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NUTRITIONAL ROLE OF LEGUME AND MICRONUTRIENTS IN THE PREVENTION AND MANAGEMENT OF NEPHROLITHIASIS: A COMPREHENSIVE REVIEW

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Abstract
Nephrolithiasis is a common urologic disease with high global recurrence rate. Dietary factors, particularly the consumption of legume and micronutrients, play a vital role in prevention and management. Calcium, magnesium, potassium, vitamin B6, phytate, and vitamin C are nutrients that affect urinary stone-forming components, notably calcium oxalate and uric acid. This article assesses the nutritional contribution of legumes and micronutrients to nephrolithiasis prevention and management based on integrating evidence from cohort studies, randomized controlled trials RCTs, systematic reviews, and meta-analyses. A systematic literature search was performed through databases such as PubMed, Science Direct, and Google Scholar 2000–2024 with the keywords "nephrolithiasis," "kidney stones," "legumes," "micronutrients," and "dietary prevention." Cohort studies, RCTs, systematic reviews, and meta-analyses relevant to the topic were included to synthesise high-quality evidence on dietary interventions and their effect on urinary biomarkers and stone risk. There is evidence to show that consumption of legumes, because of their phytate content, fibre, magnesium, and potassium, is inversely related to the formation of kidney stones. Cohort studies have established that a high vitamin B6 intake has a protective role against oxalate stones, while RCTs and meta-analyses endorse the administration of citrate salts in preventing recurrence and stone growth.The aggregate evidence from observational and interventional research favours a protective role for legumes and specific micronutrients in the prevention of nephrolithiasis. Inconsistencies between study designs emphasise the necessity of

well-powered, controlled trials to establish long-term dietary regimens as stone-preventing and recurrence-reducing interventions

INTRODUCTION

Nephrolithiasis, also known as renal stone disease, is a urological disorder in which crystals from urine precipitate and form stones within the kidneys. Crystals precipitate inside the urinary system due to either an excess of the material that forms stones or a lack of the components that stop stones from developing. About 15% of individuals with nephrolithiasis were from Western nations, making it the third most common illness in the world. Almost one in seven males and one in thirteen women globally were impacted Khan et al., 2022. In children, a study identified multiple risk factors, including low calcium and high salt intake, infections, sedentary lifestyles, obesity, metabolic diseases, and environmental factors. Clinical symptoms varied by age, with pain being the most common69.4%, followed by vomiting44.7%, fever36.5%, hematuria36.5%, and dysuria28.2%. Younger children usually came with nebulous symptoms, including fever and vomiting, while older children had more classic urolithiasis symptoms such as pain and hematuria Omar et al., 2024. In Pakistan, the Prevalence of kidney stones was 1-5%. The study highlighted noticeable regional variations in the prevalence of kidney stones worldwide. The projected lifetime prevalence in Iran is 6.6%, with the Baloch ethnic group having the highest rate18%. Kidney stones were 7.9% common in India, and they were more common in people of working age. Asymptomatic stones on routine CT scans were found in 2.8% of Pakistanis, with a prevalence of 3%. Research from Vietnam showed a male-to-female ratio of 1.96:1, indicating male preponderance. Kidney stones were discovered in 79.1% of male patients in Kenya, compared to 15.5% of hospitalised children in Sudan. In Western Algeria, a study revealed a male preponderance, with 57% of patients being overweight, while kidney stones were the third most frequent urological illness in Nigeria. In Tunisia, calcium oxalate stones accounted for 52.6% of cases. In Jordan, 68.1% of kidney stone patients were overweight or obese, while Lebanon recorded a seasonal surge in kidney stone incidence in July. Uric acid stones made up 25–34% of kidney stones in Egypt, India, and Pakistan, whereas opaline silica was present in 18% of kidney stones in Burkina Faso Murtadha Almusafer et al., 2024. Kidney stone in adolescents is a significant health issue. The researcher conducted a 25-year population-based study to ascertain the prevalence of symptomatic kidney stones in children in Olmsted County, Minnesota. According to the study, the incidence of kidney stones increased by 4% per year between 1984 and 2008. The incidence increased from 13 per 100,000 person-years in 1984–1990 to 36 per 100,000 person-years in 2003–2008, with the largest rise occurring in adolescents aged 12–17. The incidence stayed constant among younger children, 0 –5 years and 6–11 years Dwyer et al., 2012.

Methodology:

The comprehensive review was undertaken after a focused literature search to pool and synthesize available scientific evidence on the role of legumes and other principal micronutrients in preventing and managing nephrolithiasis. Systematic searches of databases like PubMed, ScienceDirect, Google Scholar, Scopus, and Web of Science with specific keywords like "legumes," "pulses," "kidney stones," "micronutrients," "nephrolithiasis," "oxalate," "calcium," "vitamin B6," "magnesium," "phytate," and "urinary biomarkers" were carried out. Only articles from the years 2000 to 2024 published in English were taken into account. Inclusion was original research studies, meta-analyses, clinical trials, and review articles of high quality that investigated dietary intervention, urinary excretion profile, or risk factors associated with kidney stone development. Exclusion was non-English language papers, case reports, animal studies that were not human relevant, and papers without dietary or biochemical significance related to nephrolithiasis. Quality and relevance of included studies were assessed and data were abstracted to investigate the influence of legume consumption and related micronutrients e.g., calcium, magnesium, potassium, vitamin B6, and folate on the biochemical pathways of stone formation and prevention. The review is thematic in nature to emphasize both the protective and risk-modifying functions of individual nutrients and legume food-based dietary patterns in nephrolithiasis management.

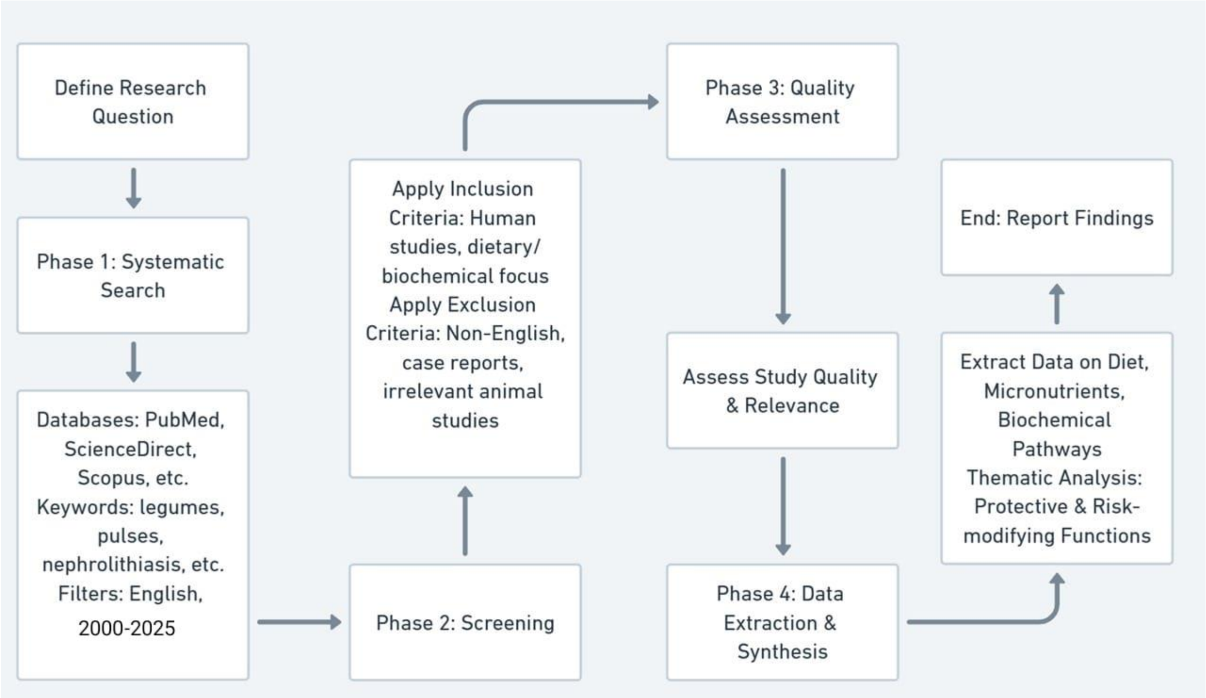

Figure 1: Methodology of thematic review

Reoccurrence of stones:
The risk of recurrent nephrolithiasis in adolescents is very high. In a retrospective cohort study, 285 adolescents aged 3 to 18 who initially developed kidney stone symptoms between 2008 and 2014 were examined. The findings showed that there was a 50% probability of developing another kidney stone within three years of the initial one, and 24% of patients experienced a recurrence. Three and five years, respectively, were the median times between the first and second recurrences. Patients who had a 24-hour urinalysis following their initial kidney stone incident had a 60% lower chance of recurrence Tasian et al., 2016 . According to the study, there was a 50% chance of recurrence within 5–10 years and a 75% chance within 20 years. The deposition of crystals caused by the supersaturation of the calcium and oxalate ions in the urine resulted in calcium oxalate kidney stones. The cause of formation varied depending on the type of stone. These deposits stick to the apical surface of renal tubular epithelial cells by a variety of crystal-binding molecules or possible crystal receptors, or they serve as a nidus for the formation of stones Wang et al., 2021.

Types of stones:
Caox, carbapatite ,urate ,struvite magnesium ammonium phosphate and brushite are the five primary forms of kidney stones based on their mineralogical composition. In general, kidney stones can be divided into two types: calcareous and non-calcareous. Calcareous and radio-opaque stones, known as calcium phosphate CaP and calcium oxide CaOx, either alone or in combination, are the two most common types of kidney stones in people .(Ye et al., 2019) also supported the composition of stones with respect to gender and age. Males were more likely to have CaOx and urate stones, while females were more likely to have carbonate and struvite stones ($P < 0.01$). Compared to other categories, people aged 20–40 and 30–50 years had higher levels of CaOx and carbapatite. The highest rates of brushite and struvite were found in those under 20 and over 70. As people aged, the detection rate of urate rose, whereas that of cystine fell. Compared to carbapatite or brushite

stones, urate stones were more common in obese patients (P < 0.01). The kidney was more likely to have CaOx, carbapatite, brushite, and cystine stones than the bladder, while the bladder was more likely to have urate and struvite stones (P < 0.01)Wang et al., 2021Ye et al., 2019.

Table 1: Thematic Summary of Legumes and Micronutrients in the Prevention and Management of Nephrolithiasis

Study Title	Authors	Year	Theme	Mechanism / Key Factor	Dietary Sources	Key Findings	Practical Implication	CitationAPA 6th
Risk of Recurrent Nephrolithiasis in Adolescents: Impact of 24-Hour Urine Testing	Tasian et al.	2016	Recurrence & Diagnostics	24-hour urine detects hypercalciuria, hyperoxaluria, hypocitraturia	N/A	50% recurrence within 3 years; 60% lower recurrence with urinalysis	Routine metabolic evaluation for young stone formers	(Tasian et al., 2016
Metabolic Abnormalities in Pediatric Stone Formers	Leslie et al.	2024	Diagnostics	Hypercalciuria, hyperoxaluria, hyperuricosuria, low urine volume	N/A	Thiazides, diet changes manage risk factors	Metabolic screening guides personalized therapy	(Leslie et al., 2024
Mineralogical Analysis of Kidney Stones by Gender and Age	Ye et al.	2019	Stone Types	CaOx most common65.9%; type varies with age/sex	N/A	Males: more CaOx, urate; females: more struvite	Tailor prevention to stone type and patient profile	(Ye et al., 2019
Crystal Deposition and Epithelial Adhesion Mechanisms	Wang et al.	2021	Stone Formation	Crystals adhere to cells; act as nidus	N/A	Supersaturation causes deposition	Address supersaturation in prevention	(Wang et al., 2021
Environmental & Dietary Contributors to Kidney Stones in Asia & Africa	Khalili et al.; Mitra et al.; Degheili et al.; Abdourahman et al.	2014–2022	Regional Risk Factors	Poor water quality, dehydration, high meat/tea intake	Regional foods, water	Regional risks vary widely	Regional prevention: water, diet, climate	(Khalili et al., 2021; Mitra et al., 2018; Degheili et al., 2022
Adolescent Risk Factors: Obesity & Hormonal Influences	Shadier et al.	2019	Lifestyle & Demographics	Hormonal/metabolic differences; dehydration; diet	N/A	Boys: ↑ BUN/creatinine; girls: ↑ UTIs, flank pain	Consider sex-specific factors in adolescents	(Shadier et al., 2019

Socioeconomic & Climate Drivers in Low-Income Countries	Murtadha Almusafer et al.	2024	Public Health	Heat, dehydration, geophagy, limited healthcare	N/A	Clay ingestion linked to opaline silica stones	Region-specific education & prevention	(Murtadha Almusafer et al., 2024
Oxalate Content of Legumes and Grains	Chai & Liebman	2005	Oxalate	High oxalate → hyperoxaluria → CaOx stones	Lentilslow, soy flour, peanuts high	Split peas, lentils safer	Select low-oxalate legumes	(Chai & Liebman, 2005
Dietary Patterns & Oxalate Load	Azimi et al.	2020	Legumes Overall	Fibre, phytates protective; moderate oxalate	Beans, chickpeas, lentils	Mixed effect; modest benefit	Emphasize lower-oxalate options	(Azimi et al., 2020
Dietary Phytate and Risk of Stones in Women	Curhan et al.	2004	Phytate	Phytate binds calcium, inhibits crystallization	Beans, cereals, seeds	NHS II: highest intake → 36% ↓ risk	Encourage phytate-rich foods	(Curhan et al., 2004
Role of Phytate in Urinary Crystallization	Grases et al.	2000	Phytate	Low phytate excretion → impaired inhibition	Legumes, cereals	Phytate-free diet ↑ risk	Maintain dietary phytate intake	(Grases et al., 2000
Plant-Based Mg & Urinary Stones	Jebir & Mustafa	2023	Magnesium	Mg binds oxalate → soluble Mg-oxalate	Beans, lentils, cereals	Higher Mg lowers supersaturation	Recommend Mg-rich foods	(Jebir & Mustafa, 2023
Potassium Intake & Stone Prevention: MR Study	Lin et al.	2023	Potassium	↑ citrate & urine pH, ↓ Ca excretion	Beans, fruits	Fresh fruit ↓ risk	Potassium-rich legumes protective	(Lin et al., 2023
Potassium & Citrate Mechanisms in Stones	Tasian et al.	2016	Citrate	Citrate binds Ca, prevents CaOx/uric acid stones	Citrus fruits, legumes	Potassium boosts citrate	Use diet to raise citrate	(Tasian et al., 2016
Citrate Therapy for Ca Stones: Cochrane Review	Phillips et al.	2015	Citrate	Citrate salts prevent stone growth	Citrus fruits	Effective but mild GI side effects	Consider citrate supplements	(Phillips et al., 2015
Vitamin B6 and Kidney Stones in Women	Curhan et al.	2000	Vitamin B6	↓ oxalate synthesis → ↓ CaOx	Beans, legumes	≥40 mg/d → 34% ↓ risk in women	Use B6 for hyperoxaluric risk	(Curhan et al., 2000
Large Cohort: B6 No	Ferraro et al.	2017	Vitamin B6	Mixed evidence	N/A	No clear protective effect	Use B6 selectively	(Ferraro et al., 2017

Protective Effect Overall								
Zinc's Dual Role in Stones	Singh & Rai	2014	Zinc	Zn can replace Ca in crystals	Beans, cereals	May inhibit/promote stones	Balance intake, avoid excess	(Singh & Rai, 2014
Phosphorus-Calcium Ratio & Stone Risk	Zhang et al.	2024	Phosphorus	High Ca:P → hypercalciuria	Beans, lentils	Ca:P >0.81 → 57% ↑ risk	Balance Ca:P ratio	(Zhang et al., 2024
DASH & Mediterranean Diets	Rodriguez et al.	2020	Diet Pattern	High K, fibre, phytate, low salt	Legumes, whole grains, nuts	DASH: 40–45% ↓ risk	Recommend DASH/Mediterranean	(Rodriguez et al., 2020
Global Research Landscape: Stone Belt Countries	Khan et al.	2022	Research Gaps	Limited research, care access	N/A	Pakistan: high burden, low awareness	Expand research & screening	(Khan et al., 2022

Factors associated with kidney stones:

In Tajikistan and Iran, poor water quality that contains elevated sulfate and chloride levels is a major contributing factor.Khalili et al., 2021Europe PMC, 2016. In Sri Lanka, the mineral composition and water geochemistry have a major impact on stone formation. Buddhika Abeywickarama et al., 2015. In Mali, severe heat and dehydration have been connected to kidney stone cases among soldiers.H Abdourahman et al., 2014 In India, consuming large amounts of tea, soft drinks, tinned food, and meat has been linked to an increased risk of kidney stonesMitra et al., 2018. While smoking, high blood pressure, and diabetes are major risk factors in Lebanon.Degheili et al., 2022 Obesity and a sedentary lifestyle are major contributors to the high prevalence of kidney stones in Jordan Abu Ghazaleh & Budair, 2013. Low socioeconomic levels and limited access to healthcare have contributed to a rise in instances, especially among adolescents, in Kenya and Sudan. Male kidney stone recurrence was greater in Western Algeria, presumably as a result of eating habits and genetic predisposition. Opaline silica was found in an exceptional 18% of kidney stones in Burkina Faso, and scientists linked this to ingesting claygeophagy. These findings underline the need for region-specific prevention strategies, including modifying diets, boosting hydration, and addressing environmental risk factorsMurtadha Almusafer et al., 2024 A retrospective file assessment of sex-specific differences in kidney stone formation included data from 136 adolescent patients treated at Akron Children's Hospital from 2009 to 2016. Additionally, they found that women's height z-scores were lower than men's, which could be related to hormonal effects, long-term illnesses, or renal acidification problems that impact bone metabolism and growth. Additionally, flank pain and positive leukocyte esterase were more common in females, which may suggest a higher association with inflammatory responses or UTIs. Males had a higher BUN/creatinine ratio, though, which may indicate that they were either more dehydrated or consumed more protein in their diet, both of which are known risk factors for kidney stones.Shadier et al. 2019. The main risk factors were family history, metabolic syndrome, high protein and salt intake, obesity, dehydration, and hormonal changes. Adolescents are particularly vulnerable if they have a positive family history of nephrolithiasis or if they have specific characteristics like renal tubular acidosis Toole et al., 2021. One of the primary risk factors is obesity, which has been identified. Additionally, consuming abundant fructose, too much animal protein, and salt leads to low magnesium levels, increased uric acid production, and increased calcium excretion—all of which are factors in the development of stones . Women were three times more likely than men to excrete phthalate metabolites, which could suggest a connection between environmental toxin exposure and a higher incidence of kidney stones.Filler et al., 2023.A cross-sectional study was conducted in Peshawar to determine the risk factors. Inadequate hydration, soft drink intake, obesity, sedentary lifestyle, smoking, family history, hyperlipidemia, diabetes mellitus, and hypertension were other factors that contributed. Treatment depended upon the size or location of the stoneMuhammad Waqas et al., 2024. Risk factors like Diabetes, obesity, cardiovascular disease, hypertension, and metabolic syndrome are among the systemic conditions linked to kidney stone formation. In contrast, people who have nephrolithiasis, often referred to as kidney stone formersKSF, are susceptible to hypertension, chronic kidney diseaseCKD and end-stage renal diseaseESRD. For instance, common risk factors associated with kidney stone production include hyperoxaluria, hyperuricosuria, and phosphaturiaWang et al., 2021.

Diagnosis of stones:

One popular diagnostic technique for assessing metabolic abnormalities associated with nephrolithiasis is 24-hour urine testing. A study described diagnostic measurements. This test could assess key urinary signs, including low urine volume, hypocitraturia, hyperuricosuria, hyperoxaluria, and hypercalciuria, that have been associated with kidney stone development. Hypercalciuria, one of the most common abnormalities, was treated with thiazide diuretics, sodium restriction, and dietary calcium optimisation. Similarly, hyperoxaluria, which was often linked to either low or excessive calcium intake or oxalate intake, was decreased by reducing high-oxalate meals and increasing dietary calcium consumption to bind oxalate in the stomach. Hyperuricosuria and an acidic urine pH were associated with uric acid stones, which were similarly treated with alkaline treatment therapy and a purine-restricted diet.Leslie et al., 2024.

Legumes in Prevention:

Dietary habits, regardless of specific nutrients, are the primary driver in kidney stone prevention. The Mediterranean diet, rich in fruits, vegetables, whole grains, legumes, nuts, seafood, and healthy fats, promotes a protective urinary composition that reduces the incidence of stone formation. The study highlights the importance of dietary modifications as a preventive measure for nephrolithiasis and encourages increased adherence to the Mediterranean diet to lower the risk of kidney stones. Previous research on the Dietary Approaches to Stop Hypertension DASH diet demonstrated a 40–45% lower risk of kidney stones Rodriguez et al., 2020. Particularly high oxalate levels in almonds, cashews, and peanuts make them inappropriate for people who are susceptible to kidney stones caused by calcium oxalate. Anasazi beans, black beans, soybeans, and small white beans were among the legumes with moderate to high levels of oxalate35–80 mg/100g, while split peas, lentils, and black eye peas had much lower levels4–8 mg/100g, making those safer options for the diet. Similarly, oxalate concentrations were relatively low37–54 mg/100g in cornmeal and brown rice flour, but high183–269 mg/100g in flour products like buckwheat and soy flour. The study emphasises the significance of controlling dietary oxalate, especially for those who are susceptible to kidney stones, and proposes that choosing low-oxalate substitutes in legumes, nuts, and flour-based goods may help lower the risk of hyperoxaluria Chai & Liebman, 2005. The relationship between dietary habits and kidney stone production caused by calcium oxalate emphasises the importance of vitamin B6 and legumes. The study divided diets into two categories: unhealthy characterised by high consumption of processed meats, high-fat dairy products, fast food, refined grains, sugary drinks, and salty snacks and healthy enriched in whole grains, legumes, poultry, fish, low-fat dairy products, nuts, fruits, and vegetables. Legumes, such as lentils, kidney beans, and chickpeas, are part of a healthy diet; however, they did not significantly lower the incidence of kidney stone OR = 0.95, 95% CI, 0.58-1.55. However, they do include fibre and phytates, which help prevent kidney stones from forming. However, moderate amounts of oxalate found in some legumes may increase the risk of stone formation in those who are vulnerable Azimi et al., 2020. Researchers have also discovered that potassium-rich foods, such as legumes, have a protective effect in kidney stone prevention by increasing citrate excretion, which helps prevent the formation of calcium stones, and decreasing urine calcium levels Tasian et al., 2016.

Citrate in prevention:

Citrate is attached to urinary calcium and raises urine pH to prevent calcium oxalate and uric acid stone formation. Citrate was abundant in citrus fruits, especially oranges, lemons, and limes. Citrate's buffering activity, a vital dietary component in kidney stone prevention, not only reduces the risk of stone formation but also increases the solubility of calcium salts in the urine Dwyer et al. 2012. Clinical data indicate that citrate salts, such as potassium citrate, work well to decrease new calcium oxalate stone formation and prevent stone growth. A Cochrane review of seven RCTs showed substantial benefit in stone recurrence and size stability. Gastrointestinal side effects and dropout rates were greater in the citrate group, though. Although outcomes were favorable, overall study quality was moderate to poor, suggesting the necessity for more intense trials Phillips et al., 2015 Citrate prevents crystallization binds to calcium oxalate crystals, preventing their growth and aggregation into stonesGul & Monga, 2014

Vitamin B6 in prevention:

The study also discovered a negative correlation between vitamin B6 supplementation and the risk of kidney stones, confirming its potential to minimise stone formation via lowering urine oxalate levels. nephrolithiasis may be avoided by increasing legume intake and obtaining adequate vitamin B6Azimi et al., 2020. Furthermore, low vitamin B6 levels were linked to raised urine oxalate, and excessive vitamin C and D intake increased the risk of stone formation by increasing calcium and oxalate excretion Hang et al., 2024. Vitamin B6 regulates oxalate metabolism; eating enough of it from foods like bananas, poultry, fish, and fortified cereals can help reduce the risk of stone formation Tasian et al., 2016. In a large prospective cohort study of more than 190,000 participants in the Health Professionals Follow-up Study and Nurses' Health Studies I and II, there was no significant relationship between vitamin B6 intake and incident risk of kidney stones. In all three cohorts, increased vitamin B6 intake didn't decrease the risk of stone formation, with pooled hazard ratios indicating no significant difference between the highest and lowest exposure groups. These results indicate that, even though it has been postulated to reduce urinary oxalate excretion, vitamin B6 supplementation per se might not be a protective measure against the formation of kidney stones in healthy adults.Ferraro et al., 2017. A 14-year prospective study in 85,557 women revealed that increased intake of vitamin B6 was independently related to a lower risk of symptomatic kidney stone development. Women with ≥40 mg/day of vitamin B6 intake had a 34% lower risk than women with <3 mg/dayRR: 0.66; 95% CI: 0.44–0.98, after adjustment for dietary and lifestyle factors. In contrast, vitamin C consumption was not found to be significantly related to stone risk at doses ≥1500 mg/day. These results indicate that high-dose vitamin B6 could provide a protective benefit in kidney stone prevention among women, but routine limitation of vitamin C intake is not warranted.Curhan et al., 2000. Although some reviews and studies report a preventive effect of vitamin B6, notably in women or in subjects with elevated urinary oxalate, others large cohort studies have not reported a significant relationship between intake of vitamin B6 and risk of kidney stones in the general populationFerraro et al., 2017Cupisti et al., 2023

Phytate in prevention:

Researchers introduced veggies into the diets of those who did not often eat them, decreasing the urinary saturation of uric acid and calcium oxalate while simultaneously increasing urine volume and citrate output. Moreover, it raised the concentrations of compounds that inhibit the formation of stones, such as citrate, magnesium, phytate, and potassium, which were associated with calcium oxalate supersaturation and uric acid. An alkaline medium of the plant increases the excretion of citrate in the urine, making calcium salts more soluble, which can help stop the formation of calcium oxalate crystals. Magnesium competes with calcium to bind oxalate and create a more soluble magnesium-oxalate complex than calcium-oxalate, which leads to the prevention of kidney stones Jebir & Mustafa, 2023.

Furthermore, a 51% lower risk of kidney stones was associated with a greater dietary phytate intake 423 mg/day; however, this association diminished when excessive oxalate intake was taken into account. It has been demonstrated that phytate, which is present in foods including cereals, seeds, nuts, and crackers, lowers the risk of stone formation by blocking the production of calcium phosphate and calcium oxalate Tasian et al., 2016. Urinary phytate concentration was significantly lower in active calcium oxalate stone formers than in healthy controls. A phytate-free diet resulted in a significant fall in urinary phytate and impairment of the ability to prevent crystallization of calcium salts, indicating low phytate excretion as a risk factor for stone formationGrases et al., 2000.

Large Prospective Cohort Nurses' Health Study II

Women in the highest quintile of dietary phytate consumption had a 36% reduced risk of symptomatic kidney stones compared with women in the lowest quintile relative risk 0.63, 95% CI 0.51–0.78.Common sources in the diet were cold cereals, dark bread, and beans.The research concluded that dietary phytate could be a safe and significant supplement to kidney stone prevention measures.Curhan et al., 2004Lo et al., 2025.

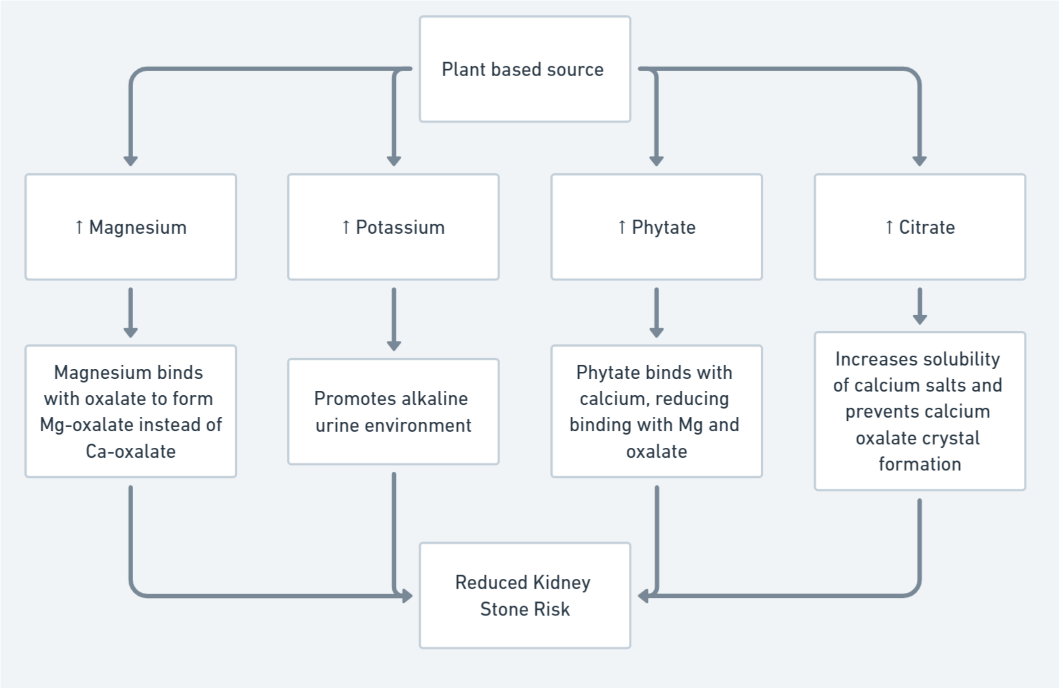

Figure 2: Schematic showing how plant-derived magnesium, potassium, phytate, and citrate help prevent kidney stones.

Potassium in prevention:

Researchers conducted a Mendelian randomization MR study to investigate the causal relationship between food consumption and the risk of urolithiasis kidney and ureteral stones. The primary finding of the study was that eating more fresh fruit was associated with a decreased risk of kidney and ureteral stones. Fresh fruit has a preventative effect due to its high water, potassium, and citrate content, which increases urine volume and decreases ion concentrations that form stones Lin et al., 2023. Using data from NHANES 2011–2018, a study assessed the American Urological Association's AUA dietary recommendations for kidney stone prevention. Higher potassium intake is significantly linked to a lower risk of kidney stones, especially when consumption surpasses 2000 mg/day. Potassium helps prevent calcium-based stones because it raises urine citrate and lowers urinary calcium excretion. As a result of its anti-oxidative and urine acidification properties, moderate-to-high vitamin C intake60–110 mg/day was also linked to a decreased risk of kidney stones Tang et al., 2024.Additionally, a higher potassium consumption has been associated with a higher urine pH, which slows the formation of uric acid stones and avoids their recurrence Tasian et al., 2016. Foods high in potassium, like fruits, vegetables, and legumes, had shown a protective function in kidney stone prevention by lowering urine calcium levels and encouraging the excretion of citrate, which helps to avoid the formation of calcium stones Additionally, a higher urine pH has been associated with increased potassium consumption, which may help avoid recurrence of uric acid stones by reducing their development..Zhang et al., 2024

Phosphorus in prevention:
An unbalanced dietary calcium-to-phosphorusCa/P ratio dramatically raises the risk of kidney stone development, according to a study. People in the highest Ca/P quartile>0.8172 have a 57% higher risk than those in the lowest quartile. Hyperphosphatemia and hypercalciuria are two conditions that can result from consuming too much calcium without enough phosphorus, and both can exacerbate kidney stones Zhang et al., 2024.

Zinc in prevention:
Zinc is an essential mineral for our body that plays an inhibitory role in kidney stone formation. According to the study, a 1 mg increase in daily zinc intake decreased the likelihood of kidney stones by 13%OR = 0.87, 95% CI: 0.75–0.99. Higher dietary zinc consumption was also substantially linked to a lower risk of kidney stones. The study suggests that zinc inhibits the formation of stones by lowering calcium phosphate levels and preventing the growth of stones in their early stages. It also emphasised the importance of maintaining an adequate zinc intake through foods high in zinc, such as pizza, red meat, and fortified cereals Tasian et al., 2016. Zinc is present in large quantities in calcium stones and has the ability to replace calcium within crystals. Epidemiological information provides conflicting findings, as some studies have attributed increased zinc consumption to greater stone risk in adults but not children. Zinc is capable of inhibiting and facilitating the growth of crystals based on concentration Negri, 2018. Data analysis from NHANES III revealed that greater dietary zinc consumption>15 mg/day was positively correlated with an elevated risk of kidney stone disease in adults in comparison with lesser consumption<7 mg/day. The research emphasises additional prospective studies to resolve causality Jaromin et al., 2025. This research revealed calcium phosphate stones have much higher levels of zinc compared to calcium oxalate stones, and proposed that zinc can speed up stone formation by replacing calcium in crystals(Singh & Rai, 2014

Prevention and Management of Kidney Stones:
Researchers advise reducing salt intake, lowering excess weight, increasing fluid intake to two to three litres each day, and performing metabolic testing beforehand. They can both cause and prevent kidney stones. To prevent uric acid stones, it is highly advised to consume 1,300 mg of calcium daily, limit consumption of foods high in oxalates such as chocolate, nuts, and spinach, promote the consumption of foods high in citrate, such as citrus fruits, and limit protein intake from animal sources Toole et al., 2021Tang et al., 2024. Additionally, the study discovered that eating junk food and oxalate-rich foods such as spinach, beets, and nuts more than three times a week increased the risk of stone formation. Tea contains a high oxalate content, which increases the risk of oxalate stones. So we should prevent high-oxalate-containing food. In the stomach, dietary calcium interacts with oxalate to prevent absorption and urine excretion. Consuming milk and dairy products regularly reduces the risk of developing stones Bhattacharya et al., 2022.

Research landscape:
According to the analysis of the research landscape, most low-income nations have not shown a high degree of evidence-based urological research. Numerous factors contributed to this lack of research achievements, including limited funding, infrastructure, and resources required to conduct top-notch studies. Further impeding scientific advancement in these areas are issues including political unpredictability, limited access to cutting-edge medical technology, and brain drain—the exodus of highly qualified people to nations with greater incomes. Furthermore, financial limitations affected nephrolithiasis care by restricting access to essential therapeutic services. Solutions such as raising healthcare financing, subsidising treatment expenses, and requesting international aid enhance healthcare accessibility and reduce the incidence of kidney stone disease in these placesMurtadha Almusafer et al., 2024. According to studies, about 3% of people may have clinically silent stones, which frequently go unnoticed until problems develop. Even if affordability remains an issue, particularly in healthcare systems where individuals bear the majority of the costs, the use of targeted screening techniques,

especially for high-risk groups, can help with early intervention. Public awareness campaigns, dietary modifications, and routine ultrasonography evaluations for individuals with a history of kidney stones or other relevant risk factors could significantly reduce the burden of urolithiasis. Furthermore, more studies comparing epidemiological data from various geographical areas were necessary to support affordable screening initiatives and preventative actions, which will ultimately improve kidney health outcomes Peter et al., 2015. The report explained the risk factors and areas for improvement. Pakistan is located in the so-called "Stone Belt" region, which also includes India, Burma, Egypt, Thailand, Sudan, Indonesia, and the Philippines. Urinary tract stones are said to be common in these nations. Nephrolithiasis had a high incidence among Pakistani natives since it was not well understood in the country, and its risk factors were not well known. Likewise, an inadequate health care system and scarce resources exacerbate health-related challenges Khan et al., 2022.

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