

Study of Kidney Stone Disease in India: Epidemiology, Risk Factors and Prevention

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Abstract

Review Article

Kidney Stone Disease (KSD) is a major and rising public health problem in India, particularly in the ‘stone belt’ regions of the north and west. Indian data suggest that approximately 2 million people are affected each year, with prevalence clustering in the third and fourth decades of life and a higher burden among men. Multiple studies have identified low fluid intake, hot climate exposure, hard or groundwater consumption, high salt and animal-protein intake, and specific regional dietary patterns (Such as high intake of calcium and oxalate rich millets) as key contributors. Socio-demographic factors, including rural residence, agricultural occupations, lower socioeconomic status, and limited health literacy, further amplify risk. This narrative review synthesizes evidence on the epidemiology and determinants of kidney stones in India and summarizes practical strategies for prevention emphasizing hydration, diet, and risk-factor modification. The review highlights gaps in population-based data, need for region specific dietary guidance, and the importance of integrating kidney stone prevention into primary care and public-health programmes in India.

Keywords: Kidney stone disease, Urolithiasis, Nephrolithiasis, Stone belt and Hydration.

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INTRODUCTION

Kidney stone disease is one of the most common urological conditions globally, with a substantial burden in Asian ‘stone belt’ countries such as India, Pakistan, and parts of China. In India, urolithiasis accounts for a considerable proportion of hospital urology workload and is increasingly recognized not only as an episodic surgical problem but as a chronic, recurrent condition with metabolic and lifestyle determinants [1]. It is also called as nephrolithiasis or urolithiasis from the Greek words nephros- for kidney, uro- for urinary and lithos- for stone. Kidney stones first appear in ancient Mesopotamian medical texts between 3200 and 1200 BC [2].

Historical and recent data indicate pronounced geographic clustering of kidney stones within India, with highest occurrence in northern, western, and central regions, moderate incidence in the Deccan plateau, and relatively lower rates in coastal southern states. Climatic conditions, patterns of water consumption, and region-specific diets are believed to underpin this variation. This paper reviews the current evidence on epidemiology, risk factors, and prevention of kidney stones in India, aiming to provide a resource for

clinicians, public-health professionals, and researchers [3].

Nephrolithiasis is a condition in which kidney stones, formed from crystals precipitating from the urine, develop within the urinary tract when the urinary concentration of crystal forming substances that inhibit stone formation is low. Approximately 80% of adults with kidney stones have stones consisting primarily of calcium oxalate, calcium phosphate or both. Other stones consist of Struvite, uric acid or cystine. The lifetime prevalence of nephrolithiasis is 13% for men and 7% for women [15,16], with 5-year recurrence rate after an initial event of 35% to 50% without treatment [17].

It has also been observed that people of all ages are affected, but those between the ages of 30 and 60 are the most affected age groups [22]. The disease burden of kidney stone disease in men and women varies throughout time. In comparison to previous generations, the latter, particularly adolescent females are more prone to acquire kidney stone disease during the course of their lives [23].

EPIDEMIOLOGY OF KIDNEY STONES IN INDIA

Population based and hospital-based studies show that urinary stone disease is common in India, but national prevalence estimates remain imprecise. A population-based survey in Ballabgarh, northern India, reported a lifetime prevalence of urinary stones of about 7.9% (95% CI 5.7–10.8%), with most diagnoses made between 20 and 40 years of age. A 13-year hospital-based series from Uttarakhand highlighted that approximately 15% of the Indian population may be affected, with the highest occurrence in northern, western, and central regions [1,19].

India contributes a substantial share to the global burden of kidney stones; recent global modelling estimated around 18.6 million incident cases in India in 2021, making it one of the highest-burden countries worldwide. Some Indian reviews cite approximately 2 million people affected by urolithiasis annually, and note that states such as Gujarat and Punjab are part of an Indian stone belt. Overall, the disease disproportionately affects young and middle-aged adults, leading to lost productivity and recurrent healthcare use [4].

REGIONAL AND DEMOGRAPHIC PATTERNS

Several Indian studies demonstrate that kidney stones are more common in men, particularly in the 20–40-year age group, although recent data suggest narrowing gender differences. The Ballabgarh study found mean age at diagnosis around 37.6 years, with nearly 56% diagnosed between 20 and 40 years, confirming a peak in economically productive age groups [5].

Geographically, higher prevalence has been reported from north-western and central India, including Rajasthan, Punjab, Haryana, Gujarat, and Uttarakhand, where hot climate, groundwater use, and local dietary habits are important. Rural populations, especially farmers and outdoor workers exposed to high temperatures, show greater risk, likely due to dehydration and concentrated urine. Urbanization, however, is bringing westernized diets, obesity, and sedentary lifestyles that may increase stone risk in cities as well [6].

MAJOR RISK FACTORS IN THE INDIAN CONTEXT

Climate, Hydration, and Water Source

Hot climate and low fluid intake are among the most consistent risk factors identified in Indian studies. Outdoor agricultural workers and labourers in high-temperature environments lose substantial fluid through perspiration, and if water intake is inadequate, urinary volume falls and supersaturation of stone-forming salts increases [7].

Use of hard water or groundwater rich in minerals has been repeatedly associated with higher

stone rates in Indian regions. A systematic review of urolithiasis in India noted that consumption of groundwater and working in high temperatures were prominent contributors in rural populations. Some studies also link use of unfiltered tap water to increased risk compared with filtered water [3][19].

Diet and Nutritional Factors

Dietary patterns in India vary widely and exert a major influence on kidney-stone risk. Studies among Indian stone patients have reported high intake of calcium- and oxalate-rich foods such as finger millet (ragi) and pearl millet (bajra), which, along with hard water and intense sunlight (vitamin D-mediated calcium absorption), can promote hypercalciuria and stone formation [6].

Other identified dietary risk factors include:

- High consumption of salt, animal protein, and dairy products, which increase urinary calcium and reduce citrate [6].
- Frequent intake of tea, coffee, and sugar, especially when not accompanied by sufficient plain water [7].
- Low intake of fruits and vegetables providing potassium and citrate, reported in some Indian cohorts [8].

A hospital-based case control study from rural Puducherry highlighted that low water intake, high sodium consumption, frequent tomato intake, and milk product consumption were associated with increased stone risk. Together, these findings suggest that both under-hydration and specific dietary excesses are important modifiable determinants in India [7].

Socio-economic and Lifestyle Factors

Several Indian studies show that urolithiasis is more common in people with lower educational and socio-economic status, probably reflecting limited awareness, poorer diet quality, and more physically demanding outdoor occupations. Sedentary lifestyle and overweight/obesity have also been associated with stone risk, mirroring global data and reflecting the transition to energy-dense diets and low physical activity [9]. Tobacco and alcohol use, daily tea intake, family history of stones, and lack of regular medical check-ups have been noted as additional contributors in South Asian cohorts. These social and behavioural factors interact with environmental exposures to shape individual risk [10].

Metabolic and Genetic Factors

Metabolic abnormalities underlying kidney stones such as hypercalciuria, hyperoxaluria, hypocitraturia, and hyperuricosuria are present in Indian patients as elsewhere, but detailed metabolic studies are limited. A case control study from West Bengal found association between kidney stones and possible genetic defects, reinforcing the role of heritable factors [11].

India's large, diverse population likely harbours considerable genetic heterogeneity in stone risk, but robust genome-wide or large-scale metabolic data are still lacking. Improved understanding of these factors could guide more targeted prevention strategies [3].

CLINICAL PRESENTATION AND MANAGEMENT PATTERNS IN INDIA

Clinical presentation in India is similar to global descriptions: acute colicky flank pain, hematuria, nausea, and sometimes urinary tract infection or obstruction. Diagnosis is frequently made by ultrasonography, particularly in resource-constrained settings, although non-contrast CT is increasingly used in tertiary centres [12].

Treatment typically combines analgesia and hydration for small stones with endourological procedures like ureteroscopy, shock-wave lithotripsy, or percutaneous nephrolithotomy for larger or obstructive stones. However, Indian studies and reviews suggest that long-term metabolic evaluation and preventive counselling are often underutilized, leading to high recurrence rates. Public hospitals may face constraints in providing systematic follow-up and individualized dietary advice [3].

PREVENTION STRATEGIES RELEVANT TO INDIA

Hydration and Environmental Measures

Increasing daily fluid intake to achieve urine output of at least 2-2.5 litres is a cornerstone of stone prevention and is particularly crucial in hot Indian climates. For outdoor workers and farmers, prevention programmes should emphasize: [13]

- Frequent small intakes of safe drinking water during work in the field.
- Access to shaded rest areas to reduce heat stress and fluid loss.
- Community messaging through agricultural extension and primary-health workers about kidney-stone risk and hydration [4].

Where groundwater is very hard or heavily mineralized, promotion of safe, treated water sources may help reduce risk [3].

Dietary Modification

Region specific dietary counselling is important in India because staple foods differ markedly between states. General advice for stone formers includes: [6]

- Limiting added salt and highly salty processed foods, while avoiding very high animal protein intake.[14]
- Maintaining adequate, but not excessive, dietary calcium from food rather than supplements, as extremely high calcium plus oxalate intake may promote stones [3].
- Moderating intake of oxalate-rich items like certain leafy greens and millets (e.g., high ragi

or bajra consumption) in people with recurrent calcium-oxalate stones [3].

- Encouraging fruits and vegetables rich in potassium and citrate, which can protect against stone formation [14].

Indian nutrition and urology experts increasingly advocate a balanced pattern akin to a traditional plant-based diet with adequate hydration, rather than extreme restrictions [8].

Clinical and Public Health Interventions

From a clinical perspective, recurrent stone formers and high-risk patients in India should undergo metabolic evaluation (including 24-hour urine studies when feasible) to guide targeted pharmacotherapy such as thiazide diuretics, potassium citrate, or allopurinol. Integrating stone-risk assessment into primary-care check-ups could help identify individuals with family history, high risk occupations, or comorbidities such as obesity and diabetes [14].

At the public health level, kidney-stone prevention can be embedded within non-communicable disease programmes, given shared risk factors with hypertension, diabetes, and cardiovascular disease. Health education campaigns should focus on hydration, diet, and early consultation for urinary symptoms, particularly in high-burden districts identified by regional studies [4].

Prevalence of Kidney Stone Disease in Jammu and Kashmir

Kidney stone disease (urolithiasis) is highly prevalent in Jammu and Kashmir, with the region situated within the 'stone belt' of North India, where the prevalence of the disease is approximately 15%, featuring calcium oxalate stones as common. Studies indicate a high burden of urolithiasis in the region, often linked to geographical factors, dietary habits, and water quality [20][21]. The present study shows that males of this province are more affected with urolithiasis than females with a ratio of 1.77:1 [21]. The male predominance may be related to the climate conditions and lifestyle in Kashmir where women, in contrary to men, spend most time indoors with their families. Advanced treatments like laser surgery are available in major cities like Srinagar and Jammu, alongside medical management, but lifestyle changes (hydration, diet) are key for prevention. A 2023 Jammu region study assessed non-genetic risk factors among patients, finding higher rates in males (21.42%) versus females (23.81%), predominantly rural residents, with risks from physical inactivity, caffeine intake, and non-vegetarian diet [20]. In Kashmir, a study of 186 urolithiasis patients identified hypercalciuria in 60.8%, mostly males (64%) aged 14 and above. No exact community prevalence was reported, but these align with India's overall urolithiasis estimate of about 7.9% [20][21]. Hypercalciuria predominates as a urinary abnormality in Kashmiri

patients. Additional factors include rural living, diet, climate, and low recurrence rates in some Jammu cases. Northern India's higher incidence ties to environmental and genetic elements [20].

Research Gaps and Future Directions

Despite numerous regional studies, India still lacks nationally representative data on kidney stone prevalence, recurrence, and treatment patterns. Large population-based surveys and registry systems could clarify trends across states, urban-rural gradients, and socio-economic groups [18,20,21].

Future research priorities include:

- Detailed metabolic profiling and genetic studies of Indian stone formers.
- Evaluation of culturally tailored dietary interventions and community-level hydration programmes.
- Health-systems research on improving long-term preventive care in public hospitals.

Such work would support development of Indian guidelines and help align kidney stone management with broader non-communicable disease control strategies.

CONCLUSION

Kidney stone disease is a significant and probably under-recognized health problem in India, with concentrated burden in hot, arid regions and among young and middle-aged adults. Evidence consistently implicates dehydration, mineral rich water, high salt and specific regional dietary patterns, and socio-economic and occupational factors as key determinants. Strengthening prevention through hydration, diet modification, and systematic follow-up in primary care supported by better epidemiological data and region-specific research could substantially reduce the morbidity and economic impact of kidney stones in India.

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