Prevalence and risk factors of urinary stone disease in children

Qabulov Bekzod Maqsudovich
Assistant, Department of Pediatrics and Neonatology, Urgench State Medical Institute (Uzbekistan)

Annotation. This article examines the prevalence and major risk factors of urinary stone disease (urolithiasis) in children. The study analyzes current epidemiological trends, age- and region-specific prevalence patterns, and the influence of environmental, dietary, metabolic, anatomical, and genetic factors on the development and recurrence of pediatric urolithiasis. Based on a systematic review of scientific literature and epidemiological data, the research identifies dehydration, poor dietary habits, metabolic abnormalities, urinary tract anomalies, and hereditary predisposition as the principal contributors to stone formation. The findings emphasize the importance of early risk stratification, metabolic correction, and preventive lifestyle interventions to reduce recurrence rates and preserve long-term renal function in pediatric patients.

Keywords: Pediatric urolithiasis, urinary stone disease, nephrolithiasis, children, prevalence, risk factors, hypercalciuria, hyperoxaluria, dehydration, dietary factors, urinary tract abnormalities, genetic predisposition, recurrence, chronic kidney disease, prevention.

Introduction. In recent years, the incidence and detection rates of urinary stone disease (urolithiasis) within the pediatric population have experienced a progressive global escalation, positioning this pathology as one of the most critical challenges in modern pediatrics and pediatric urology. Historically considered an adult-onset condition, urolithiasis is increasingly diagnosed in preschool and school-aged children, driven by escalating environmental imbalances, shifts in dietary habits, and the younger onset of metabolic disorders. A defining and alarming characteristic of pediatric urolithiasis is its high propensity for recurrence (tendency to recur); epidemiological data indicates that a significant percentage of pediatric patients experience recurrent stone formation within the first few years following the initial episode.

The disease exerts a profoundly detrimental impact on children’s overall quality of life and physical development. Persistent or recurrent pain syndromes, frequent hospitalizations, and the necessity for repeated invasive interventions severely disrupt the patient's psycho-emotional stability and social integration. Furthermore, if left unmanaged or inadequately treated, pediatric urolithiasis triggers long-term, irreversible structural and functional complications involving the urinary system. The high risk of developing obstructive uropathy, chronic calculous pyelonephritis, renal parenchymal scarring (nephrosclerosis), and ultimately, chronic kidney disease (CKD) leading to renal failure, underscores the profound clinical, social, and economic significance of optimizing preventive and therapeutic approaches for this vulnerable cohort.

To comprehensively evaluate the contemporary epidemiological patterns and prevalence of urinary stone disease (urolithiasis) in the pediatric population across regional, age, and gender-specific cohorts, and to systematically identify, differentiate, and categorize the primary endogenous (metabolic, genetic, anatomical) and exogenous (environmental, climatic, dietary) risk factors contributing to its pathogenesis, clinical manifestation, and recurrence.

To achieve this overarching objective, the study delineates the following specific aims:

- To assess the dynamics and chronological trends of urolithiasis prevalence across distinct pediatric age categories, including infants, preschool, and school-aged children;
- To investigate the direct impact of local biogeochemical factors, drinking water quality, and specific dietary habits (such as sodium, animal protein intake, and hydration volumes) on the kinetics of urinary lithogenesis;

- To analyze the pathogenetic correlation between underlying metabolic disturbances (such as hypercalciuria, hyperoxaluria, hyperuricosuria, and hypocitraturia), congenital anomalies of the urinary tract, and active stone formation;
- To establish a robust, data-driven scientific foundation for developing early screening protocols, targeted risk-stratification models, and personalized preventive strategies to mitigate long-term renal complications in children.

Materials and Methods. To comprehensively evaluate the epidemiological patterns and multifaceted risk factors associated with pediatric urolithiasis, a systematic literature review and a retrospective clinical-epidemiological analysis were performed. The underlying data architecture was constructed through a methodical synthesis of peer-reviewed scientific literature, global clinical guidelines, and multicenter epidemiological registries focusing on pediatric urology and nephrology.

A comprehensive literature search was systematically executed across prominent international bibliographic databases, including PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar. The search matrices utilized combinations of Medical Subject Headings (MeSH) terms and Boolean operators, incorporating keywords such as *"pediatric urolithiasis"*, *"urinary stone disease in children"*, *"epidemiological risk factors"*, *"metabolic abnormalities"*, and *"environmental and dietary influences"*.

Strict eligibility criteria were established to ensure high methodological quality:

- Inclusion Criteria: Original research articles, cohort studies, and meta-analyses addressing pediatric urolithiasis within age cohorts ranging from newborns to 18 years, featuring distinct clinical outcomes and validated statistical data;
- Exclusion Criteria: Studies restricted solely to adult cohorts, anecdotal case reports, brief abstracts lacking comprehensive datasets, and literature with unverified or ambiguous methodological frameworks.

To evaluate the complex etiology of the disease, extracted data were categorized into four primary interactive domains: environmental (geographic climate, solar radiation levels, and hydrochemical characteristics of drinking water), dietary (nutritional architecture, electrolyte consumption, and chronic hypohydration status), metabolic (quantifiable imbalances such as hypercalciuria, hyperoxaluria, and hypocitraturia), and genetic/constitutional influences (hereditary predisposition and hereditary metabolic defects). The synthesized quantitative and qualitative datasets were processed using standard descriptive epidemiology techniques and multivariate regression analysis models to accurately determine relative risk factors and odds ratios.

Results and discussion. Clinical and epidemiological analyses indicate that the prevalence of urinary stone disease (urolithiasis) in the pediatric population is strongly correlated with geographical, environmental, and socioeconomic determinants. The highest endemic prevalence was observed in regions characterized by hot, arid climates and high solar radiation, which contribute to chronic dehydration and increased urine concentration. Furthermore, poor water quality—specifically elevated levels of hardness, calcium, and magnesium salts—combined with low socioeconomic conditions, significantly amplifies exogenic risk factors.

The study systematically identified the primary etiopathogenetic risk factors contributing to pediatric urolithiasis:

1. Dietary Factors: Insufficient daily fluid intake (hypohydration) and excessive consumption of sodium chloride (salt) and animal proteins alter urinary pH, thereby accelerating crystal nucleation and aggregation.
2. Metabolic Disorders: The most prevalent metabolic imbalances identified include hypercalciuria (elevated urinary calcium excretion), hyperoxaluria (increased oxalate excretion), hyperuricosuria, and hypocitraturia (deficiency of urinary citrate, a key stone inhibitor).
3. Anatomical and Infectious Factors: Urinary stasis (urostasis) resulting from congenital anomalies of the urinary tract (e.g., ureteric stenosis, vesicoureteral reflux) and chronic urinary tract

infections (specifically involving urease-producing pathogens) directly facilitate the formation of a lithogenic matrix.

4. Genetic and Constitutional Factors: A positive family history of urolithiasis (genetic predisposition), a sedentary lifestyle (hypodynamia), and the rising incidence of childhood obesity and metabolic syndrome serve as progressive stimulants for nephrolithiasis development.

Pediatric urinary stone disease (urolithiasis) is a complex, multifactorial, and systemic condition arising from the intricate interplay of environmental, metabolic, dietary, and socioeconomic factors superimposed on an individual's genetic predisposition. The findings of this study demonstrate that the escalating global prevalence and high recurrence rates of pediatric nephrolithiasis are driven not only by regional biogeochemical and climatic challenges but also by modern shifts in lifestyle, including suboptimal hydration habits, high dietary sodium and animal protein intake, and physical inactivity.

To achieve effective disease management, optimize long-term outcomes, and mitigate the risk of recurrence, a comprehensive, multi-tiered approach is critically required:

- Early Risk Stratification: Establishing robust screening protocols to identify high-risk pediatric cohorts—particularly those with a positive family history or residing in highly endemic zones—and placing them under strict clinical and radiological surveillance;
- Targeted Metabolic Correction: Executing timely and pathogenetically sound medical and dietary interventions to correct metabolic aberrations, such as hypercalciuria, hyperoxaluria, and hypocitraturia, before permanent structural renal damage occurs;
- Dietary and Lifestyle Modification: Promoting community-wide and individualized lifestyle optimization, focusing on age-appropriate daily fluid optimization (adequate hydration) and the restriction of lithogenic dietary compounds.

Conclusion. In conclusion, addressing pediatric urolithiasis extends beyond conventional urological interventions, necessitating a well-coordinated, multidisciplinary collaboration involving pediatricians, nephrologists, nutritionists, and public health authorities. Implementing early, data-driven preventive algorithms is vital to preserving long-term renal function, reducing the clinical burden of obstructive uropathies, and ultimately enhancing the overall quality of life for pediatric patients.

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