Original Article

Exploring the incidence and characteristics of urolithiasis in the central region of Saudi Arabia: Insights from a prominent medical center

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Abstract

Introduction: Urolithiasis is a common and recurrent condition with a rising global incidence. Stones typically develop in the upper urinary tract, primarily the kidneys. Various factors such as age, gender, diet, fluid intake, climate, occupation, genetics, and metabolic diseases influence stone formation. Stones can vary in size and location, causing obstruction, urine stasis, and complications such as infection. The prevalence of urolithiasis in Saudi Arabia has significantly increased in recent decades, and the study aims to determine the current prevalence and composition trends of urolithiasis, guide treatment and prevention strategies, as well as understand predictors of occurrence and recurrence.

Materials and Methods: It is a retrospective cohort study where the data was collected in the time frame of 2015–2021. The study was conducted in the Department of Surgery and the Division of Urology at King Abdulaziz Medical City in Riyadh, Kingdom of Saudi Arabia.

Results: The study reveals significant trends in the sociodemographic profile and clinical aspects of urolithiasis patients. With a higher incidence among males (68.5%). Stone compositions predominantly consist of calcium oxalate (67.8%) and uric acid (19.7%), while site distribution shows the left kidney as the most common location (36.5%). Notably, hypertensive patients exhibit a significant association with stone site ($P = 0.014$). Encouragingly, the majority of patients do not experience reoccurrence (91.6%), and the study demonstrates an increasing recurrence rate with subsequent visits. The relatively shorter hospital stays (55.9% with 1-day stays) indicate efficient management, and this knowledge can aid in optimizing patient care.

Conclusion: This study sheds light on the multifaceted nature of urolithiasis by examining various facets. Low recurrence rate of kidney stones offers positive prospects for effective initial management. The shorter hospital stays, suggest advancements in medical practices, enhancing patient convenience and healthcare resource optimization. Investigating the underlying causes behind the observed stone compositions yield

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insights into potential preventive strategies. Furthermore, extended studies examining the impact of lifestyle modifications and medical interventions on stone recurrence could contribute to refined treatment protocols. These findings can guide healthcare professionals in optimizing patient care, preventive strategies, and future research endeavors.

Keywords: Components, composition, prevalence, risk factors, urine analysis, urolithiasis

INTRODUCTION

Urolithiasis, or urinary tract stones, is a common, often recurrent disease.[1,2] There is a recurrence rate of up to 50% within 5 years of the initial episode of stone formation.[3,4] Stones are formed when urine supersaturates its constituents.[3] Dehydration or abnormally increased solutes can result in supersaturation; This clarifies why low fluid intake is a significant risk factor for urolithiasis.[3] Changes in urine pH, crystallization, and bacterial infections are also well-recognized predisposing factors.[5-7] Poorly soluble dietary contaminants can also crystallize and form stones.[3]

Stones can occur at any level of the urinary tract; however, they usually arise in the upper urinary tract, particularly in the kidneys.[8] Around 80% of kidney stones are calcium oxalate (CaOx) combined with calcium phosphate. Struvite, uric acid (UA), and cystine stones account for 10%, 9%, and 1% of stones, respectively.[9,10] Stones can cause obstruction, stasis of urine, and hydronephrosis, which increases the risk of infection.[3-5] Furthermore, patients with kidney stones are at risk of hypertension (HTN), chronic kidney disease (CKD), and end-stage renal disease.[11-14]

Due to changing lifestyles, dietary habits, and global warming, the prevalence of stones has steadily increased over the past 50 years.[15,16] Diabetes, obesity, HTN, and metabolic syndrome are risk factors for developing stones.[17-21] Around 12% of men and 5% of women in the United States (US) will have kidney stones at some point of their life.[22] There has been a 37% increase in the prevalence of kidney stones in the US between 1976–1980 and 1988–1994 in both males and females.[23] A recent study in the US in 2021 showed that the prevalence was 8.8%, with men affected more than women (10.6% vs. 7.1%).[24] A meta-analysis conducted in China from 1990 to 2016 to assess the prevalence of kidney stones showed that the overall prevalence was 7.54%.[25] Locally, the prevalence of urolithiasis in Saudi Arabia has increased in the past few decades. From 1989 to 2008, the prevalence rose from 6.8% to 19.1%.[26,27]

Urolithiasis has a geographical variability with a higher prevalence of stone formation in a hot climate region than in moderate climates.[28,29] As a result of global warming, the number of kidney stone cases is predicted to rise by 1.6–2.2 million by 2050, especially in the southeast US.[30]

Climate and nutritional habits were the most critical factors determining the prevalence, incidence, recurrence rates, and calculi composition.[10] Our study aims to determine the current prevalence and trends in the composition of urolithiasis in Riyadh, Saudi Arabia.

Aim of the study

The purpose of this study is to describe the incidence of urinary stones alongside its composition, site, and recurrence in King Abdulaziz Medical City (KAMC), Riyadh, Saudi Arabia. And to investigate the influence of age, gender, body mass index (BMI), and comorbidities on stone composition and site.

MATERIALS AND METHODS

This was a retrospective study conducted in the department of Surgery and the division of urology in KAMC in Riyadh – Kingdom of Saudi Arabia. KAMC provides tertiary services and has approximately 3 million outpatient visits a year with a capacity of 1501 beds. The department of Surgery has 96 beds. The urology division works closely with the Pathology and Laboratory Medicine department, which supports KAMC and provides a wide range of laboratory services, including urine and stone analysis.

Nonprobability consecutive sampling technique was used, and we included all patients who underwent surgical removal of urinary tract stones at KAMC in Riyadh between 2015 and 2021.

We included 1175 patients in the study. In addition to the stones, baseline variables, including age, gender, BMI, nationality, and co-existence of co-morbid conditions, were collected. Some variables were not recorded for some patients. Such as sociodemographic, composition, and sites. Sociodemographic was recorder for 1154 patients. While stone composition was recorded for 833 patients only, and 932 stone sites recorded.

Data collection methods, instrument used, measurements

After we received King Abdullah International Medical Research Center IRB approval, we accessed patients' electronic medical records. The research team extracted the data from the BestCare system, an existing system in the hospital for collecting patient data. Then the data was stored and arranged in a Microsoft Excel sheet with our points of interest.

Stones were collected intraoperatively or after spontaneous passage and sent for analysis. Analysis of stones included: site and composition. Urinary stones are named for their solid phase, and stone type represents the supersaturation present in the urine when the stone was formed.[9] Kidney stone compositions in our study include CaOx, carbapatite, cystine, magnesium ammonium phosphate (MAP), UA, and "others." Others are for stones with no specific component or could not be assessed during stone analysis. Classification of stones was based on their single largest component. For example, a stone would be categorized as a CaOx stone if it was discovered to contain 40% CaOx monohydrate, 30% UA, and 30% magnesium ammonium phosphate (MAP).

Data management and analysis plan

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL, USA version 28.0). Categorical data were presented as frequencies and percentages, while continuous data were presented as mean and standard deviation. Cross-tabulation (Chi-square test) was used for the data in which the predictor and the outcome are categorical. One-way ANOVA was used to test Statistical differences among the means of two or more groups. $P < 0.05$ was considered statistically significant for all the statistical tests.

Ethical considerations

Patients' privacy and confidentiality will be assured, and no identifiers will be collected. All data hard and soft copies will be kept in a secure place and will be accessed by the research team only.

RESULTS

Sociodemographic of urolithiasis patients

A total of 1154 patients for whom sociodemographic data were available and included in the study. In terms of gender distribution, a higher incidence of urolithiasis was observed among males, with 791 cases (68.5%), while females accounted for 363 cases (31.5%). With a male-to-female ratio of 2.1:1. Regarding age distribution, the mean age was 48.9 years and exhibited the following breakdown: 98 individuals (8.5%) were younger than 20 years, 317 (27.5%) fell within the age range of 21–40 years, 371 (32.1%) were aged between 41 and 60 years, 312 (27.0%) were in the 61–80-year age bracket, and 56 (4.9%) were aged over 80 years.

With respect to BMI, the mean was 28.6 and the classification was as follows: 55 patients (7.8%) were categorized as underweight (<18.5), 139 (19.8%) were within the ideal weight range (18.5–25), 225 (32.0%) were classified as overweight (25.0–30), 185 (26.3%) fell into the obese class 1 category (30.0–35), 64 (9.1%) were in the obese class 2 category (35.0–40), and 35 (5.0%) were categorized as obese class 3 (>40). These findings indicate a notable prevalence of urolithiasis among patients classified as overweight and obese.

Concerning nationality, the dataset revealed that 71 patients (6.2%) were non-Saudi, while the majority, comprising 1083 individuals (93.8%), were of Saudi nationality. In terms of comorbidities, it was observed that 340 patients (29.4%) had concurrent Urinary Tract Infections, followed by 170 (14.7%) patients with diabetes mellitus, and 150 (13.01%) patients with HTN. Additional comorbidities are detailed in Table 1.

Table 1: Demographics of urolithiasis patient

	Stone incidence, *n* (%)
Gender	
Female	363 (31.5)
Male	791 (68.5)
Age (years)	
<20	98 (8.5)
21–40	317 (27.5)
41–60	371 (32.1)
61–80	312 (27)
>80	56 (4.9)
BMI	
Underweight	55 (7.8)
Normal	139 (19.8)
Overweight	225 (32)
Obese class 1	185 (26.3)
Obese class 2	64 (9.1)
Obese class 3	35 (5)
Nationality	
Non-Saudi	71 (6.2)
Saudi	1083 (93.8)
Comorbidities	
DM	170 (14.7)
HTN	150 (13)
Hyperlipidemia	125 (10.8)
UTI	340 (29.4)
BPH	130 (11.3)
CKD	35 (3)
Gout	4 (0.3)
Hypercalciuria	4 (0.3)
Obstructive uropathy	9 (0.8)

BMI: Body mass index, DM: Diabetes mellitus, HTN: Hypertension, CKD: Chronic kidney disease, UTI: Urinary tract infection, BPH: Benign prostatic hyperplasia

Compositions and site of urolithiasis

Our study reported the composition of kidney stones for 833 study participants. 67.8% (565 participants) of stones are composed of CaOx, followed by 19.7% (164 participants) of stones are composed of UA. 6.8% (57 participants) have carbapatite, 2.9% (25 Participants) MAP, 1.4% (11 Participants) Cysteine, and 1.4% (11 Participants) other as shown in Figure 1.

Eight hundred and ten study participants had a recorded site. 36.5% (296 Participants) of stones were present in the left kidney, followed by 31.7% (257 Participants) of stones present in the right kidney followed by 20.7% (168 Participants) of stones in the ureter, and 10.9% (89 Participants) of stones are in the bladder as shown in Figure 2.

Table 2 delineates the distribution of kidney stone compositions with respect to various anatomical locations within the urinary tract. Predominantly, CaOx constituted the prevailing stone components observed in the left and right kidneys as well as the ureter, with frequencies of 279, 216, and 68 occurrences, respectively. Notably, UA emerged as the predominant stone constituent within the bladder.

Regarding localization of kidney stones, the bladder had 76 cases, significantly associated with UA (65 cases) most commonly as $P < 0.001$. The left kidney had 296 cases, significantly composed of CaOx (279 cases) as $P < 0.001$. The right kidney had 257 cases, with CaOx (216 cases) and MAP (21 cases) being the most common stone types as $P < 0.001$. The ureter had 168 cases, with CaOx (68 cases) and UA (55 cases) being the predominant stones as $P < 0.001$. Thus, differences in stone compositions based on the localization of stones were statistically significant for all four locations, with $P < 0.001$.

Interplay of demographic and comorbid factors in shaping urolithiasis composition and site

Tables 3 and 4 present a detailed overview of patient characteristics stratified by stone composition and site, respectively. In the context of gender, CaOx emerged as the predominant stone composition in both females (158 cases) and males (407 cases). However, chi-square tests did not reveal statistically significant differences for females ($\chi^2 = 8.7$, $P = 0.189$) and males ($\chi^2 = 9.4$, $P = 0.148$). There was a marginally significant association between the age group and a component of kidney stones as $P = 0.057$. CaOx stone is more in all age groups as compared to UA stones.

The stone location showed a statistically significant association with gender ($P < 0.05$), with a higher prevalence of stones in the left kidney among males and in the right kidney among females.

Age-wise analysis demonstrated that the 19–40 years age group exhibited the highest frequency of stone occurrences (233 cases), with CaOx being the prevalent composition (173 cases). Differences in stone compositions across age groups were not statistically significant ($\chi^2 = 8.5$, $P = 0.176–0.250$). The demographic analysis unveiled distinct age-related patterns in stone site among the study cohort. Specifically, there were 58 patients below 18 years, with the right kidney exhibiting 33 stones. In the age group of 19–40 years, a total of 233 individuals were identified, and the right kidney manifested 97 stones. Moreover, the cohort aged between 41 and 60 years comprised 261 patients, with the left kidney harboring 125 stones. Notably, only four patients above 60 years were observed, and all instances of stone formation were localized in the bladder. The observed variation in stone site distribution across age groups was found to be

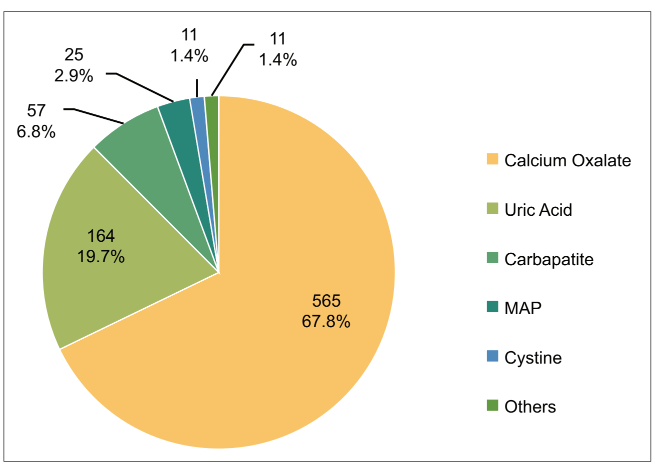

Figure 1: Stone composition

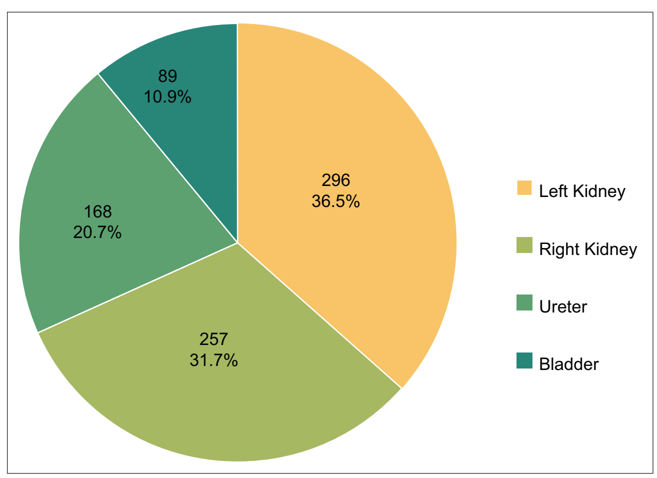

Figure 2: Stone site

Table 2: Cross-tab of composition and site of urinary stones

	CaOx	$CaPO_4$	Cystine	MAP	UA	*P*
Bladder	1	0	10	0	65	<0.001
Left kidney	279	11	0	3	3	<0.001
Right kidney	216	1	2	21	8	<0.001
Ureter	68	45	0	0	55	<0.001

CaOx: Calcium oxalate, CaP04: Carbapatite, MAP: Magnesium ammonium phosphate, UA: Uric acid

Table 3: Characteristics of patients stratified by stone compositions

	n	CaOx	$CaPO_4$	Cysteine	MAP	UA	χ^2	*P*
Gender								
Female	250	158	16	4	9	63	8.7	0.189
Male	571	407	41	8	15	100	9.4	0.148
Age (years)								
<18	61	38	6	0	5	12	8.9	0.176
19–40	233	173	19	2	4	35	8.5	0.197
41–60	266	179	17	7	9	54	4.5	0.609
>60	4	1	0	0	0	3	7.8	0.250
BMI								
Under‑weight	54	40	5	0	2	7	3.7	0.714
Normal	138	108	11	0	4	15	12.9	0.052
Over‑weight	225	172	20	1	7	25	23.1	<0.001
Obese class 1	182	150	12	0	8	12	34.3	<0.001
Obese class 2	63	51	2	1	2	7	6.1	0.416
Obese class 3	33	25	2	0	0	6	9.5	0.146
DM	134	97	5	2	5	25	3.5	0.611
HTN	120	84	2	2	6	26	8.3	0.140
Hyperlipidemia	94	67	3	3	4	17	5.6	0.339
BPH	65	39	3	1	2	20	3.7	0.580
UTI	171	119	5	5	1	41	6.1	0.299
CKD	19	13	1	0	0	5	1.2	0.938
Reoccurrence	75	51	6	1	2	15	0.61	0.999

CaOx: Calcium oxalate, CaP04: Carbapatite, MAP: Magnesium ammonium phosphate, UA: Uric acid, BMI: Body mass index, DM: Diabetes mellitus, HTN: Hypertension, UTI: Urinary tract infection, BPH: Benign prostatic hyperplasia, CKD: Chronic kidney disease

statistically significant ($P < 0.001$). One-way ANOVA we conducted to determine if age was different according to different stone locations. The mean age for Ureter stone is round about 52 and for right kidney stone is round about 50 and $P < 0.001$.

The study identified a significant correlation ($P < 0.001$) between elevated BMI, particularly in overweight and obese Class one patients, and the occurrence of CaOx stones. No statistically significant differences were observed in other BMI categories. Additionally, BMI analysis revealed a significant variation in stone locations ($P < 0.001$) among Underweight, Normal, and obese patients (including Obese Class 1 and higher). One-way ANOVA we conducted to determine if BMI was different according to different stone locations. The mean BMI for Ureter stone is round about 30 and for right kidney stone is round about 30.1 and $P < 0.001$.

The impact of medical conditions such as diabetes, HTN, hyperlipidemia, benign prostatic hyperplasia, urinary tract infections, CKD, and stone recurrence on stone compositions was explored. However, no statistically significant associations were identified. In regard to stone site, HTN showed a significant association with stone site ($P = 0.014$), with higher occurrences in patients with stones in the left kidney. Hyperlipidemia also exhibited a strong association with stone location ($P < 0.001$), with a higher frequency of hyperlipidemia in patients with left and right kidney stones.

Table 4: Characteristics of patients stratified by stone site

	n	Bladder	Left kidney	Right kidney	Ureter	χ^2	*P*
Gender							
Female	249	38	76	82	53	9.7	0.021
Male	560	50	220	175	115	10.9	0.012
Age (year)							
<18	58	1	7	33	17	29.8	<0.001
19–40	233	15	61	97	60	29.8	<0.001
41–60	261	36	125	54	46	32.9	<0.001
>60	4	4	0	0	0	32.5	<0.001
BMI							
Under‑weight	55	0	10	27	18	21.6	<0.001
Normal	139	2	59	49	29	16.1	<0.001
Over‑weight	223	3	90	76	54	29.5	<0.001
Obese class 1	184	0	89	61	34	36.1	<0.001
Obese class 2	64	1	27	23	13	6.6	0.085
Obese class 3	35	2	13	12	8	1.1	0.781
DM	131	17	53	42	19	4.2	0.238
HTN	116	18	44	42	12	10.6	0.014
Hyperlipedemia	93	17	35	35	6	16.8	<0.001
BPH	62	11	20	20	11	0.3	0.955
UTI	163	26	63	48	26	3.4	0.354
CKD	16	1	5	7	3	1.4	0.620
Reoccurrence	73	7	26	25	15	0.3	0.56

BMI: Body mass index, DM: Diabetes mellitus, HTN: Hypertension, UTI: Urinary tract infection, BPH: Benign prostatic hyperplasia, CKD: Chronic kidney disease

Length of stay during the first visit with urolithiasis

Among the 738 patients analyzed, a predominant portion (55.9%) experienced a 1-day hospital stay. Additionally, 9.2% of patients had a 2-day hospital stay, 9.4% stayed for 3 days, while smaller percentages had stays of 4, 5, or 6 days or longer. This distribution underscores the feasibility of providing efficient and timely treatment for a significant proportion of urolithiasis cases as outpatient day surgery.

Stone incidence recurrence

Out of the total sample size of patients (n = 1175), 1076 (91.6%) did not experience a reoccurrence of stones, while 99 (8.4%) did. Further analysis reveals that among the 99 patients with a second recurrence, 19 (19.1%) continued to experience kidney stones on their third recurrence. Finally, among the 19 patients with a third recurrence, 6 (31.5%) still had kidney stones on their fourth recurrence.

DISCUSSION

The aim of this study was to investigate the incidence, composition, site, and recurrence of urinary stones in the KAMC in Riyadh, Saudi Arabia. The sociodemographic analysis revealed that urolithiasis was more prevalent among males (68.5%). This gender disparity may be due to hormonal and anatomical differences. Overweight and obese patients showed a relatively high prevalence of urolithiasis, suggesting a complex interplay of factors such as dietary habits, metabolic influences, and hydration status, warranting further investigation. The majority of patients fell within the 21–60 age range, reflecting the impact of modern lifestyles on stone formation. The notable comorbidities like urinary tract infections, diabetes, and HTN hint at potential links between urolithiasis and these conditions, raising questions about shared risk factors or causative mechanisms.[14]

The prominence of CaOx as the predominant stone composition corroborates its well-established role in stone formation.[15] UA's significant representation suggests its clinical relevance and possible connections to dietary habits or metabolic factors. The distribution of stones across kidney sites underscores the need for investigating factors influencing stone localization, possibly anatomical or physiological variations. The bladder's association with UA stones could hint at specific urinary pH conditions conducive to their formation. Understanding these compositional trends and site-specific associations could aid in targeted prevention and treatment strategies for urolithiasis. Khan *et al*. reported similar results in terms of stone composition, with CaOx and UA being the primary components.[16]

The study's finding of a high proportion (91.6%) of patients not experiencing stone recurrence is promising and suggests that initial interventions were effective for a significant portion of individuals. However, the recurrence rate among a subset of patients (8.4%) underscores the need for long-term monitoring and management to prevent relapses. The observation that most recurrences happened on subsequent visits indicates the possibility of delayed factors contributing to stone formation, which could include lifestyle factors or physiological changes. This aligns with the previous studies, which emphasized the importance of long-term follow-up to monitor and manage recurrent stones effectively.[17]

The investigation of factors influencing stone composition based on demographics and comorbidities highlighted that while some trends were observed, statistical significance was not consistently achieved. This finding supports the study by Pricop *et al*., which explored similar associations and stressed the complexity of such relationships due to multifactorial influences.[18]

Regarding the comparison of gender distribution of stone sites, Kakkar and Kakkar observed similar trends in stone locations among male and female patients.[19] They reported that males were more likely to have stones in the left kidney, which aligns with the current study's finding of a higher prevalence of stones in the left kidney among males. On the other hand, Moftakhar *et al*. reported a higher incidence of right kidney stones in females, differing from the present study's results.[20] These variations highlight the complexity of stone site associations and may be attributed to differences in patient populations.

The age-wise distribution of stone sites revealed significant variations across different age groups. This corresponds with the work of López and Hoppe who noted an age-dependent shift in stone localization.[21] However, the lack of significant association between age and stone components contrasts with the findings of Lieske *et al*., who reported that stone composition varied with age.[22] These discrepancies emphasize the need for further investigation to ascertain the impact of age on stone components.

The correlation between BMI and stone site echoes the findings of previous studies. Mosli *et al*. demonstrated a link between obesity and stone location, supporting the current study's observation that obese patients showed varied locations of stones.[23] In contrast, Semins *et al*. did not find a significant association between BMI and stone site, highlighting the mixed evidence in this area.[24]

Analyzing the medical conditions associated with the stone site, the significant association between HTN and stone location echoes the work of Cappuccio *et al*., who observed a higher occurrence of HTN among patients with left kidney stones.[25] Similarly, the strong correlation between hyperlipidemia and stone location aligns with Masterson *et al*. finding of a connection between hyperlipidemia and kidney stone formation.[26]

The statistical analyses, particularly the one-way ANOVA, shed light on the complex interplay between age, BMI, and stone components. Although a marginal association between age and stone composition was observed, this result diverges from the findings of Wang *et al*., who documented more pronounced age-related differences in stone components.[27] The absence of a significant association between BMI and stone components is consistent with the research by Wang *et al*., where no substantial correlation between BMI and stone composition was reported.[28] These disparities in findings might be attributed to variations in sample characteristics, methodologies, or regional factors, underscoring the need for further investigation to fully comprehend the intricate relationships between these factors and stone formation.

Notably, a recent study reported the characteristics and types of urolithiasis in a single center in the Eastern region of Saudi Arabia (Alasker *et al*., 2022).[29] In the comparison of our study with the findings of Alasker *et al*., several substantial parallels and divergences were observed. Both studies reported a higher incidence of urolithiasis in males (68.5% vs. 74.5%), with CaOx as the predominant stone composition (67.8% vs. 76%), followed by UA stones (19.7% vs. 18%). This consistency underscores the significant role of gender and stone composition in the incidence and pathogenesis of urolithiasis. However, our study reported the left kidney as the most common stone location (36.5%), the association of HTN with a stone site in our study ($P = 0.014$), the hospital length of stay, and the recurrence rate which were not reported by Alasker *et al*. These results, collectively, can be instrumental in optimizing patient care and provide valuable insights for future research in urolithiasis.

This study has some limitations that should be considered. Firstly, the research was conducted at a single center, potentially limiting the generalizability of findings. Additionally, the retrospective nature of the study may introduce biases and incomplete data. The sample size, though considerable, may not fully encompass the diversity of patients and stone compositions. Moreover, relying on patient records for comorbidity data could lead to underreporting or misclassification. The study's focus on a specific geographic location may not account for regional variations in stone prevalence. Therefore, a future multicenter study of all Saudi Arabian regions is recommended. Lastly, the cross-sectional design limits the establishment of causal relationships between variables.

CONCLUSION

This study sheds light on the multifaceted nature of urolithiasis by examining various facets. Low recurrence rate of kidney stones offers positive prospects for effective initial management. The shorter hospital stays, suggest advancements in medical practices, enhancing patient convenience and healthcare resource optimization. Investigating the underlying causes behind the observed stone compositions yield insights into potential preventive strategies. Furthermore, extended studies examining the impact of lifestyle modifications and medical interventions on stone recurrence could contribute to refined treatment protocols. These findings can guide healthcare professionals in optimizing patient care, preventive strategies, and future research endeavors.

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Conflicts of interest
There are no conflicts of interest.

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