Review

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Unveiling the Burden of Nephrolithiasis in Low- and Lower-Middle Income Countries: A Review on Presentation, Risk Factors, Treatment Practices and Future Navigations

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Abstract: Background: Nephrolithiasis, or kidney stone disease, presents a significant global health burden, with incidence rates and treatment practices varying widely globally. This study aims to discuss the epidemiology, risk factors, treatment modalities, and challenges for nephrolithiasis in the lower half of the World Bank Rank; low and lower-middle-income countries. **Methods**: A comprehensive literature review was conducted using PubMed for each country on the list, focusing on studies published from January 2000 onwards and reporting data on prevalence, risk factors, treatment practices, and economic implications. **Results**: Nephrolithiasis represents a significant burden for healthcare systems, with noteworthy geographical variability in prevalence possibly dependent on socioeconomic status and gender. Risk factors include dietary habits, climate, pollution, and infectious diseases. Treatment practices in some regions still rely on open surgery due to limited access to advanced endourological techniques, while other regions demonstrate high proactivity in research. The burden is exacerbated by inadequate healthcare infrastructure and training. **Conclusions**: Addressing nephrolithiasis in challenging economic circumstances requires targeted interventions, including improved access to modern treatment methods, enhanced training for healthcare professionals, and better socioeconomic and environmental conditions. Future research should focus on region-specific strategies and the development of sustainable healthcare solutions.

Keywords: Low-income; lower-middle income; economies; nephrolithiasis; kidney stones

1. Introduction

Nephrolithiasis, or kidney stone disease, demonstrates significant geographical diversity in its occurrence and varying rates across different continents. Since 1990, global incidence trends have been mixed, with Eastern Europe, Central Europe, and Southeast Asia experiencing declines, while the Caribbean and Central Asia have seen increases, underscoring the need for region-specific studies to address the growing burden effectively [1]. Despite the declining rates in some regions, the number of new cases, recurrence rates, and the emergency and outpatient visits highlight the impact on healthcare. In economies like the U.S., the management of nephrolithiasis incurs substantial costs,

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estimated in billions of dollars [2]. Moreover, factors such as low income, education level, insurance coverage, mental health, and gender disparities further restrict access to optimal care [3]. Current social and economic settings may exacerbate disparities, as access to modern technology, research capabilities, and training varies globally. A survey of over 100 urologists from 27 low- and middle-income countries revealed that only 19% believe there are sufficient professionals to meet patient needs and provide standard care in their countries [4]. Additionally, a recent Cochrane review identified gaps in health equity in nephrolithiasis research, particularly an underrepresentation of low-income countries in systematic reviews; socioeconomic status alongside traditional to fully understand the burden of kidney stone disease is necessary [5]. In Sub-Saharan Africa, despite a shift towards minimally invasive procedures like external shock wave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), and ureteroscopy (URS), many regions still depend on open surgery [6]. This situation underscores the need for investment in medical infrastructure and training. Last, but not least, some regions have geographic burden as changes in climate, rainfall and temperature correlates with lithogenesis [7]. The need for development in urological care within emerging economies is supported by organizations like U-Merge, which promotes knowledge transfer and research (U-merge - Home). In this paper, we aim a discussion into the challenges of urolithiasis in the lower half of the World bank rank, the low and lower-middle income countries, discussing presentation, practices, particular risk factors associated with nephrolithiasis, and we comment on areas where further action and initiatives appear necessary.

2. Material & Methods

According to the World Bank database for 2024, the income status of countries is determined using their Gross National Income (GNI) per capita. Countries with a GNI of $1,135 or less are classified as low-income countries. Countries with a GNI between $1,136 and $4,465 are classified as lower-middle-income countries. Countries with a GNI ranging between $4,465-$13.845 are categorized as upper-middle-income countries and those exceeding the latter are considered high-income economies (World Bank Country and Lending Groups – World Bank Data Help Desk). Taking into consideration that over 3 billion of people living in lower-middle income countries, the exploration of healthcare burden in these regions is topical (Population, total - Lower middle income | Data (worldbank.org)). In our research, both lower-middle (LMICs) and low-income countries (LICs) were included to capture a broader range of economic and healthcare conditions reflecting the diversity within the lower half of the World Bank rankings. The countries are present in Table 1.

Table 1. Low and lower-middle income countries.

Continent	Income category	Countries
Africa	Low	Burkina Faso, Burundi, Central African Republic, Chad, Congo, Dem. Rep., Eritrea, Ethiopia, Gambia, Guinea-Bissau, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Rwanda, Sierra Leone, Somalia, South Sudan, Sudan, Togo, Uganda
	Lower-middle	Algeria, Angola, Benin, Cabo Verde, Cameroon, Comoros, Congo, Rep., Côte d'Ivoire, Djibouti, Eswatini, Ghana, Guinea, Kenya, Lesotho, Mauritania, Morocco, Nigeria, São Tomé and Principe, Senegal, Tanzania, Tunisia, Zambia, Zimbabwe
Asia	Low	Afghanistan, Korea, Dem. People's Rep., Syrian Arab Republic, Yemen, Rep
	Lower-middle	Bangladesh, Bhutan, Cambodia, Egypt, India, Iran, Jordan, Kyrgyz Republic, Lao PDR, Lebanon, Micronesia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Syria, Tajikistan, Timor-Leste, Uzbekistan, Vietnam

America	Low	Haiti
	Lower-middle	Bolivia, El Salvador, Guatemala, Honduras, Nicaragua
Europe	Low	-
	Lower-middle	Ukraine
Oceania	Low	-
	Lower-middle	Kiribati, Papua New Guinea, Samoa, Solomon Islands, Vanuatu

Then, a literature review was conducted using the PubMed database. The following search string was used in the PubMed Advanced Search Builder: (nephrolithiasis OR "Kidney stones" OR urolithiasis OR "Renal stones"[Title/Abstract]) AND (*country).* Studies published from January 2000 to the present were evaluated, to focus on recent trends and data. Articles that report on the prevalence, risk factors, economic burden, research landscape or management strategies of nephrolithiasis which pose challenges in were evaluated. Conference abstracts, editorials, opinion pieces, and non-peer-reviewed literature were excluded but searched for crossover references.

3. Prevalence and Presentation

Understanding the prevalence and presentation of urolithiasis across various continents and subcontinents reveals critical insights into the regional differences and commonalities in this significant health issue**.**

3.1. Asia

In Iran, the estimated national lifetime prevalence of urolithiasis is 6.6%, higher in men than women (7.9% vs 5.3%), urban men had no raised risk compared to rural men and the Baluch ethnicity showed the highest prevalence at 18%. The authors advised that socioeconomic factors, including dietary habits, healthcare access, and environmental exposures, may influence these variations [8]. The same authors reported a prevalence rate of recurrent urolithiasis at 2.6%, whereas residence in urban areas raised the risk, indicating that effects of urbanization on diet, occupation, and income may complicate stone disease and recurrence [9]. A survey from India, using the Ballabgarh health information system, showed a lifetime prevalence of 7.9%, with a mean diagnosis age of 37.6 years, concluding a high prevalence in the working-age group [10]. In Manipur, an equal gender distribution was observed, but aging was associated with more stones, with 68.4% of patients being overweight. Stones were more common among students, housewives, office workers, and business people, and less common among retirees and farmers, indicating a modern lifestyle's adverse effects [11]. In Pakistan, kidney stone prevalence ranges from 1% to 5%, with a recent study finding 2.8% of individuals undergoing routine CT scans had asymptomatic stones [12,13]. In Northern Vietnam, 231 patients with urinary stones showed a male predominance with a male-to-female ratio of 1.96:1. Seasonal trends indicated fewer stones during the Lunar New Year (February) and Ghost Month (August) [14].

3.2. Africa

A study in Kenya on 67 patients, median age of 42, with urolithiasis over 17 months, showed a 46% of stones in the ureters and a male majority of 79.1% [15]. In regional Nigeria, upper tract calculi were the third most commonly urological diagnosis, affecting 10.3% of new patients, though lower compared to the north [16]. A study from Cameroon found nephrolithiasis caused obstructive uropathy in 35% of cases, with stents used urgently in 19% of patients [17]. Examining paediatric renal diseases in resource-poor settings, a study in Sudan analysed a population of 150 hospitalized children, the majority of whom (83%) were from low socio-economic backgrounds. Urolithiasis was found in 15.5% of cases, whereas site of renal calculi in these patients included one or both kidneys and/or ureters in 67.7% of cases and the bladder in 32.3% [18]. Another interesting aspect is presented by a study in Western Algeria. During 2012-2019, authors analysed data from 1104 stone formers

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reporting a male dominance, overweight in 57% of cases, 53.1% having a poor education level, whereas males would also experience more recurrences than female [19]. A study in Tunisia (2003-2010) of 310 children (ages 3 months to 19 years) found a male predominance with 70.7% of stones in the upper urinary tract. Calcium oxalate stones were most common (52.6%) and increased with age, while struvite stones were more frequent in boys aged 2-9 years [20].

4. Risk Factors

The role of the environment was highlighted in several studies. A study in Vietnam analysed 58,330 hospital admissions from 2003 to 2015, found that each 1°C increase in daily mean temperature over a week significantly raised the odds of hospitalization for kidney diseases, including urolithiasis (OR: 1.09) [21]. In Sri Lanka's Central Highlands, a study linked high kidney stone incidence to drinking water geochemistry, finding significant differences in pH, hardness, and mineral levels between patient and non-patient areas, with water composition influenced by rock-water interactions and mineral weathering being a key factor in stone formation and highlighting the environmental impact on health [22]. During Operation Serval in Mali, 11.7% of repatriated French soldiers had renal colic, with 29% having a history of kidney stones. Dehydration and high temperatures were key contributors, suggesting the need for targeted preventive measures and further research [23].

A possible link between stones and metabolic factors was reported in a few regions. In Jordan, among 8,346 patients, 68.1% were categorized as obese or overweight, suggesting higher body weight may contribute to urinary stone development, emphasizing the need for weight management in prevention [24]. A study in Ghana found crystalluria common in type 2 diabetes mellitus patients, with a prevalence of 17.5% compared to 5.0% in non-diabetics, mostly calcium oxalate (12.7%), with higher fasting blood glucose levels and lower urine pH being significant factors [25]. A study in Pakistan found key risk factors for nephrolithiasis included age 15-30, male gender, illiteracy, low socioeconomic status, inadequate water intake, use of tap water, high vegetable consumption, sedentary lifestyle, family history of renal stones, and high BMI, indicating socioeconomic factors and lifestyle choices significantly impact its prevalence [26]. A study of 9,932 participants from Iran identified key risk factors for kidney stones as male gender, hypertension, obesity, diabetes, alcohol consumption, opium use, hookah smoking, higher socioeconomic status, and lower purified water consumption, highlighting the multifactorial nature of kidney stone formation and the need for comprehensive prevention strategies [27]. In Lebanon, where calcium oxalate stones are most common, risk factors include male gender, smoking, hypertension, and diabetes, with incidence peaking in July [28].

Dietary factors and water consumption have also been linked to kidney stone formation. A study in Iran found that daily consumption of tea, soft drinks, coffee, bread, meat, liver, fish, and canned foods significantly increased kidney stone risk, highlighting the crucial role of dietary modifications [29]. In southwest Iran, a study of over 10,000 participants found an 18.7% prevalence of stones, with higher intake of carbohydrates and copper as associated factors, suggesting the need for further evaluation [30]. In India, a study of 1,266 kidney stone formers found that over 50% drank less than 3 litres of water daily, but acidity, hardness, solutes, electrical conductivity, and salinity did not differ compared to areas with zero prevalence, implying that other elements of the water may be responsible for stone formation [31]. Finally, chewing betel quid in the Indian subcontinent, affecting 20-40% of the population, has been linked to hypercalciuria, alkaline urine, and low urinary citrate, all increasing calcium oxalate stone formation [32].

In Tajikistan, a study of 1,180 patients aged 14-76 found higher urolithiasis rates in areas with poor environmental conditions, high pollution, natural mineralization, water hardness, and elevated chloride and sulfate levels, highlighting the crucial impact of water quality and pollution on health [33]. Groundwater contamination with cadmium in India may disturb calcium metabolism, linking it to urolithiasis [34]. A 2011 study in Telangana State, India, found increased fluoride in drinking water, making it unsuitable and increasing the risk of toxicities, including stone formation [35].

In Burkina Faso, a retrospective study linked schistosomiasis with urolithiasis, highlighting infectious agents as critical risk factors in endemic areas [36]. In Mali, a study of 23 patients with

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urinary bilharziasis-related stones found pain and fever in over 50% of cases, with 91.3% requiring surgical treatment [37]. These studies underscore the importance of schistosomiasis as significant risk factor for urolithiasis in endemic areas and need of high clinical suspicion.

Last but not least, a study in Somalia on 204 patients with renal stones found a significant correlation between dental calculi grade and renal stone size, suggesting a link between dental health and kidney stones due to socioeconomic status [38].

5. Stone Composition

A multicentric study from U-merge reported that in Egypt, India, and Pakistan, calcium-containing stones were most common, but uric acid stones were surprisingly high at 30%, 34%, and 25% respectively, higher than in upper- and high-income countries (except Bulgaria and Poland), potentially linked to diet, water quality, or environmental influences regulated by income [39]. In neighbouring Nepal, calcium stones were most common (>70%) followed by uric acid, struvite, and cystine stones [40,41]. In Algeria, stone composition appears similar to industrialized countries, with calcium oxalate being most common (up to 75%) followed by calcium phosphate and uric acid stones [19]. Similar stone composition was reported also in Morocco, where a population of 123 samples showed calcium oxalate as the commonest by 61% followed by uric acid stones by 15% [42]. In a study from Congo, although calcium oxalate stones remained the most common prevalence of anhydrous uric acid stones (22.7%), higher than typically observed in high-income countries [43]. Furthermore, in a study of 100 kidney stones in Burkina Faso showed that while 65% of the stones primarily contained calcium oxalate, a notable 18% had opaline silica as the second main component. This pattern suggests a unique factor influencing stone formation, potentially linked to the regular consumption of clay (geophagy), a behaviour believed to contribute to this anomaly [44]. Nevertheless, in the area of Maiduguri in Nigeria calcium containing stones account for vast majority of cases, followed by uric acid stones [45].

6. Treatment and Research Landscape

Focusing on surgical norms, a recent study from Ethiopia observed that 51.5% of patients were treated initially with endoscopic procedures but still 43.6% underwent open stone surgery, whereas and endoscopy was significantly associated with incomplete stone clearance particularly in patients with multiple stones [46]. In a survey study published in 2024 involving 46 centres across 27 African, only 34 centres had access to endo-urological equipment, but only 30 perform endourology and began practising endourology less than 10 years ago. Notably, open surgery is still employed to treat kidney stones in 20 centres [47]. Governance challenges have also been highlighted. In Yemen, the study of the retention of encrusted ureteral stents was enlightening: poor patient compliance (47.5%), inability to return to the hospital due to financial reasons (30%), delayed referral after ESWL to the endourology department for timely stent replacement or removal (12.5%), and poor communication between patients and physicians (10%) [48]. Despite the increasing popularity of endoscopic techniques, surgeons in some regions remain mindful of cost constraints. In Ghana, semi-rigid ureteroscopy (URS) was the most common modality (53%), followed by PCNL (37.4%), and flexible URS (5%), however the flexible ureteroscope was reserved for exceptional cases if the rigid scope was unable to reach stones in the pelvis and calyces; a pragmatic approach balancing surgical options with the economic realities [49]. Finally, a study from Cameroon reveals that metabolic screening for nephrolithiasis is rarely conducted, and blood tests for calcium, phosphorus, and uric acid were performed in only 15.8%, 0.8%, and 12.5% of cases, respectively. The authors advised that financial constraints may deprive of necessary medical tests [50].

#In the research landscape, our review indicates that the majority of countries in the low-income group have not demonstrated high levels of evidence-based research in the field of urology. This lack of research achievements can be attributed to several factors, including limited resources, insufficient funding, and inadequate infrastructure for conducting high-quality studies. Additionally, challenges such as political instability, lack of access to advanced medical technologies, and brain drain, where skilled professionals migrate to higher-income countries, further hinder research progress in these

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regions. On the other hand, countries such as Egypt, India, Pakistan, and Jordan have made remarkable efforts in urological research, particularly in endourology and percutaneous stone surgery [51–56]. These nations have conducted high-quality studies focusing on post-operative pain management and the handling of complex stone cases, including randomized studies, which have been pivotal in enhancing the evidence base and advancing training in PCNL and URS.

7. Comment

Nephrolithiasis represents a substantial burden for all low- and lower-middle-income countries. Environmental factors like climate, water quality, pollution, and dehydration significantly contribute to this burden due to the geographical terrain and socio-economic conditions prevalent in most of these countries. Addressing these issues through improving water infrastructure, controlling pollution, and promoting hydration and heat mitigation is essential. These measures can significantly reduce the incidence and impact of kidney stone disease in these regions. Economic restraints play undoubtedly a critical role, severely impacting the management of nephrolithiasis by limiting access to necessary treatment services. Solutions such as increasing healthcare funding, subsidizing treatment costs, and seeking international aid can improve healthcare accessibility and reduce the burden of kidney stone disease in these areas. It is notable that, although some LMICs like Egypt, Pakistan, and India perform apparently well and lead in managing nephrolithiasis, not all countries in this group enjoy such advancements. To improve care in both LIC and LMIC, it is necessary to enhance training programs, establish fellowships, foster international collaboration, and develop local training facilities. Countries like aforesaid Egypt, Pakistan, and India can take a more leading role in setting examples and providing support to improve care in less advanced regions. Specific areas for development and suggestions are presented in Table 2.

Table 2. Challenges in LIC and LMICs and possible areas of action.

Challenges	
Environmental	Health campaigns (hydration, diet, special factors) and screening
	Screening programs during peak seasons to manage kidney stones
	Strict regulations to reduce pollution / management of industrial waste
	Warning systems for heatwaves and guidelines for prevention
Economic restraints	Increase funding for auditing and research
	Invest on early detection and standardization of diagnostic methods
	Collaborations between governments and non-governmental organizations (NGOs) among clinicians worldwide
	International aid and support
Training needs	Developing international training and fellowships opportunities
	Fostering partnerships and collaboration between urological societies
	Invest in local facilities with up-to-date technology
Governance	Formulate national health policies and guidelines
	School health programs
	Public awareness campaigns and community workshops
	Healthcare provider training in guidelines, auditing and research

Our paper has several limitations. It is not a systematic review, and the data collected are heterogeneous, and reader must be cautious to draw definitive conclusions. Additionally, the classification of countries by income does not fully explain the differences observed in healthcare practices and outcomes, necessitating a critical interpretation of our findings. Furthermore, some regions are underrepresented due to a lack of available research or data, leading to potential gaps in our analysis. Despite these limitations, our findings underscore the need for more comprehensive and systematic research to better understand and address nephrolithiasis in the lower half of World Bank ranking.

8. Conclusions

Nephrolithiasis presents a significant health burden in low- and lower-middle-income countries, driven by environmental, economic, and healthcare infrastructure challenges. Factors such as climate, water quality, pollution, and dehydration play crucial roles, compounded by limited access to advanced medical technologies and training. Addressing these issues requires enhancing healthcare funding, improving infrastructure, promoting public health education, and fostering international collaborations. Despite the limitations of our paper, including heterogeneous data and non-systematic review methods, our findings highlight the urgent need for targeted interventions and further research to better manage and reduce the incidence of kidney stone disease in these vulnerable regions.

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