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RISK FACTORS FOR RECURRENT PEDIATRIC UROLITHIASIS STUDY AT JINNAH MEDICAL COLLEGE AND JINNAH TEACHING HOSPITAL

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ABSTRACT
Background: There is growing evidence that pediatric urolithiasis is a relapsing and remitting condition that can be affected by several metabolic, dietary, infectious, anatomical, familial and treatment factors. Children are at risk of frequent pain, urinary tract infection, urinary tract obstruction, repeated procedures, and progressive renal damage with recurrent stone formations. Therefore, it is crucial to identify the recurrence predictors at an early stage in order to plan preventative treatment and long term follow-up.
Objective: To determine the frequency of recurrent pediatric urolithiasis and identify the clinical, dietary, metabolic, radiological, and treatment-related factors associated with recurrence among children treated at Jinnah Teaching Hospital, Peshawar.
Methodology: This prospective observational cohort study was carried out in Jinnah Teaching Hospital, Peshawar from June 2024 to January 2026. The patients consisted of 91 children, consecutively sampled and with a confirmed diagnosis of urolithiasis using radiology. Demographic data, family history, diet/hydration habits, clinical presentation, UTI history, stone characteristics, anatomical abnormalities, metabolic findings, treatment history, and compliance with prevention measures were recorded. The participants were divided into two groups; recurrent and non-recurrent. Appropriate statistical analysis was used to make group comparisons and multivariable binary logistic regression was used to determine independent predictors of recurrence. The p-value was set at < 0.05.
Results: The mean age of the participants was 9.36 ± 3.82 years, and 55 (60.4%) were male. Recurrent urolithiasis was identified in 32 children, giving a recurrence rate of 35.2%. Positive family history, parental consanguinity, recurrent urinary tract infection, inadequate fluid intake, high salt intake, multiple and bilateral stones, larger stone size, hydronephrosis, nephrocalcinosis, residual stone fragments, hypercalciuria, hypocitraturia, low urine volume, and poor adherence to preventive recommendations were significantly associated with recurrence. On multivariable analysis, positive family history, inadequate fluid intake, recurrent urinary tract infection, multiple stones, residual fragments, hypercalciuria, and poor preventive adherence remained independent predictors. Residual stone fragments showed the strongest association with recurrence.
Conclusion: Recurrent pediatric urolithiasis affected more than one-third of the study population. Familial predisposition, inadequate hydration, urinary infection, increased stone burden, residual fragments, metabolic abnormalities, and poor preventive adherence contributed substantially to recurrence. Comprehensive metabolic evaluation, complete stone clearance, dietary modification, adequate fluid intake, infection control, and structured follow-up are essential for reducing recurrent stone formation in children.

KEYWORDS: Pediatric urolithiasis; stone recurrence; hypercalciuria; urinary tract infection; fluid intake; residual stone fragments

INTRODUCTION
Urolithiasis in children is an important and increasingly recognized health problem that may lead to considerable short- and long-term morbidity. While the prevalence of urinary stone disease in adults has long been believed to be greater, in many parts of the world stone disease is becoming progressively more common in children. Children may have abdominal or back pain, blood in the urine (hematuria), painful urination (dysuria), vomiting, or UTI, urinary obstruction or passage of a stone. Symptoms in younger children may be more vague, such as irritability, decreased appetite, fever or abdominal pain of unknown cause, and this may delay the diagnosis [1-3].

Pediatric urolithiasis is often polycausal in nature. Commonly implicated metabolic abnormalities include hypercalciuria, hypocitraturia, hyperoxaluria, hyperuricosuria, cystinuria and low urine volume. These abnormalities lead to a higher risk of stone formation and the formation of a supersaturated urine. Urinary tract anatomical abnormalities could play a role in urinary stasis, obstruction and incomplete drainage. Recurrent UTI especially with urease-producing organisms may also contribute to stone formation by increasing urinary pH and promoting mineral precipitation [4-6].

Pediatric stone disease is also influenced by factors such as environment, diet and behavior. Frequent dehydration, inadequate hydration, hot climatic conditions, excessive salt intake, high animal protein intake, frequent intake of soft drinks, and low intake of fruits and vegetables may lead to increased urinary concentration and lithogenic activity levels. Children in warmer climates may be especially at risk because sweating will cause fluid loss, which will in turn decrease urine output. The higher incidence of urolithiasis in children with a positive family history can be attributed to shared dietary habits within the family and to the inherited predisposition to the condition [7-9].

Recurrence is one of the most important problems of pediatric urinary stones management. A child who has formed one stone may be at risk of developing another for many years, especially if there is a metabolic, anatomical, infectious, or genetic abnormality which persists. Recurrent stones may lead to recurrent pain, blood in the urine, infection, enlargement of the kidneys, blockage of the urine flow and damage to the kidney tissue. They also might need further imaging, hospitalizations, anesthesia, lithotripsy, endoscopy or surgery. Therefore, paediatric urolithiasis is to be viewed as a chronic rather than an acute event and should be prevented and monitored [10-12].

Other factors related to the stone, such as its size, might also affect the risk of recurrence. Several stones, bilateral stones, nephrocalcinosis, more stones to grow from, and stones that remain after treatment may be a source of stone growth. When metabolic abnormalities are unchecked or fluids are inadequate, small bits of tissue that seem harmless at first may grow and develop, causing problems to worsen over time. Stone clearance, as such, is a significant therapeutic goal and metabolic evaluation and prevention is still required following the procedure [13, 14].

To prevent recurrent pediatric urolithiasis, a holistic approach to the problem is necessary, which includes sufficient hydration, dietary management, correction of metabolic disorders, timely treatment of UTI, resolution of anatomical obstruction, and periodic radiologic monitoring. Depending on the metabolic disorder, potassium citrate, thiazide diuretics or other specific drugs may be necessary. However, these measures can be highly effective only if parents are aware of them and follow them, as well as if they can be followed up properly [15].

Despite the clinical importance of recurrent pediatric urolithiasis, data regarding its predictors remain limited in many local healthcare settings. Regional differences in climate, diet, water intake, socioeconomic conditions, infection burden, genetics, and access to metabolic evaluation may influence the pattern of recurrence. Identifying locally relevant risk factors can help clinicians recognize high-risk children and develop targeted preventive strategies. Therefore, this study was conducted to determine the frequency of recurrent pediatric urolithiasis and evaluate the demographic, familial, dietary, clinical, metabolic, anatomical, radiological, and treatment-related factors associated with recurrence among children treated at Jinnah Teaching Hospital, Peshawar.

METHODOLOGY

This hospital-based prospective observational cohort study was conducted in the Departments of Pediatrics and Urology at Jinnah Teaching Hospital, Peshawar, from June 2024 to January 2026. The study was designed to determine the clinical, metabolic, dietary, anatomical, and treatment-related factors associated with recurrent urolithiasis in children. Pediatric patients diagnosed with urinary tract stones during the study period were enrolled and followed to identify recurrence and its potential predictors.

A total of 91 children with radiologically confirmed urolithiasis were included in the study. Children were recruited using consecutive non-probability sampling from the pediatric and urology inpatient departments, outpatient clinics, and emergency department. Children who appeared eligible were approached for study until the required sample size was reached, during the time frame of the study.

Children, both male and female, up to 16 years of age, who had urinary tract stones (UTS) diagnosed using ultrasonography, plain radiography, computed tomography (CT) or a combination of these imaging modalities, were eligible for study inclusion. The included children with their first episode of urolithiasis and also those children with a known history of stone disease. Patients had to have adequate clinical and laboratory or radiologic data for assessment of the potential risk factors for recurrence.

Children with incomplete medical records, uncertain radiological diagnosis, or insufficient follow-up information were excluded. Patients whose urinary tract calcifications were secondary to renal tumors or foreign bodies were also excluded. Children whose parents or legal guardians did not provide informed consent were not enrolled.

Pediatric recurrent urolithiasis was defined as occurrence of a new urinary stone following spontaneous stone passage, complete surgical clearance or radiological absence of stones after treatment. The appearance of a stone at the same or a different anatomical location during follow-up was considered recurrence. If there was residual fragments immediately after treatment, these were not considered as recurrence, but as a potential risk factor for stone formation in the future. The patients were further divided into two groups for analysis. The recurrent group comprised children who either had a definite previous stone recurrence or who had one or more additional stone episodes with follow up. The non-recurrent group were children who had no stones at follow-up.

A structured proforma designed for the study was used to gather data. Data was collected using interviews with the parents/legal guardians, clinical examination, hospital records, laboratory reports, radiological investigation, operative notes and follow-up visits. The demographic data such as age, sex, place of residence, socioeconomic status, consanguinity of the parents, nutritional status, and family history of urinary stone disease were considered. Clinical data consisted of age at time of the first stone episode, presenting symptoms, prior passage of stones, prior urinary tract surgery, prior history of recurrent UTI, congenital urinary tract abnormalities, chronic diarrhea, malabsorption, prolonged immobilization and other renal or metabolic disorders. Abdominal/flank pain, hematuria, dysuria, fever, vomiting, urinary retention, and spontaneous stone passage were recorded as symptoms. Parents/caregivers were interviewed for a detailed dietary and hydration history. Daily fluid intake, frequency of dehydration, consumption of animal protein, oxalate-containing food, calcium, vitamin D, soft drinks and fruits and vegetables were documented. Children were classified as consuming an adequate or inadequate amount of fluid based on their age, size, clinical status and the amount of fluid they consumed daily.

All participants had a comprehensive physical exam. The body weight was taken by a calibrated weighing machine and the height was measured by stadiometer. Weight measurement was used to work out BMI which is calculated by dividing weight in kilograms by the square of the height in metres. The nutritional status was assessed using the age-specific criteria for children. The following factors were evaluated: blood pressure, hydration, abdominal tenderness, palpable abdominal masses, and urinary obstruction and/or infection. As the first radiological investigation all participants had US of kidneys, ureters and urinary bladder. Stones were documented for their number, size, location and laterality. The size of the stones was measured in millimetres based on the maximum diameter recorded. Stones were classified as single or multiple; unilateral or bilateral. The location of the stone was renal, ureteric or urinary bladder. Radiological parameters such as hydronephrosis, hydroureter, nephrocalcinosis, renal structural abnormalities and remnant stone fragments were noted. Where ultrasonography was inconclusive, where complications were suspected, or when clinical indications for more complete anatomical evaluation were present, the kidneys, ureters and bladder were scanned with non-contrast computed tomography was performed.

Congenital urinary tract abnormalities, including pelviureteric junction obstruction, vesicoureteral reflux, ureterocele, duplex collecting system, horseshoe kidney, neurogenic bladder, and posterior urethral valve, were documented when identified through ultrasonography, voiding cystourethrography, renal scans, computed tomography, or other clinically indicated investigations.

Serum calcium, phosphate, uric acid, creatinine, blood urea nitrogen (BUN), sodium, potassium, bicarbonate and magnesium were obtained in an aseptic manner. Selected patients with possible hypercalcemia, stone and/or nephrocalcinosis or underlying metabolic disorder, had their serum parathyroid hormone and vitamin D levels measured. A urinalysis was conducted to evaluate the urine pH, specific gravity, hematuria, proteinuria, pyuria, crystalluria and any other abnormalities. Urine culture and antimicrobial sensitivity test was performed in children with fever, dysuria, pyuria, recurrent urinary tract infection and clinical suspicion of infection. UTI was suspected if clinically significant bacterial growth was found in an appropriate urine specimen that was collected. The isolated microorganisms were recorded. Where facilities and patient age allowed, metabolic evaluation consisted of urinary calcium, oxalate, citrate, uric acid, sodium, and cystine. Twenty-four hour urine collection was preferred in older children which were cooperative. Spot urinary solute to creatinine ratio was utilized for younger children or individuals who could not do a 24-hour spot collection. Metabolic abnormalities were grouped as hypercalciuria, hyperoxaluria, hypocitraturia, hyperuricosuria, cystinuria, abnormal urine pH, or low urine volume based upon pediatric laboratory reference values (pLRVs) adjusted for the child's age.The metabolic abnormalities were categorized as hypercalciuria, hyperoxaluria, hypocitraturia, hyperuricosuria, cystinuria, abnormal urine pH, or low urine volume based upon age-adjusted pediatric laboratory reference values (pLRVs).

Any stones that fell off or were retrieved during an interventional procedure were sent for biochemical or compositional analysis. The type of stone was determined as calcium oxalate, calcium phosphate, uric acid, struvite, cystine or mixed urinary stone. If stone analysis was performed, the stone composition was recorded, however if it was not performed, the stone was not inferred only on the basis of the radiological appearance.

Treatment was decided upon based on the size of the stone, its location, symptoms, degree of obstruction, the presence of infection, anatomical abnormalities, renal function, and the child's overall clinical status. Conservative treatment, fluid therapy, analgesics, medical expulsive therapy, extracorporeal shock-wave lithotripsy, ureteroscopy, percutaneous nephrolithotomy and open surgery were all possible treatments. Imaging performed after surgery or after a follow-up time was used to evaluate stone clearance. Complete stone clearance was defined as stones which were not seen on follow-up imaging. Persistent stones (residual fragments) were stones that could still be found after treatment. Treatment of the abnormality depended on the diagnosis, with preventive therapy, such as potassium citrate, thiazide diuretics, allopurinol or other metabolic therapy prescribed. Counselling was provided to parents and children on adequate fluid intake, reduction of dietary salt, balanced calcium intake, avoiding excess animal protein or oxalate rich foods and taking prescribed medicines. Adherence to fluid advice, dietary recommendations, preventive medications and follow-up visits was measured using caregiver interview and clinical diaries. Adherence was defined as good or poor for the regularity of preventive practices and prescribed treatment.

Outpatient visits and hospital records were used to monitor participants. Follow-up assessments included clinical assessment, urinalysis and ultrasonography when clinically indicated. Parents were advised to return earlier if the child complained of abdominal or flank pain, hematuria, dysuria or fever or even if it complained of reduced urinary output or if the stone passed spontaneously. On each visit, the appearance of new symptoms, UTI, compliance with preventive measures, and complications of treatment, stone clearance, the presence of stone remnants, and the formation of a new stone were noted. Where available, the time interval between documented clearance or first treatment and first episode of recurrence was documented in months. The primary outcome was recurrent pediatric urolithiasis, defined as the presence or absence of the condition. Independent variables were: age, sex, family history of stone disease, consanguinity of the parents, residence, nutritional status, inadequate fluid intake, high dietary salt intake, frequent urinary tract infection, congenital urinary tract defects, stone size, stone number, bilateral involvement, hydronephrosis, nephrocalcinosis, presence of residual stones, stone composition, hypercalciuria, hyperoxaluria, hypocitraturia, hyperuricosuria, cystinuria, low urine volume, treatment modality, and compliance with preventive recommendations.

Data obtained were recorded and analysed using IBM SPSS statistics. The continuous variables such as age, stone size were tested for normality and were presented as mean ± SD when normally distributed. The continuous variables that were not normally distributed were summarized by median and interquartile range. For categorical variable, frequencies and percentages were used. Demographic, clinical, dietary, radiological, metabolic and treatment-associated parameters of the children who had recurrent urolithiasis and those who did not had been compared. Normally distributed continuous data were analysed using independent-samples t-test and non-normally distributed continuous data were analysed using the Mann–Whitney U test. Association between categorical variables was tested for using the chi-square test. Fisher's exact test was applied when the number of cells in the tables was low. Recurrent pediatric urolithiasis was studied by binary logistic regression to identify independent risk factors. Those variables that were clinically important, or had a p-value <0.20 on univariable analysis were entered into the multivariable regression model. Odds ratio and 95% confidence intervals were used to present results. The Hosmer–Lemeshow goodness-of-fit test was used to evaluate model calibration. A p value < 0.05 was deemed as statistically significant.

RESULTS

There were 91 diagnosed cases of urolithiasis included in the study. The mean age of the participants was 9.36 ± 3.82 years (range: 2-16 years). Of the total patients, 55 (60.4%) were male and 36 (39.6%) were female. The overall recurrence rate was 35.2%, as 32 children had a recurrence of urolithiasis during the follow up period, and 59 children (64.8%) did not have any recurrence of the condition during the follow-up period. The age of most of the participants was 5 to 10 years. The mean age of children with recurrent stone was slightly higher than children without the recurrence, but it was not statistically significant. Children with recurrent urolithiasis were more likely to have a positive family history of urinary stone and a consanguineous marriage with the parents.

Table 1. Demographic and baseline characteristics of the study participants

Variable	Total, n = 91	Recurrent, n = 32	Non-recurrent, n = 59	p-value
Age, years, mean ± SD	9.36 ± 3.82	10.06 ± 3.65	8.98 ± 3.88	0.201
Age <5 years	14 (15.4%)	3 (9.4%)	11 (18.6%)	0.453
Age 5–10 years	42 (46.2%)	15 (46.9%)	27 (45.8%)	
Age >10 years	35 (38.5%)	14 (43.8%)	21 (35.6%)	
Male sex	55 (60.4%)	21 (65.6%)	34 (57.6%)	0.456
Female sex	36 (39.6%)	11 (34.4%)	25 (42.4%)	
Rural residence	52 (57.1%)	21 (65.6%)	31 (52.5%)	0.228
Urban residence	39 (42.9%)	11 (34.4%)	28 (47.5%)	
Positive family history	30 (33.0%)	17 (53.1%)	13 (22.0%)	**0.003**

Parental consanguinity	34 (37.4%)	17 (53.1%)	17 (28.8%)	**0.022**
Underweight nutritional status	18 (19.8%)	8 (25.0%)	10 (16.9%)	0.354
Overweight or obesity	13 (14.3%)	6 (18.8%)	7 (11.9%)	0.374

The most common complaints were abdominal or flank pain, hematuria and dysuria. Children with a history of recurrent stones had significantly more recurrent UTI. Other factors associated with recurrence were previous history of stone passage and congenital urinary tract abnormalities.

Table 2. Clinical presentation and medical history

Variable	Total, n = 91	Recurrent, n = 32	Non-recurrent, n = 59	p-value
Abdominal or flank pain	68 (74.7%)	25 (78.1%)	43 (72.9%)	0.586
Hematuria	39 (42.9%)	16 (50.0%)	23 (39.0%)	0.311
Dysuria	35 (38.5%)	15 (46.9%)	20 (33.9%)	0.223
Fever	28 (30.8%)	13 (40.6%)	15 (25.4%)	0.132
Vomiting	24 (26.4%)	10 (31.3%)	14 (23.7%)	0.437
Recurrent urinary tract infection	29 (31.9%)	17 (53.1%)	12 (20.3%)	**0.001**
Previous spontaneous stone passage	23 (25.3%)	13 (40.6%)	10 (16.9%)	**0.013**
Congenital urinary tract abnormality	17 (18.7%)	10 (31.3%)	7 (11.9%)	**0.022**
History of chronic diarrhea or malabsorption	8 (8.8%)	5 (15.6%)	3 (5.1%)	0.124
Previous urinary tract surgery	12 (13.2%)	7 (21.9%)	5 (8.5%)	0.092

In 49 children, there was a lack of fluid intake, which was significantly more common in the recurrent group. Other factors which were associated with recurrent stone formation included high dietary salt consumption, drinking of frequent soft drinks and low consumption of fruits and vegetables.

Table 3. Dietary, hydration and lifestyle-related risk factors

Risk factor	Total, n = 91	Recurrent, n = 32	Non-recurrent, n = 59	p-value
Daily fluid intake below recommended level	49 (53.8%)	24 (75.0%)	25 (42.4%)	**0.003**
Frequent dehydration	37 (40.7%)	19 (59.4%)	18 (30.5%)	**0.007**
High dietary salt intake	43 (47.3%)	21 (65.6%)	22 (37.3%)	**0.010**
High animal-protein intake	31 (34.1%)	14 (43.8%)	17 (28.8%)	0.150
Frequent oxalate-rich food intake	36 (39.6%)	16 (50.0%)	20 (33.9%)	0.134
Frequent soft-drink consumption	33 (36.3%)	17 (53.1%)	16 (27.1%)	**0.014**
Low fruit and vegetable intake	38 (41.8%)	18 (56.3%)	20 (33.9%)	**0.038**
Calcium or vitamin D supplementation	16 (17.6%)	7 (21.9%)	9 (15.3%)	0.428

In 58 patients a single stone was detected and in 33 children more than one stone was found. The multiple stones, bilateral stones or stones that remained after treatment were found to be significantly associated with stone recurrence. There was also a greater mean stone size for children with recurrent disease.

Table 4. Stone characteristics and radiological findings

Variable	Total, n = 91	Recurrent, n = 32	Non-recurrent, n = 59	p-value
Mean stone size, mm	8.74 ± 4.06	10.34 ± 4.31	7.86 ± 3.67	0.005
Stone size ≥10 mm	34 (37.4%)	18 (56.3%)	16 (27.1%)	0.006
Multiple stones	33 (36.3%)	18 (56.3%)	15 (25.4%)	0.003
Bilateral stones	20 (22.0%)	12 (37.5%)	8 (13.6%)	0.008
Renal stones	61 (67.0%)	23 (71.9%)	38 (64.4%)	0.469
Ureteric stones	22 (24.2%)	7 (21.9%)	15 (25.4%)	0.706
Bladder stones	8 (8.8%)	2 (6.3%)	6 (10.2%)	0.709
Hydronephrosis	38 (41.8%)	18 (56.3%)	20 (33.9%)	0.038
Nephrocalcinosis	13 (14.3%)	8 (25.0%)	5 (8.5%)	0.032

Residual stone fragments	21 (23.1%)	14 (43.8%)	7 (11.9%)	<0.001

Calcium oxalate was the most common elemental component of stones, and calcium phosphate and uric acid were the next most common stones, among children for whom stone composition was available. Cystine stones were rare but had a fairly high recurrence rate.

Table 5. Distribution of stone composition

Stone composition	**Total, n = 91**	**Recurrent, n = 32**	**Non-recurrent, n = 59**
Calcium oxalate	43 (47.3%)	16 (50.0%)	27 (45.8%)
Calcium phosphate	17 (18.7%)	6 (18.8%)	11 (18.6%)
Uric acid	9 (9.9%)	3 (9.4%)	6 (10.2%)
Struvite	8 (8.8%)	3 (9.4%)	5 (8.5%)
Cystine	5 (5.5%)	4 (12.5%)	1 (1.7%)
Mixed composition	9 (9.9%)	0 (0.0%)	9 (15.3%)

The difference between the stone composition in the recurrent and non-recurrent groups was statistically significant ($p = 0.029$), although the difference was small, with cystine stone being more common among children with recurrence.

Fifty-eight children had metabolic abnormalities; at least one abnormality was present in every child. Hypercalciuria was the most prevalent followed by hypocitraturia and hyperoxaluria. Patients with recurrent urolithiasis significantly had hypercalciuria and hypocitraturia and low urine volume.

Table 6. Laboratory and metabolic abnormalities

Variable	**Total, n = 91**	**Recurrent, n = 32**	**Non-recurrent, n = 59**	**p-value**
Hypercalciuria	28 (30.8%)	16 (50.0%)	12 (20.3%)	**0.003**
Hypocitraturia	24 (26.4%)	14 (43.8%)	10 (16.9%)	**0.005**
Hyperoxaluria	18 (19.8%)	10 (31.3%)	8 (13.6%)	**0.041**
Hyperuricosuria	14 (15.4%)	7 (21.9%)	7 (11.9%)	0.205
Cystinuria	5 (5.5%)	4 (12.5%)	1 (1.7%)	0.047
Low urine volume	39 (42.9%)	21 (65.6%)	18 (30.5%)	**0.001**
Abnormal urine pH	26 (28.6%)	13 (40.6%)	13 (22.0%)	0.059
Positive urine culture	27 (29.7%)	15 (46.9%)	12 (20.3%)	**0.007**
Elevated serum uric acid	11 (12.1%)	6 (18.8%)	5 (8.5%)	0.185
Impaired renal function	7 (7.7%)	4 (12.5%)	3 (5.1%)	0.240

The most common organism isolated from urine cultures with organisms was Escherichia coli, with 27 culture-positive patients (16 patients). Klebsiella species, Proteus species and Enterococcus species were other organisms. In 28 children, a conservative and medical approach was employed and in 63 children, an interventional procedure was needed. Noncompliance with medication for prevention, fluid, and dietary recommendations was significantly associated with recurrence.

Table 7. Treatment and follow-up characteristics

Variable	**Total, n = 91**	**Recurrent, n = 32**	**Non-recurrent, n = 59**	**p-value**
Conservative or medical treatment	28 (30.8%)	8 (25.0%)	20 (33.9%)	0.380
Extracorporeal shock-wave lithotripsy	18 (19.8%)	7 (21.9%)	11 (18.6%)	0.710
Ureteroscopy	22 (24.2%)	8 (25.0%)	14 (23.7%)	0.892
Percutaneous nephrolithotomy	16 (17.6%)	7 (21.9%)	9 (15.3%)	0.428
Open surgical procedure	7 (7.7%)	2 (6.3%)	5 (8.5%)	1.000
Complete stone clearance	70 (76.9%)	18 (56.3%)	52 (88.1%)	**<0.001**
Preventive medication prescribed	45 (49.5%)	19 (59.4%)	26 (44.1%)	0.163
Poor medication adherence	25 (27.5%)	15 (46.9%)	10 (16.9%)	**0.002**
Poor adherence to fluid advice	39 (42.9%)	21 (65.6%)	18 (30.5%)	**0.001**

Poor adherence to dietary advice	35 (38.5%)	19 (59.4%)	16 (27.1%)	**0.002**
Irregular follow-up	30 (33.0%)	17 (53.1%)	13 (22.0%)	**0.003**

All variables with p-values < 0.20 in the univariate analysis were included in a multivariable binary logistic regression analysis. Recurrent UTI, poor adherence to preventive measures, insufficient intake of fluids and metabolic disturbances also played an important role in determining the risk of recurrence.

Table 8. Multivariable logistic regression analysis of predictors of recurrent pediatric urolithiasis

Predictor	**Adjusted odds ratio**	**95% confidence interval**	**p-value**
Positive family history	3.18	1.18–8.59	**0.022**
Low daily fluid intake	3.42	1.20–9.73	**0.021**
Recurrent urinary tract infection	3.76	1.35–10.49	**0.011**
Multiple stones	3.11	1.12–8.65	**0.030**
Bilateral stones	2.28	0.76–6.88	0.143
Residual stone fragments	5.24	1.66–16.54	**0.005**
Hypercalciuria	3.35	1.18–9.49	**0.023**
Hypocitraturia	2.51	0.87–7.25	0.089
Congenital urinary tract abnormality	2.43	0.76–7.78	0.135
Poor adherence to preventive advice	3.68	1.29–10.50	**0.015**

The regression model demonstrated an acceptable fit according to the Hosmer–Lemeshow test (p = 0.681) and correctly classified 78.0% of the study participants. Residual stone fragments were the strongest independent predictor of recurrence, increasing the odds of recurrent urolithiasis by more than five times. Recurrent urinary tract infection, poor adherence to preventive measures, inadequate fluid intake and metabolic abnormalities also contributed substantially to the risk of recurrence.

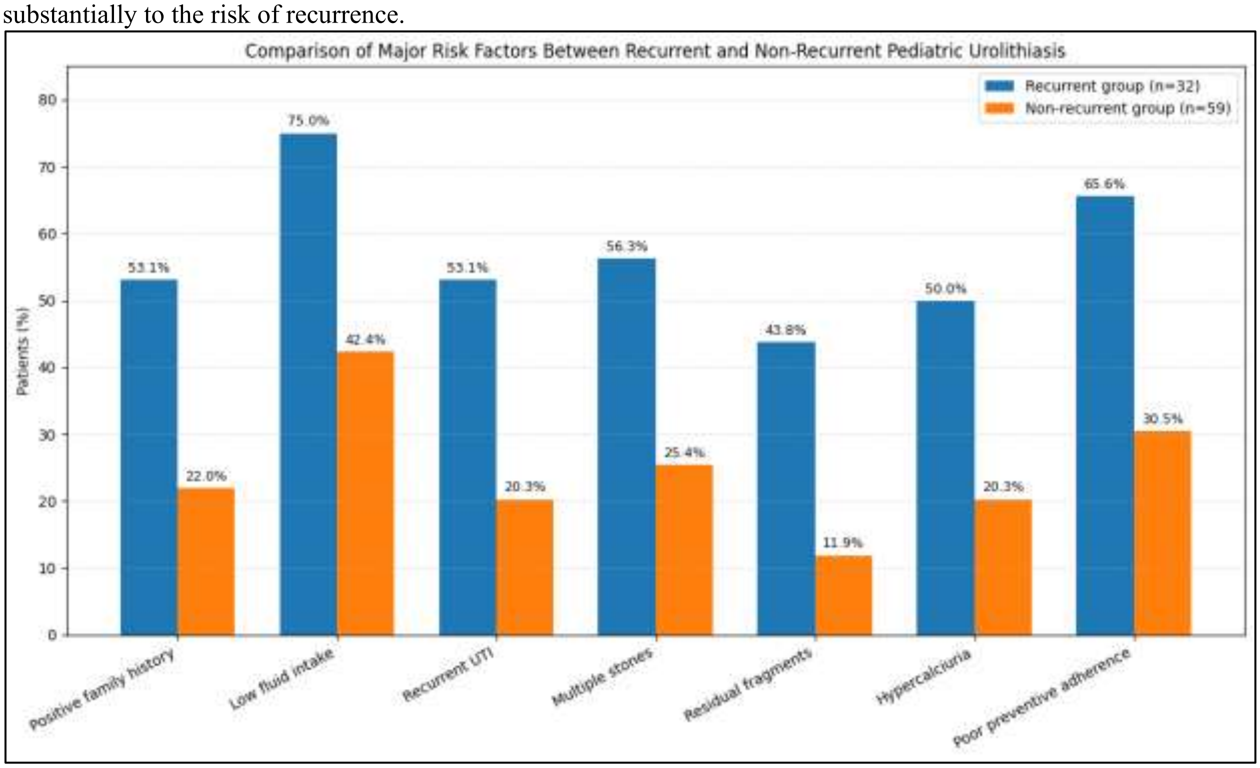

Figure 1. Comparison of major risk factors between children with recurrent and non-recurrent pediatric urolithiasis.

Low fluid intake, poor adherence to preventive measures, multiple stones, positive family history, recurrent urinary tract infection, hypercalciuria, and residual stone fragments were more frequent in the recurrent group.

DISCUSSION

The present study examined the factors associated with recurrent urolithiasis among 91 pediatric patients treated at Jinnah Teaching Hospital, Peshawar. Recurrent stone formation was identified in 32 children, representing 35.2% of the study population. This finding indicates that recurrence is a substantial clinical concern among children with urinary stones and highlights the need for continued surveillance after the initial episode. Pediatric urolithiasis should not be regarded as an isolated event because persistent dietary, metabolic, anatomical, infectious, and familial factors may remain present after stone removal. Previous pediatric studies have also reported clinically important recurrence rates, although the exact frequency varies according to the population studied, duration of follow-up, definition of recurrence, and availability of metabolic evaluation. A tertiary referral-centre study reported recurrence in approximately one-quarter of children during follow-up, supporting the need for long-term monitoring after initial treatment [16].

Children with recurrent stones were significantly more likely to have a positive family history, to have parents who are consanguineous, to not drink enough fluid, to get dehydrated often, and to eat a lot of salt in their diet. Positive family history was an independent risk factor for recurrence, indicating that there is an important role of inherited metabolic susceptibility and shared household dietary habits. Children with similar family activity levels can also drink the same amount of water and consume a comparable amount of salt, animal protein and hot weather, leading to an increase in the concentration of urine and the development of stones. One of the most prevalent modifiable factors associated with recurrence was inadequate fluid intake, with 75.0% of children with recurrence compared to 42.4% of those without recurrence. Decreased fluid intake decreases urine volume, and also makes urine more concentrated by increasing the amount of lithogenic substances. Excessive salt intake can also result in excess calcium loss in the urine, and can even counteract preventive treatment. The literature in paediatrics has highlighted that prevention of recurrence requires sufficient hydration, low sodium diet and tailored nutritional counseling [17].

Recurrent UTI, urine culture, and congenital urinary tract abnormalities were also associated with UTI recurrence. Persistent inflammation, urinary stasis, change of urine pH, and production of urease by organisms like Proteas species are some of the factors which can facilitate urinary infection to induce stone formation. Anatomical abnormalities can also further contribute to recurrence by causing urinary stasis or obstruction preventing complete drainage and can lead to the presence of crystals and bacteria in the collecting system. The results of these studies indicate that the early diagnosis and treatment of RUTI is warranted, and a careful evaluation of the anatomy should be considered in children who develop repeated stone episodes. There have also been previous associations between persistent infection, especially urease-producing infection, and recurrent and progressive stone disease. The results of the present study indicate that antibiotic treatment alone is not sufficient if there is an underlying underlying obstructive or structural defect that is not corrected [17].

Stone burden and metabolic abnormalities were important factors that influenced recurrence. Recurrent disease occurred more often in children with stones ≥ 10 mm in size, with multiple stones, bilateral stones, nephrocalcinosis, hydronephrosis and stones that left behind stones after treatment. Residual stone fragments remained the most important independent predictor in the multivariable model and were over five times the odds of recurrence when compared to other factors. Small pieces can act as nucleating agents for crystal deposition and grow in size over time, especially if metabolic or infectious risk factors do not get well controlled. In the past, children have been shown to develop symptoms from seemingly insignificant stone remnants or to experience symptoms of stone growth later in life. The recurrent group also had higher rates of hypercalciuria, hypocitraturia, hyperoxaluria, cystinuria and low urine volume. Hypocitraturia has a positive albeit non-significantly elevated adjusted association and hypercalciuria remained an independent predictor. The findings are further supporting the importance of metabolic work-up in children who form stones. Twenty-four hour urine testing or age adjusted spot urine ratios may detect abnormalities not detected by routine serum investigations and may help to direct focused preventive therapy [18-20].

Failure to follow recommendations for preventive medication, fluid intake, diet and follow-up appointments was highly associated with recurrent urolithiasis. The results of this study suggest that successful stone removal is not enough to protect from recurrence of the stone and there is a need for structured preventive care. Residual fragments, metabolic abnormalities, familial risk, and recurrent infection are factors that should be monitored closely in children. Parents should be well informed about their child's fluid requirements and how much salt to feed, how to ensure that medications are taken, how to recognize urinary infection symptoms, and the need for regular imaging. There are several limitations for this study. It was carried out in one teaching hospital with relatively small study samples; therefore, the results may not be generalizable. Dietary and adherence data were collected using caregiver report which may have introduced some recall bias. Not all participants may have had metabolic testing and not all may have had stone composition analysis. The length of follow-up varied among participants, which may have affected the ability to detect stones. Nevertheless, this study found clinically relevant and potentially modifiable factors that can aid in risk-based follow-up and recurrence prevention in the pediatric practice setting.

CONCLUSION

Recurrent pediatric urolithiasis was common in the study population, affecting more than one-third of the included children. Positive family history, inadequate fluid intake, recurrent urinary tract infection, multiple stones, residual stone fragments, hypercalciuria, and poor adherence to preventive measures were identified as independent predictors of recurrence. Residual stone fragments represented the strongest predictor, emphasizing the importance of achieving complete stone clearance whenever clinically possible.

A comprehensive approach involving metabolic evaluation, treatment of urinary infection, correction of anatomical abnormalities, adequate hydration, dietary modification, preventive medication, and regular radiological follow-up is required to reduce recurrent stone formation. Children with multiple or bilateral stones, metabolic abnormalities, residual fragments, or a strong family history should be classified as high risk and monitored more closely. Early identification of modifiable factors and active involvement of parents in long-term preventive care may reduce recurrence, repeated procedures, renal complications, and the overall burden of pediatric urolithiasis.

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