Effects of Diet Type and Hydration Status on Kidney Stone Formation Controlling for Confounders**

Predictor	B (Coef)	SE	OR	95% CI for OR	P-value
Gender	0.332	0.704	1.39	[.5181222-3.754924]	0.51
Age	0.011	0.182	1.01	[.7104646-1.440059]	0.949
Family					

history of kidney stone	0.372	0.822	1.451	[.4779933-4.404947]	0.511
Other kidney conditions	-0.611	0.16	0.542	[.3046161-.9675781]	<b>0.038</b>
Diet Type	-0.559	0.314	0.571	[.1945865-1.679877]	0.309
Hydration status	-0.099	0.455	0.905	[.3378148-2.42568]	0.843

This multivariate logistic regression model assesses the association between diet type and hydration status with kidney stone formation, while adjusting for key confounders: gender, BMI, age, family history of kidney stones, and other kidney conditions. After adjustment, **neither diet type** (OR = 0.571, 95% CI: 0.19–1.68,  $p = 0.309$ ) nor **hydration status** (OR = 0.905, 95% CI: 0.34–2.43,  $p = 0.843$ ) showed a statistically significant relationship with kidney stone formation. Among the confounders, **only other kidney conditions** remained significantly associated ( $p = 0.038$ ), with an odds ratio of 0.542, suggesting a potential modifying or protective effect. These findings indicate that, within this model, diet and hydration alone do not independently predict kidney stone risk when accounting for underlying health and demographic factors.

## DISCUSSION

This study investigated the association between hydration status, diet type, and the risk of kidney stone formation, while accounting for potential confounding factors such as age, gender, BMI, and clinical history. Although the descriptive analysis showed that kidney stones were more common among dehydrated individuals and non-vegetarians, these differences were not statistically significant in unadjusted comparisons. The Mantel-Haenszel test also did not show a significant interaction between hydration status and diet type, suggesting that their combined influence on kidney stone risk was not substantial within this sample. An important aspect of the analysis involved evaluating the role of other kidney conditions—including urinary tract infections (UTI) and chronic kidney disease (CKD). The chi-square test identified a statistically significant association between kidney conditions and kidney stone formation ( $p = 0.029$ ), particularly among individuals with CKD or CKD Stage 1, who had the highest unadjusted stone prevalence (75%). However, the bivariate odds ratios for these conditions were not statistically significant, and the confidence intervals were wide, suggesting a lack of precision in the estimates. In contrast, the logistic regression, which adjusted for age, gender, BMI, and family history, showed a significant inverse association (OR = 0.542, 95% CI: 0.30–0.97,  $p = 0.038$ ), indicating a lower adjusted likelihood of kidney stones in patients with other kidney conditions. This discrepancy likely stems from the small sample sizes in CKD subgroups, which may affect the stability of both the bivariate and multivariate estimates.

Overall, the findings suggest that while hydration and diet are key lifestyle factors, their isolated effects on kidney stone risk may not be strong without considering the broader clinical context. The significant role of underlying kidney conditions—combined with inconsistent directionality across analytical methods—warrants further study with larger and more clinically stratified populations. Future work should also incorporate biochemical and longitudinal data to better understand the causal mechanisms at play.

## CONCLUSION

This study explored the complex relationships between hydration status, diet type, and kidney stone formation, with adjustments for demographic and clinical confounders. While descriptive and chi-square analyses suggested that dehydration and non-vegetarian diets may increase stone risk, these associations did not remain significant in adjusted models. Interestingly, the presence of other kidney conditions, particularly CKD, showed a high unadjusted prevalence of stones but a protective effect in multivariable analysis—likely due to behavioral adaptations or confounding factors. These findings underscore the multifactorial nature of kidney stone disease and highlight the importance of considering clinical context, comorbidities, and behavioral changes in preventive strategies. A more comprehensive and prospective approach is necessary to unravel the complex interaction of diet, hydration, and renal health in stone pathogenesis.

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