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Urolithiasis Risk Factors and Burden: A Hospital-Based Case-Control Study in Northern State Sudan

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Research Article

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Abstract

Background

Urolithiasis is a common urological disease and an important public health problem worldwide, resulting in considerable morbidity, health care utilization of resources, and economic burden. However, the epidemiological evidence on its associated risk factors and disease burden in Sudan is limited. This study aimed to determine the factors associated with urolithiasis and the disease burden of urolithiasis among adults in Northern State, Sudan.

Methods

A hospital-based frequency-matched case–control study was conducted at Dongola Specialized Hospital, Northern Sudan, between August 2024 and September 2025. The study included 273 participants (91 cases and 182 controls), matched by age, sex, and residence. Cases had ultrasound- or computed tomography-confirmed urolithiasis, while controls had no evidence of stones on imaging. Data were collected using interviewer-administered structured questionnaires covering sociodemographic characteristics, lifestyle, dietary habits, family history, comorbidities, and disease burden. Variables with $p < 0.20$ in bivariate analysis were included in multivariable logistic regression to identify factors independently associated with urolithiasis.

Results

The mean age of participants was 52.0 ± 15.4 years, and 54.6% were male. Positive family history (AOR = 5.68, 95% CI: 1.90–16.99), regular fish consumption (AOR = 2.40, 95% CI: 1.08–5.35), tea consumption, soft drink intake (AOR = 4.15, 95% CI: 1.16–14.82), higher physical activity, and comorbidities were independently associated with urolithiasis. Patients experienced substantial disease burden, including severe pain, frequent healthcare visits, productivity loss, and financial hardship. The median treatment cost was 150,000 Sudanese pounds.

Conclusion

Urolithiasis in Northern Sudan is associated with familial, dietary, lifestyle, and metabolic factors and imposes a considerable clinical and socioeconomic burden. Prevention strategies emphasizing adequate hydration, healthy dietary practices, and effective management of chronic diseases may help reduce the burden of urolithiasis in this setting.

INTRODUCTION

Kidney stone disease or urolithiasis is a common chronic disease affecting people all over the world. [1]. Worldwide, prevalence rates range from 1% to 13%, and are higher in men than in women. [2, 3]. Urine stones are a major public health problem causing many hospital admissions, surgeries and renal problems. [4]. In developed countries, 1,500-2,000 cases of stone formation are encountered per million population annually. About 25% of patients will need active intervention to remove the stone. [5]. Research indicates that 50 to 60 percent of people will have calcium stones again within ten years. [6, 7]. Factors like age, gender, genetics, history of urinary diseases, lifestyle and diet can all play a role in the formation of stones. But too much animal protein and sodium (especially from fizzy drinks) increases your risk. You know drinking water is good for you. [8]. A recent study found that eating plans with an emphasis on drinking lots of fluids, in combination with eating lots of fruits and vegetables, such as the Mediterranean or vegetarian diet, are linked to a lower risk of developing and recurring stones. However, high meat and salt diets such as in the West, are associated with increased risk of stones [9]. Nutritional factors can alter the composition of urine, resulting in supersaturation and stone formation. Too much protein, salt, calcium and oxalate can increase the risk of stones. But drinking enough water and certain minerals like potassium and magnesium can prevent stones from developing. Age and sex have different effects. [10, 11]. Food and hydration are known to play a role in the prevention of stone development, but less is known about their effects on the Sudanese populations whose dietary practices and lifestyles may differ from the West.

The objective of this study was to identify risk factors and assess the burden of urolithiasis disease among adults in Northern State Sudan.

Materials and Methods

Study design and setting

A hospital-based frequency-matched case–control study was conducted from August 2024 to September 2025 at Dongola Specialized Hospital, the main governmental tertiary referral hospital in Dongola City, Northern State, Sudan. The hospital serves as a major referral center for patients across the Northern State and surrounding regions.

The facility is centrally located and includes six operating theatre complexes, one dedicated to endo-urological procedures and others for open surgeries. The urology unit performs both open and endo-urological procedures twice weekly, with an average of approximately 20 operations per week. Procedures for urolithiasis management include ureteroscopy, percutaneous nephrolithotomy (PCNL), and cystolitholapaxy, in addition to open surgeries such as pyelolithotomy, nephrolithotomy, ureterolithotomy, and vesicolithotomy.

The hospital operates 24 hours a day, 7 days a week, with outpatient clinics running during working hours (8:00 a.m.–2:00 p.m.) and continuous emergency services. It includes multiple departments, a central laboratory, pharmacy services, surgical theatres for minor and major operations, and inpatient

wards for male, female, and pediatric patients with a total capacity exceeding 200 beds. An educational center with lecture halls is also available within the facility.

Participants

The study included adults aged ≥ 18 years. **Cases** comprised 91 patients with newly diagnosed urolithiasis confirmed by ultrasound or computed tomography (CT), recruited from urology clinics, inpatient wards, and the emergency department.

Controls comprised 182 individuals with no evidence of urolithiasis on imaging. Controls were selected using a **frequency-matched design** at a ratio of **1:2 (cases:controls)** based on age (± 5 years), sex, and residence.

Patients who were critically ill, non-Arabic speakers, recently displaced due to conflict, or with incomplete questionnaire responses were excluded.

Variables and definitions

The **outcome variable** was the presence of urolithiasis (case) versus absence of stones on imaging (control).

Exposure variables included sociodemographic characteristics, dietary habits (assessed using a food frequency questionnaire with emphasis on salt and fluid intake), physical activity, family history of urolithiasis, and comorbidities such as diabetes mellitus and hypertension.

Potential confounders included age, sex, and residence, which were controlled for in multivariable analysis.

Sample size

The sample size was calculated using OpenEpi software based on findings from a previous study (12), assuming 25% exposure to high-salt diet among controls and an odds ratio (OR) of 2.139. At a 95% confidence level and 80% power, the required sample size was 91 cases and 182 controls (1:2 ratio).

Data collection

Data were collected through trained research assistants using a pretested semi-structured questionnaire administered via face-to-face interviews. The questionnaire covered sociodemographic characteristics, dietary habits, physical activity, family history, comorbidities, and disease burden indicators, including pain intensity measured by the visual analogue scale (VAS), healthcare utilization, and associated costs. Data were entered electronically using KoboCollect.

Statistical analysis

Data were analyzed using IBM SPSS Statistics version 28.0. Categorical variables were summarized using frequencies and percentages, while continuous variables were presented as mean ± standard deviation or median (interquartile range), as appropriate.

Bivariate analysis was performed using Chi-square or Fisher's exact test to assess associations between independent variables and urolithiasis. Variables with **$p < 0.20$** in bivariate analysis were entered into a multivariable logistic regression model to identify independent predictors of urolithiasis.

Adjusted odds ratios (AORs) with 95% confidence intervals (CI) were reported, and statistical significance was set at $p < 0.05$. Multicollinearity was assessed prior to model fitting.

Results

Participant characteristics

A total of 273 participants were included in the study, comprising 91 cases and 182 controls. The mean age of participants was 52.0 ± 15.4 years (range: 20–90 years). Males accounted for 54.6% of the study population. Most participants (62.6%) resided in rural areas, and 60.1% belonged to the Danagla ethnic group (Table 1).

Table 1
Sociodemographic Characteristics of the Study Population Northern state Sudan 2025 (n = 273)

Variable	Category	Frequency (n)	Percentage (%)
Locality	Dongola	144	52.7
	Aldabbah	45	16.5
	Algolid	33	12.1
	Wadi Halfa	6	2.2
	Dalgo	3	1.1
	Alborgeg	27	9.9
	Merowe	15	5.5
Area of Living	Urban	102	37.4
	Rural	171	62.6
Ethnic Group	Danagla	164	60.1
	Mahas	29	10.6
	Manasir	12	4.4
	Kababish	55	20.1
	Halfawi	3	1.1
	Shawaika	7	2.6
	Hawawir	3	1.1
Marital Status	Married	198	72.5
	Divorced	8	2.9
	Widow/ed	17	6.2
	Single	50	18.3
Occupation	Not working	108	39.6
	Farmer	35	12.8
	Worker	56	20.5
	Employee	50	18.3
	Student	24	8.8

Anthropometric and lifestyle characteristics

Cases had significantly higher median body weight than controls (75.0 vs. 67.0 kg; $p = 0.022$) and greater median height (165.0 vs. 159.5 cm; $p = 0.020$). However, body mass index (BMI) did not differ significantly between the two groups ($p = 0.096$).

A positive family history of urolithiasis was more common among cases than controls (73.1% vs. 26.9%; $p < 0.001$). Physical activity was significantly associated with urolithiasis ($p < 0.001$). Compared with physically inactive participants, those reporting higher levels of physical activity had higher odds of urolithiasis. Comorbid conditions were also more prevalent among cases than controls (50.4% vs. 26.3%; $p = 0.013$) (Table 2).

Table 2
Anthropometric, Occupational, and associated with Urolithiasis (n = 273)

Variable	Cases (n = 91)		Controls (n = 182)		Total (n = 273)		P-Value
	n	%	n	%	n	%	
Weight							
Weight in kg Median (IQR)	75.00 (20.00)		67.00 (27.00)		70.00 (25.50)		0.022
Height							
Height in cm Median (IQR)	165.00 (14.00)		159.50 (13.00)		160.00 (13.50)		0.020
BMI							
BMI in kg/m² Median (IQR)	27.34 (6.28)		25.79 (6.92)		26.45 (7.23)		0.096
Work Under Sunlight							
Yes	42	40.4	62	59.6	104	38.1	0.053
No	49	29.0	120	71.0	169	61.9	
Hours Per Day Worked Under Sunlight							
Working Hours/Day Under Sunlight Median (IQR)	5.00 (4.00)		5.00 (3.00)		5.00 (3.00)		0.241
Family History of Stone Disease							
Yes	19	73.1	7	26.9	26	9.5	< 0.001
No	72	29.1	175	70.9	247	90.5	
Physical Activity							
None	18	15.4	99	84.6	117	42.9	< 0.001
30 mins	20	55.6	16	44.4	36	13.2	
30–60 mins	12	50.0	12	50.0	24	8.8	
More than 60 mins	41	42.7	55	57.3	96	35.2	
Comorbidities							
Yes	55	50.4	81	59.6	136	49.8	0.013
No	36	26.3	101	73.7	137	50.2	
Smoking Status							

Mann-Whitney U-test, Chi-square or Fisher's Exact.

Variable	Cases (n = 91)		Controls (n = 182)		Total (n = 273)		P-Value
	n	%	n	%	n	%	
Weight							
Smoker	**9**	**45.0**	**11**	**55.0**	**20**	**7.3**	**0.250**
Non-smoker	**82**	**32.4**	**171**	**67.6**	**253**	**92.7**	
Alcohol Consumption							
Yes	**2**	**100.0**	**0**	**0**	**2**	**0.7**	**0.110**
No	89	32.8	182	67.2	271	99.3	
Mann-Whitney U-test, Chi-square or Fisher's Exact.							

Dietary factors associated with urolithiasis

Daily meat consumption was more frequent among cases than controls (52.5% vs. 47.5%). In unadjusted analysis, daily meat consumption was associated with higher odds of urolithiasis (COR = 4.64, 95% CI: 2.68–8.05; $p < 0.001$). However, this association was no longer statistically significant after adjustment for potential confounders (AOR = 1.49, 95% CI: 0.68–3.24; $p = 0.320$).

Regular fish consumption (weekly/daily versus rarely/never) remained significantly associated with urolithiasis after adjustment (AOR = 2.40, 95% CI: 1.08–5.35; $p = 0.032$).

Consumption of butter, cream, or kaymak showed a significant association in the crude analysis ($p < 0.001$), but this association was not statistically significant in the adjusted model (AOR = 1.15, 95% CI: 0.56–2.37; $p = 0.702$).

Tea consumption was associated with urolithiasis when compared with the reference category (≥ 6 cups/day). Participants consuming 2–3 cups/day (AOR = 4.51, 95% CI: 1.23–16.47; $p = 0.023$) and 4–5 cups/day (AOR = 4.42, 95% CI: 1.09–17.89; $p = 0.037$) had significantly higher odds of urolithiasis. Consumption of 1 cup/day showed a borderline association (AOR = 3.91, 95% CI: 0.98–15.56; $p = 0.053$).

Regular soft drink consumption (weekly/daily versus rarely/never) was also independently associated with urolithiasis (AOR = 4.15, 95% CI: 1.16–14.82; $p = 0.029$).

Overall, fish consumption, tea intake, and soft drink consumption remained significantly associated with urolithiasis after adjustment, whereas the associations observed for meat and dairy fat products were not statistically significant in the multivariable model (Tables 3–5).

Table 3
Relationship between Beverage Consumption Patterns and Urolithiasis Risk (n = 273)

Variable	Category	Cases (n = 91) n (%)	Controls (n = 182) n (%)	Total n (%)	P-value
Water (daily amount)	1 glass	0 (0.0%)	8 (5.3%)	8 (2.93%)	0.198
	2–3 glasses	9 (6.0%)	16 (10.7%)	25 (9.16%)	
	4–5 glasses	27 (18.0%)	45 (30.0%)	72 (26.37%)	
	6 + glasses	55 (36.7%)	113 (75.3%)	168 (61.54%)	
Mineral water	Never	29 (19.3%)	38 (25.3%)	67 (24.54%)	0.096
	Rarely	49 (32.7%)	118 (78.7%)	167 (61.17%)	
	Weekly	7 (4.7%)	20 (13.3%)	27 (9.89%)	
	Daily	6 (4.0%)	5 (3.3%)	12 (4.40%)	
Tea (daily amount)	1 cup	26 (17.3%)	32 (21.3%)	58 (21.25%)	0.006
	2–3 cups	41 (27.3%)	98 (65.3%)	139 (50.91%)	
	4–5 cups	21 (14.0%)	28 (18.7%)	49 (17.95%)	
	6 + cups	3 (2.0%)	24 (16.0%)	27 (9.89%)	
Coffee	Never	19 (12.7%)	15 (10.0%)	34 (12.45%)	0.001
	Rarely	26 (17.3%)	89 (59.3%)	115 (42.12%)	
	Weekly	7 (4.7%)	20 (13.3%)	27 (9.89%)	
	Daily	39 (26.0%)	58 (38.7%)	97 (35.53%)	
Natural juice	Never	2 (1.3%)	4 (2.7%)	6 (2.20%)	0.513
	Rarely	37 (24.7%)	91 (60.7%)	128 (46.89%)	
	Weekly	20 (13.3%)	33 (22.0%)	53 (19.41%)	

Variable	Category	Cases (n = 91) n (%)	Controls (n = 182) n (%)	Total n (%)	P-value
	Daily	32 (21.3%)	54 (36.0%)	86 (31.50%)	
Soft drink	Never	20 (13.3%)	27 (18.0%)	47 (17.21%)	0.050
	Rarely	61 (40.7%)	147 (98.0%)	208 (76.19%)	
	Weekly	7 (4.7%)	6 (4.0%)	13 (4.76%)	
	Daily	3 (2.0%)	2 (1.3%)	5 (1.83%)	
Industrial drink	Never	11 (7.3%)	24 (16.0%)	35 (12.82%)	0.947
	Rarely	68 (45.3%)	137 (91.3%)	205 (75.09%)	
	Weekly	9 (6.0%)	17 (11.3%)	26 (9.52%)	
	Daily	3 (2.0%)	4 (2.7%)	7 (2.57%)	

Note: Mann-Whitney U-test for continuous variables; Chi-square or Fisher's Exact Tests for categorical variables

Table 4
Food Consumption Patterns and Urolithiasis Risk (n = 273)

Variable	Cases (n = 91)		Controls (n = 182)		Total (n = 273)		P-Value
	n	%	n	%	n	%	
Meat							
Never	0	0	2	100.0	2	0.7	< 0.001
Rarely	25	18.0	114	82.0	139	50.9	
Weekly	35	47.9	38	52.1	73	26.7	
Daily	31	52.5	28	47.5	59	21.6	
Liver							
Never	3	27.3	8	72.7	11	4.0	0.010
Rarely	69	30.1	160	69.9	229	83.9	
Weekly	15	53.6	13	46.4	28	10.3	
Daily	4	80.0	1	20.0	5	1.8	
Fish							
Never/Rarely	3	30.0	7	70.0	10	3.7	< 0.001
Rarely	57	27.0	154	73.0	211	77.3	
Weekly	27	60.0	18	40.0	45	16.5	
Daily	4	57.1	3	42.9	7	2.6	
Canned food of all types							
Never	5	83.3	1	16.7	6	2.2	0.005
Rarely	69	31.8	148	68.2	217	79.5	
Weekly	15		18		33	12.1	
Daily	2	11.8	15	88.2	17	6.2	
Legumes							
Never	1	50.0	1	50.0	2	0.7	0.340
Rarely	8	50.0	8	50.0	16	5.9	
Weekly	8	38.1	13	61.9	21	7.7	
Daily	74	31.6	160	68.4	234	85.7	
Butter, cream or Kaymak							

Variable	Cases (n = 91)		Controls (n = 182)		Total (n = 273)		P-Value
	n	%	n	%	n	%	
Meat							
Never	5	13.5	32	86.5	37	13.6	< 0.001
Rarely	48	30.4	110	69.6	158	57.9	
Weekly	9	36.0	16	64.0	25	9.2	
Daily	29	54.7	24	45.3	53	19.4	
Ice-cream							
Never	34	30.1	79	69.9	113	41.4	0.239
Rarely	50	34.0	97	66.0	147	53.8	
Weekly	6	50.0	6	50.0	12	4.4	
Daily	1	100.0	0	0	1	0.4	

Note: *Mann-Whitney U-test for continuous variables; Chi-square or Fisher's Exact Tests for categorical variables

Table 5
Multivariable Analysis of Independent Risk Factors for Urolithiasis (n = 273)

Variable	COR(95% CI)	P-value	AOR(95% CI)	P-value
Family History of Stone Disease				
Yes	6.60 (2.66–16.37)	< 0.001	Yes	6.60 (2.66–16.37)
No	1			
Physical Activity				
None	1			
30 mins	4.10 (2.15–7.81)	< 0.001	30 mins	4.10 (2.15–7.81)
30–60 mins	5.50 (2.14–14.15)	< 0.001	30–60 mins	5.50 (2.14–14.15)
More than 60 mins	6.88 (3.01–15.72)	< 0.001	More than 60 mins	6.88 (3.01–15.72)
Comorbidities				
Yes	1.91 (1.14–3.18)	0.014	Yes	1.91 (1.14–3.18)
No	1			
Tea(daily amount)				
1 cup	3.26 (0.99–10.72)	0.051	1 cup	3.26 (0.99–10.72)
2–3 cups	3.03 (0.99–9.28)	0.052	2–3 cups	3.03 (0.99–9.28)
4–5 cups	3.34 (1.00-11.20)	0.051	4–5 cups	3.34 (1.00-11.20)
6 cups or more	1			
Coffee (daily frequency)				
Never/Rarely	1			
Weekly/Daily	1.37 (0.72–2.61)	0.346	Weekly/Daily	1.37 (0.72–2.61)
Soft drinks				
Never/Rarely	1			
Weekly/Daily	2.69 (1.02–7.06)	0.045	Weekly/Daily	2.69 (1.02–7.06)
Meat				
Never/Rarely	1			

Note:COR = Crude Odd Ratio | **AOR** = Adjusted Odd Ratio

Variable	COR(95% CI)		AOR(95% CI)	
		P-value		
Weekly/Daily	4.64 (2.68–8.05)	< 0.001	Weekly/Daily	4.64 (2.68–8.05)
Liver				
Never/Rarely	1			
Weekly/Daily	3.17 (1.51–6.66)	0.002	Weekly/Daily	3.17 (1.51–6.66)
Fish				
Never/Rarely	1			
Weekly/Daily	3.96 (2.11–7.43)	< 0.001	Weekly/Daily	3.96 (2.11–7.43)
Canned food				
Never/Rarely	1			
Weekly/Daily	1.04 (0.54–1.98))	0.912	Weekly/Daily	1.04 (0.54–1.98))
Butter, cream or Kaymak				
Never/Rarely	1			
Weekly/Daily	2.55 (1.48–4.39)	0.001	Weekly/Daily	2.55 (1.48–4.39)
Note:COR = Crude Odd Ratio | **AOR** = Adjusted Odd Ratio				

Disease burden of urolithiasis

Among cases, 95.6% reported pain, and 52.7% experienced severe pain (visual analogue scale [VAS] score 7–10), with a median VAS score of 7. Loin pain was reported by 43.2% of cases, while hematuria was reported by 22.4%.

Regarding healthcare utilization, 57.1% of cases reported monthly outpatient visits, and 24.2% reported more than three emergency department visits or hospital admissions per month.

Urolithiasis was also associated with a substantial socioeconomic burden. Nearly one-third of cases (29.7%) reported missing more than 10 workdays because of illness, with a median absence of 14 days. Urinary tract infection (16.5%) and kidney damage (12.1%) were the most commonly reported complications.

The median treatment cost was 150,000 Sudanese pounds (approximately USD 70). Overall, 91.2% of cases reported financial hardship related to the disease, and 67.0% had no health insurance coverage (Tables 6–8).

Table 6
Clinical Burden of Urolithiasis - Pain Characteristics and Symptom Frequency (n = 273)

Variable	Frequency	Percent
Pin Frequency		
Never	4	4.4
Sometimes	85	93.4
Always	2	2.2
Pain Severity (VAS 0–10)		
Mild (1–3)	26	28.6
Moderate (4–6)	17	18.7
Severe (7 – 0)	48	52.7
Median (IQR) of pain severity	7.00 (6.00)	
Symptoms Reported		
Loin pain	79	43.2
Nausea/Vomiting	27	14.8
Hematuria	41	22.4
Urinary frequency	27	14.8
Others	9	4.9

Table 7
Healthcare Utilization Patterns Among Urolithiasis Patients (n = 273)

Variable	Frequency	Percent
Frequency of Seeking Stone-related Medical Care		
Rarely (once or twice a year)	15	16.5
Occasionally (once every few months)	16	17.6
Regularly (once every month)	52	57.1
Days Missed Work/School in the past Year		
Never	43	47.3
1–5	8	8.8
6–10	13	14.3
> 10	27	29.7
Median (IQR) of days missed	14.00 (14.00)	
Number of Hospitalizations or ER Visits last Month		
Never	15	16.5
Once	28	30.8
2–3	26	28.2
> 3	22	24.2
Complications		
None	62	68.1
UTIs	11	16.5
Hydronephrosis	2	2.2
Kidney damage	15	12.1

Table 8
Economic Impact of Urolithiasis - Treatment Costs and Productivity Loss (n = 273)

Variable	Frequency	Percent
Treatment cost (last episode)		
Median (IQR) cost of last treatment	150,000.00 (450,00.00) SDG	
Lost Income/Month		
Median (IQR) of estimated lost income per month	30,000.00 (90,000.00) SDG	
Out-of-pocket Expenses		
Yes	3	3.3
No	88	96.7
Insurance Coverage		
Yes	30	33.0
No	61	67.0
Financial Stability Affected		
Yes	83	91.2
No	8	8.8

Discussion

This case–control study examined the demographic characteristics, risk factors, and disease burden associated with urolithiasis among adults in Northern State Sudan. The findings demonstrated that urolithiasis was associated with family history, physical activity patterns, comorbid conditions, and dietary factors, including tea intake, soft drink consumption, and fish consumption. The disease was also associated with a substantial clinical, social, and economic burden.

The mean age of participants (52.0 ± 15.4 years) indicated that urolithiasis predominantly affected middle-aged and older adults. This finding was consistent with studies from India and the UAE, which reported higher frequencies of stone disease in similar age groups (13,14). This pattern may have reflected cumulative exposure to environmental, dietary, and metabolic factors over time, as well as age-related changes in renal function and urinary composition.

Male sex was more common among participants, supporting the known male predominance of urolithiasis. Similar findings were reported in the UAE, India, and the Global Burden of Disease 2021 study (12–14). This distribution may have been linked to hormonal differences, occupational exposure, dietary habits, and metabolic factors that increase urinary supersaturation.

The majority of participants resided in rural areas, reflecting the population structure of Northern Sudan. Although rural residence was not consistently assessed in other studies, it may have been linked to environmental heat exposure, limited healthcare access, and reduced hydration practices. The predominance of the Danagla ethnic group likely reflected the regional population distribution rather than a specific ethnic susceptibility.

Anthropometric findings showed higher weight and height among cases, whereas BMI was not significantly associated with urolithiasis. This finding partially contrasted with results from the UAE, where obesity was associated with stone disease (14). The absence of a significant association may have suggested that environmental and dietary factors played a greater role in this setting than generalized adiposity.

Family history was strongly associated with urolithiasis, consistent with findings from the UAE study (14). This association may have reflected shared genetic susceptibility and common environmental or dietary exposures within families. However, differences from some Indian studies highlighted possible population variation in genetic and environmental influences (13).

Physical activity was associated with urolithiasis. This finding may have reflected occupational physical activity under high ambient temperatures, which may have been linked to increased fluid loss and reduced urine volume rather than exercise itself. Similar studies have emphasized dehydration as a key factor associated with stone risk (14).

Comorbid conditions such as diabetes and hypertension were also associated with urolithiasis. These conditions may have been linked to metabolic alterations affecting urinary pH and solute excretion, which may have increased the likelihood of stone formation.

Tea consumption showed a significant association with urolithiasis. Lower intake levels were associated with higher odds compared with consumption of ≥ 6 cups/day. This finding was partially consistent with studies from Iran and India, although the direction of association varied across populations (13,15). Differences in tea concentration, preparation methods, and hydration status may have explained these variations.

Soft drink consumption was also associated with higher odds of urolithiasis. This finding was consistent with studies from Iran (4). Soft drink consumption may have been linked to lithogenic risk through fructose-related metabolic effects and substitution of water intake.

Fish consumption remained associated with urolithiasis after adjustment. This association may have reflected increased animal protein intake, which has been linked to metabolic changes such as increased acid load and altered urinary solute excretion. However, findings differed across populations, and further studies are needed to clarify this association.

Meat consumption showed an association in crude analysis but not after adjustment, suggesting that its effect may have been influenced by other dietary and lifestyle factors. Similarly, butter and dairy fat

intake were not independently associated with urolithiasis, consistent with mixed findings reported in previous studies.

The disease burden was substantial, with most patients experiencing pain and more than half reporting severe symptoms. These findings were consistent with the Global Burden of Disease 2021 study, which identified urolithiasis as a major cause of disability (12). Recurrent renal colic may have significantly affected quality of life and daily functioning.

Healthcare utilization was high, reflecting the recurrent nature of the disease and placing considerable strain on healthcare services in resource-limited settings.

The socioeconomic consequences were considerable, including work absenteeism, financial burden, and lack of health insurance coverage. These findings suggested that urolithiasis was associated not only with clinical morbidity but also with reduced productivity and economic hardship.

Complications such as urinary tract infections and kidney damage were also observed, highlighting the importance of early detection and management to reduce long-term adverse outcomes.

Overall, urolithiasis in Northern Sudan appeared to be associated with a combination of familial, dietary, metabolic, and environmental factors. The findings were broadly consistent with studies from the UAE, India, Iran, and Korea while also reflecting the unique climatic conditions of the region. Preventive strategies focusing on adequate hydration, dietary modification, and management of comorbidities may help reduce the burden of urolithiasis.

Strengths

This study has several strengths.

First, it is among the first hospital-based case–control studies conducted in Northern State Sudan to investigate both the risk factors and disease burden of urolithiasis.

Second, the inclusion of age-, sex-, and residence-matched controls improved comparability between cases and controls.

Third, multivariable logistic regression was used to identify factors independently associated with urolithiasis while controlling for potential confounding variables.

Finally, the study comprehensively assessed demographic, anthropometric, lifestyle, dietary, and clinical factors, in addition to healthcare utilization, productivity loss, and financial burden, providing a broad assessment of the impact of urolithiasis in this setting.

Limitations

Several limitations should be considered when interpreting these findings.

First, the case–control design does not allow causal or temporal relationships between exposures and urolithiasis to be established.

Second, dietary habits, physical activity, and other lifestyle variables were self-reported and may have been affected by recall and reporting bias.

Third, the study was conducted at a single tertiary hospital in Northern Sudan, which may limit the generalizability of the findings to other regions of the country.

Fourth, biochemical investigations, 24-hour urine analysis, stone composition analysis, and detailed dietary quantification were not available, limiting assessment of the underlying metabolic mechanisms.

Finally, residual confounding from unmeasured factors, such as total fluid intake, occupational heat exposure, and genetic predisposition, cannot be excluded despite adjustment for measured confounders. Future multicenter prospective studies incorporating laboratory investigations and stone composition analysis are recommended to validate and extend these findings.

Public Health Implications

Urolithiasis in Northern State Sudan represents an important public health concern. The findings suggest that prevention efforts should focus on modifiable factors such as hydration practices, dietary habits, and management of chronic diseases.

Public health interventions should prioritize education on adequate water intake, particularly among individuals exposed to high environmental temperatures. Increased awareness regarding the potential role of soft drinks and concentrated tea in relation to stone risk may also be beneficial.

Integration of urolithiasis prevention into non-communicable disease programs is recommended, particularly for patients with diabetes and hypertension. Family-based health education may be useful given the observed association with family history.

The substantial clinical and economic burden observed in this study highlights the need to strengthen urological services, improve access to affordable care, and expand health insurance coverage to reduce financial strain on affected households.

Conclusion

Urolithiasis in Northern state Sudan is associated with familial, dietary, metabolic, and environmental factors and imposes a substantial clinical and socioeconomic burden. The disease is linked to significant pain, frequent healthcare utilization, productivity loss, financial hardship, and complications such as urinary tract infections and kidney damage.

Preventive strategies focusing on improved hydration, dietary modification, and management of comorbid conditions are essential to reduce disease burden. Strengthening healthcare services and early

identification of high-risk individuals may further improve outcomes. Further multicenter and longitudinal studies are needed to better understand the epidemiology of urolithiasis in Sudan

Abbreviations

AOR — Adjusted Odds Ratio
BMI — Body Mass Index
CI — Confidence Interval
COR — Crude Odds Ratio
CT — Computed Tomography
GBD — Global Burden of Disease
KoboCollect — Kobo Toolbox Data Collection Application
NLM — National Library of Medicine
OR — Odds Ratio
PCNL — Percutaneous Nephrolithotomy
SPSS — Statistical Package for the Social Sciences
VAS — Visual Analogue Scale
UTI — Urinary Tract Infection
WHO — World Health Organization

Declarations

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Ethical considerations

Ethical approval was obtained from the Health Research Ethics Committee, Ministry of Health, Northern State, and the administration of Dongola Specialized Hospital. Written informed consent was obtained from all participants prior to enrollment. Participation was voluntary, and refusal did not affect access to medical care. All collected data were anonymized and securely stored to ensure confidentiality in accordance with the Declaration of Helsinki.

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Competing interests

The authors declare no conflict of interest.

Data availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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Author Contribution

Author ContributionsOsama Mohamed: Conception and design of the study, data collection, data management, statistical analysis, interpretation of results, and manuscript preparation.Mohamed Ali Alzain: Study supervision, methodological guidance, interpretation of findings, critical revision of the manuscript, and scientific oversight.Both authors: Reviewed and approved the final version of the manus

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