Demographic Diversity of Food Intake and Prevalence of Kidney Stone Diseases in Indian Continent

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Abstract: Food intake plays a pivotal role of human growth, which necessarily contributes 45% of global economy and wellbeing in general. Consumption of balanced food is elementary for overall good health while a shift of equilibrium can lead to malnutrition, prenatal death, obesity, osteoporosis and bone fractures, coronary heart diseases (CHD), idiopathic hypercalciuria, diabetes and many more. Though CHD, osteoporosis, malnutrition, obesity are being classified thoroughly in the literature, there are fragmented findings in the regime of kidney stone diseases (KSD) and the correlation with food intake therein. KSD associated with hematuria and renal failure poses an increasing threat to the healthcare and global economy while its emergence of Indian populations is being affected with multifactorial urological disorder resulting from several factors. In this realm, epidemiological, biochemical, macroeconomic situations been portrayed when food intake is also a paramount importance which rarely been forecasted. Hence, in this article we will be reviewing the corollary connotation with diverse food consumption and the efficacy it plays in KSD extrapolating in Indian context.

Keywords: food intake; food diversity; kidney stone disease; social epidemiology

1. Introduction

Kidney stone diseases (KSD) and associated research became rampant since calcium based kidney stone and its correlation with genetic predisposition analysis been introduced with convincing outcomes. To illustrate more, in USA itself, there was a sharp rise of KSD nearly 200% since 1964 through 1972 [1]. In the same way, European countries unlike Scotland (3.83% in 1977 to 3.5% in 1987), Germany, Spain, and Italy also have shown an increasing trend in KSD prevalence over the last decades [2-5]. Along with these geographical boundaries, Japan and some parts in Iran, USA etc. soon started investing money in conducting research to forecast KSD with generic pattern for the age population both for men and women [6-8]. While conducting studies, it found out that, KSD is considered to be prevalent with nearly 35% of the controlled group affected with hypercalcaemic nephrolithiasis disorder [9]. Along with this, reports holistically demonstrated that monozygotic twins (32.4%) have approximately 15% high frequency rate in comparison to dizygotic twins (17.3%; P<0.001) [10]. To extrapolate more in this paradigm, reports aptly depicted in Canadian context that even though the presence of dent disease and hypophosphatemic rickets with hypercalciuria, still a firm corollary established with the ancestors and genetic pattern with the family history [11]. Furthermore, to conclude the hypothesis they have counterfact with several genetic analysis namely encoding VDR, calcium sensing receptor (CaSR), 25(OH)D 1α-hydroxylase, osteocalcin, uromodulin, and osteopontin etc [12]. On the other hand, studies portraying gender and age as
principle parameters revealed, Iran and USA as peak KSD prevalent locations for 40-49 age group, while Japanese women shown the same in 50-59 age groups [1]. Data disclosed a similar pattern in Japan and USA for male group in 40-49 years of age regime, while Iran followed with a different trend [13]. This initial investigation lead to a conclusion that, it is increasingly unscientific to extrapolate KSD pattern based on age and sex only indifferent geographic locations. So, the researchers were challenged to come up with a set of new parameters to fine-tune more realistic solution in the regime of KSD and its prevalence therein.

Diet is an integral part of renal accumulation and thus filtration, which in turn will affect absorption and bodily homeostasis for renal stone occurrence [14-15]. The epidemiology differs in accordance with different geographical regions and social construct. In this context, food habit was proposed to be one of the major risk factor in renal stone formation as a form of epidemiology to urine composition [16-17]. Food pattern is one of the major factors for renal stone formation and stone material deposition can be manageable by regulating food intake. In the context of Indian food, there are collection of many tastes and flavours of food with diversity yet identity. From the colour rich food of Rajasthan, to the spicy food of Punjab, to the slightly sweet with oil based Gujarat food, to the southern little sour tasted sea foods, all are found in this land of paradise. Though several communities in the country are vegetarian, there is still a large range of non-vegetarian recipes with full of richness. Increase in urinary calcium excretion is highly related to high consumption of animal protein with reduction of urinary pH and citrate excretion which are the ultimatum of stone formation. Due to this vast food pattern in Indian soil, we believe there is a paramount interest to describe through this review article the nutritional aspect causing renal stone formation and the immediate effects therein.

2. Diverse Food Habits in India

The era of rapid globalization and packaged market products has shifted the equilibrium of nutritional scenario in India. Urban areas of Indian population has seen to absorb more packaged foods into their dietary meals thus overpowered bodily mass and causing premature obesity. In this realm, Indian cooking vastly reflects thousands years of history leading to diversity of flavours and thus innumerable regional unique dishes found herein [18]. Diversified food habit ranges parts of India with different geographical area span from Rajasthan desert to Madhya Pradesh forest or Maharashtra seashore to Jammu & Kashmir Mountain [18]. For the ease of description, Indian cooking is classified principally into the North Indian, East Indian, West Indian and South Indian cuisine based on the similarity and differences in the food habits. North Indian cuisines are distinguished by its unusually high use of dairy products and the prevalence of flat breads like roti and paratha, baked in clay ovens, over rice dishes. Even though parts of Western India like Gujarat and Rajasthan are predominantly vegetarian, the remaining cuisines have their fair share of meat or animal protein owing its origin to the Muslim incursion in India. South India can boast of a simply bewildering range of regional cuisine. With cuisine ranging from the rich northern style Mughlai cooking of the pre-dominantly Muslim dominant Hyderbad to the simple vegetarian dishes of Tamil Nadu, from the seafood, kebabs and puris of Maharashtra to the strong Portuguese influenced cuisine of Goa, from the coconut based recipes of Kerala and the Malabar fish dishes to the unique cuisine of a small diminishing Franco-Indian populace in Pondicherry, South Indian food habit encompasses a wide spectrum of culinary choices [18]. Socio-demographic, macroeconomic and alike life style in the coastal part of Karnataka and Kerala supports the fact of close proximity results in dietary habits and food style. Transition from South Indian to Eastern Indian food habit encompasses the cuisines from the states of West Bengal and Orissa to the North eastern states. The staple food of this region is largely depends on rice and wheat. East Indian food habit has a fair balance of vegetarian and non-vegetarian dishes with fish curries being the cornerstone of its non-vegetarian platter. Steaming and frying are the popular methods of cooking. So to quantify the diversity and correlate Indian food
style with KSD, this review article investigates to curtail the prevalence of KSD cases which affect directly or indirectly with food consumption therein.

2.1. Stone Forming Area in India

In the context of India, KSD is very much prevalent with an expectancy of 12% in a total population as reported prone to urinary stones [19]. Out of this 12%, 50% of the population are severely affected with renal damage and thus even lead to loss of kidneys [19]. Unlike the South India where a few reported percentages affected from Urolithiasis, in North Indian there is a steep 15% of the population inside the regime of KSD [20]. So in the prospect of kidney stone belt that affected by KSD in India, a proper corollary needed to be established [20]. This stone belt occupies areas of Maharashtra, Gujarat, Rajasthan, Punjab, Haryana, Delhi, Madhya Pradesh, Bihar and West Bengal (Fig.1). In these regions, the frequency of prevalence and recurrence rate of renal stone is high in the most of the members of a family.

![Stone belt Area](image)

**Figure 1.** Stone belt Area: (A) Major Kidney stone prevalent states of India continents, (B) Animal protein consumption per gram per day per capita that lead to KSD (*Ministry of Statistics and Programme Implementation 2012*)

<table>
<thead>
<tr>
<th>Stone belt States</th>
<th>Protein Consumption (gm/day/capita)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rural Area</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>71.4</td>
</tr>
<tr>
<td>Haryana</td>
<td>70.7</td>
</tr>
<tr>
<td>Punjab</td>
<td>67.2</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>62.7</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>60.2</td>
</tr>
<tr>
<td>Bihar</td>
<td>57.6</td>
</tr>
<tr>
<td>Gujrat</td>
<td>56</td>
</tr>
<tr>
<td>Jharkhand</td>
<td>53.6</td>
</tr>
<tr>
<td>Bihar</td>
<td>57.6</td>
</tr>
<tr>
<td>West Bengal</td>
<td>53.3</td>
</tr>
</tbody>
</table>
### 2.2. Food Habits with Stone Formation

Indian food habit has been widely recognized risk factor of kidney stone formation [21]. An increase in calcium excretion after a load of protein was stated by many studies [22, 23]. The increase amount of consumption of animal product lead to higher calcium, oxalate and phosphorous in the urinary track [24, 25, 26]. These are the reason of stone formation initially in the form of insoluble calcium oxalate or calcium phosphate crystals. Proteins also increase uric acid generation which may end up in stone formation [25, 26]. High carbohydrate and lipid consumption have been shown similar changes [27]. Presence of high amounts of salt in the fast food especially in industrialized countries causes higher calcium in the kidneys [28]. Contrary of this, low calcium diet is suggested a risk factor as it increases intestinal absorption of oxalate [29]. Citric acid, potassium and magnesium act as negative regulator of stone synthesis [25]. For this reason inadequate intake of fruits, vegetables are considered as a risk factor for stone synthesis although some oxalate rich fruits like berries, chikoos and vegetables like tomatoes, spinach, beets are still there [30,31]. Vitamin C, when administered in higher quantities into the human body, is reported to have caused kidney stones in some cases [32]. It is inferred that Vitamin C gets converted to oxalates [33]. But some study reported that the oxalate excretion is little related to the dietary intake [34]. There are number of comparative studies between stone former and healthy control dietary habits [27, 29]. But results are contradictory. Most of these studies support the relation between food habit and kidney stones whereas opposite result is also there [35]. So the development and the progression of the disease are not so clear till now. In this regime, Table 1 corresponds to the reports conducted in different geographical study population to strengthening the correlation of food intake and its impact in KSD.

<table>
<thead>
<tr>
<th>Food Content</th>
<th>Impact on Stone Formation</th>
<th>Studied Zone</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary oxalate</td>
<td>Intestinal hyper absorption of oxalate, increased urinary oxalate excretion</td>
<td>Western part of India</td>
<td>Pendse et al., 1986 [36]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Germany</td>
<td>Hesse et al., 1993 [2]; Siener et al., 2003 [37]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>North Carolina, USA</td>
<td>Holmes et al., 2001 [38]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Italy</td>
<td>Meschi et al., 2004 [31]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boston</td>
<td>Taylor and Curhan, 2007 [39]</td>
</tr>
<tr>
<td>Dietary ascorbic acid</td>
<td>Increases urinary oxalate excretion</td>
<td>New York</td>
<td>Urivetzky et al., 1992 [40]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Italy</td>
<td>Trinchieri et al., 1998 [41]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Washington</td>
<td>Massey et al., 2005 [42]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sweden</td>
<td>Thomas et al., 2013 [32]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boston</td>
<td>Ferraro et al., 2016 [43]</td>
</tr>
<tr>
<td>High dietary calcium</td>
<td>Reduces calcium oxalate stone formation</td>
<td>France</td>
<td>Bataille et al., 1983 [60]</td>
</tr>
<tr>
<td>----------------------</td>
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<tr>
<td></td>
<td></td>
<td>Boston</td>
<td>Curhan et al., 1993 [35]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Germany</td>
<td>Siener et al., 2003 [37]</td>
</tr>
<tr>
<td>High intake of carbonated beverage</td>
<td>Increases urinary oxalate</td>
<td>Boston</td>
<td>Curhan et al., 1997 [45]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Women of Omaha</td>
<td>Heaney and Rafferty, 2001 [46]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Netherland</td>
<td>Asselman and Verkoelen, 2008 [47]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boston</td>
<td>Taylor et al., 2009 [15]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>North Carolina</td>
<td>Saldana et al., 2007 [48]</td>
</tr>
<tr>
<td>Protein rich diet</td>
<td>Increases acid load in kidney, increases risk of stone formation</td>
<td>Boston</td>
<td>Curhan et al., 1997 [45]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chicago, USA</td>
<td>Reddy et al., 2002 [49]</td>
</tr>
<tr>
<td></td>
<td>Reduce the body’s ability to absorb calcium</td>
<td>Switzerland</td>
<td>Nguyen et al., 2001 [81]</td>
</tr>
<tr>
<td></td>
<td>Increases urinary calcium</td>
<td>Italy</td>
<td>Borghi et al., 2002 [14]</td>
</tr>
<tr>
<td>High intake of sodium</td>
<td>Increases urinary calcium</td>
<td>Northern India</td>
<td>Awasthi and Malhotra, 2013 [51]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-menopausal women of Korea</td>
<td>Park et al., 2014 [52]</td>
</tr>
</tbody>
</table>

### 2.2.1. Protein:

High intake of protein especially animal protein is responsible for the relatively high prevalence of stones [23, 49, 53]. Animal protein containing purines are precursors of uric acid stones [54]. Amino acids like glycine, tyrosine and tryptophan convert into oxalate which is a very common component of kidney stone [55]. It also causes renal acid excretion, increased calcium reabsorption and increased renal reabsorption of citrate which ultimately leading to kidney stone formation [49]. Thus protein has a well contribution in making a bridge between calcium (increased calcium) and uric acid (decreased citrate) stone by its activity. While a balanced amount of protein intake is required to ignite metabolism, more consumption on the other hand increase the burden in kidney and liver [56]. To support the fact of protein consumption and associated kidney stone, reports have shown to increase three times in meat consumption in developed nation than developing ones like Asia in between 1970 to 1990 [57].
2.2.2. **Calcium Rich Food:**

Nishiura (2002) demonstrated a comparative study between the control individuals with stone former individuals in respect of oral consumption of calcium diet with urinary excretion. In stone formers there is dependency of urinary calcium excretion on diet whereas in controls there is variation in calcium excretion with diet [34]. On the contrary, in a study it was shown that lower calcium intake have a higher risk of stone formation than higher calcium intake [58]. Calcium rich cereals like ragi, rajma, soyabean or dairy products are main ingredients of regular diet in India especially in stone belt region [18]. Conversely, the intake of calcium supplements outside of meals causes an increased risk of stone formation in patients taking more calcium supplements [34]. Calcium intake in the outside of meal results a different effect than calcium intake with other nutrients [45].

2.2.3. **Carbohydrate Rich Food:**

Calcium stone formers exhibit an enhanced urinary calcium excretion to dietary content containing high carbohydrates in comparison to healthy controls [59]. Carbohydrates reduce reabsorption of calcium at the level of the distal tubule, but subsequent studies have shown that glucose in a high concentration can enhance the intestinal absorption of calcium [60]. In addition fructose increases the urinary excretion of calcium and oxalate, both of which are important risk factors for calcium stones. Low urinary pH which is a major reason behind uric acid formation is the trailing step of insulin resistance due to excessive fructose intake [61]. It was reported that uric acid synthesis upregulated due to a single carbohydrate component fructose [62]. In India north and east region contain maximum sucrose content in everyday life [63].

2.2.4. **Sodium, Potassium:**

Modification of sodium by cutting down the daily intake of salt is advised for reducing kidney stone recurrence [64]. Changes in the composition of urine i.e. increased calcium or decreased citrate is attributed by increased sodium in diet [14]. It is shown that sodium can greatly affect urinary excretion of calcium i.e. 25 mmol/day increases in urinary sodium causes an increase of 0.6 mmol/day in urinary calcium [65]. Sodium and calcium excretion in the urine are well correlated shown in some studies [52, 66]. Potassium also regulates value of urinary calcium in the body [67]. In one study it was reported that in healthy subjects’ diet with normal sodium quantity, dietary potassium deprivation is associated to an increase in urinary calcium excretion [68]. The regular salty food pattern is one of the reasons behind kidney stone formation in India [69, 70]. In contrast sodium and potassium also increase urinary volume and pH which is required in cystine lithiasis [71].

2.2.5. **Oxalate Rich Food:**

The dietary oxalate and the metabolism of vitamin C both originate Oxalate [38-40]. Urinary oxalate excretion derives from metabolism but 10-50% comes from dietary oxalate [38]. In the Western countries intake of oxalate ranges 100-300 mg/day and approximately 5-10% of the total is absorbed in the intestine [72]. Intestinal absorption depends on the form in which it is consumed i.e. soluble or insoluble and on its interaction with other food materials [73]. The main sources of dietary oxalate are relatively few: spinach (45%), potatoes (10%), cold cereal (4%), nuts, coffee and tea account for about 70% of all dietary oxalate [30, 31]. Although some study claimed that renal stone formers consume more oxalate than healthy controls, but there are some studies where the oxalate quantity of the diets of renal calcium stone does not only reason for renal stone formation [34]. Here in Table 2, we compiled diverse food intake in different Indian regions and its impact in KSD therein.
Table 2. Different geographic regions of Indian population and their food habits.

<table>
<thead>
<tr>
<th>Indian Part</th>
<th>Food*</th>
<th>Protein</th>
<th>Calcium</th>
<th>Carbohydrates</th>
<th>Sodium-Potassium</th>
<th>Oxalate %</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>Mughlai</td>
<td>10-18</td>
<td>7</td>
<td>20-56</td>
<td>1</td>
<td>-</td>
<td>Protein</td>
</tr>
<tr>
<td></td>
<td>Mushroom</td>
<td>6</td>
<td>1</td>
<td>-</td>
<td>9</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bamboo shoots</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>15</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pickle</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>50</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>East</td>
<td>Fish</td>
<td>44</td>
<td>1</td>
<td>-</td>
<td>2-10</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meat</td>
<td>52</td>
<td>0</td>
<td>-</td>
<td>2-12</td>
<td>-</td>
<td>Protein and Carbohydrate</td>
</tr>
<tr>
<td></td>
<td>Egg</td>
<td>26</td>
<td>5</td>
<td>-</td>
<td>3-5</td>
<td>-</td>
<td>Te</td>
</tr>
<tr>
<td></td>
<td>Rice</td>
<td>5</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potato</td>
<td>4</td>
<td>1</td>
<td>10-20</td>
<td>6-12</td>
<td>1</td>
<td>Protein and Carbohydrate</td>
</tr>
<tr>
<td></td>
<td>Tomato</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spinach</td>
<td>5</td>
<td>9</td>
<td>1</td>
<td>3-15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chives</td>
<td>6</td>
<td>9</td>
<td>1</td>
<td>2-8</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dairy</td>
<td>3</td>
<td>8</td>
<td>1</td>
<td>2-4</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>North</td>
<td>Kidney bean</td>
<td>48</td>
<td>14</td>
<td>20</td>
<td>20-40</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>28</td>
<td>3</td>
<td>23</td>
<td>12</td>
<td>-</td>
<td>Protein and Carbohydrate</td>
</tr>
<tr>
<td></td>
<td>Corn</td>
<td>18</td>
<td>-</td>
<td>24</td>
<td>1-8</td>
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<td></td>
<td>Mughlai</td>
<td>10-18</td>
<td>7</td>
<td>20-56</td>
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<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paratha-Saag</td>
<td>10</td>
<td>11</td>
<td>30</td>
<td>1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tomato</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2-5</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
**Legume**  
10 2 4 0-6 1  

**Dairy**  
3 8 1 2-4  

**Seafish** 30-40 - 2-10 -  

**Crabs** 36 9 7-15 -  

**Nut** 40 11 7 11 1  

**West**  

**Rice** 5 1 20-28 - -  

**Coconut** 6 13 - 1 -  

**Sweets** 3 8 1 2-4 -  

**Dosa/Idli** 3 6 23 - -  

**Grains** 26 10 14 6-15  

**Fish** 44 1 - 2-10 -  

**Meat** 52 0 - 2-12 -  

**Coconut** 6 13 - 1 -  

**Pickle** - - - 50 -  

Protein  

Protein and Carbohydrate  

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*Some most common food consumed by different parts of India*

3. **Mechanism of Different Types of Stones According to Food Habits**

3.1 **Impact of Food in the Mechanism of Stone Formation**

Kidney stones are named according to the names of the crystals which make up the hard part of the stones: Calcium Oxalate, Calcium phosphate, Uric Acid, Cysteine, Struvite. In India, calcium oxalate and calcium phosphate stones are predominant whereas report of uric acid and cystine stone is very few [74]. Struvite stones are not in consideration as it is formed by bacteria kind ammonia in urinary tract infections and generally not found in Indian population in much extent [21].

3.1.1 **Calcium Stone**

Calcium is the major element of about 80-90% of all urinary stones [75]. They are usually made of calcium oxalate or calcium phosphate or mixed of them detected in chemical or infrared spectrometric analysis [76]. Calcium phosphate may solidify in the renal interstitium and later on papillary surface along with Calcium oxalate [77]. Many studies reported the derivation of 10-50% of the urinary oxalate from diet like dark-green leafy vegetables, spinach, beets, beans, cereals, dietary...
ascorbic acid, glycine rich food like animal proteins, chocolate, black tea etc. [2,38-40,73,78] Protein breakdown product glycine in a metabolic pathway oxidised to glyoxylate which is the precursor of oxalate, a major stone component [79]. In a study it was shown overconsumption of animal protein create observable increased rate of urinary calcium (23%) and oxalate (24%) [80]. High fructose consumption from soft drinks is associated with an increased risk of hypercalciuria, hyperoxaluria and hyperuricosuria [39, 81]. In an experiment higher urinary calcium excretion occurred in rats fed high-fructose diets compared to rats fed high-starch diets [82, 83]. An insufficient supply of dietary calcium is also a notable risk factor for both calcium oxalate and phosphate stone formation [34, 45]. High salt intake has been associated with elevated urinary calcium excretion by reducing tubular reabsorption which is an output of free particle model on crystallization [84]. This high concentrations of calcium in the urine combines with oxalate and phosphorus to form stones (Figure 2).
Figure 2. Calcium stone formation with food habits (A) calcium oxalate stone formation (B) calcium phosphate stone aggregation.

KSD is mostly accompanied with hypercalciuria nearly 30–60% due to high intestinal calcium absorption [85]. In hypercalciuria, calcium stimulates supersaturation of mineral crystallization and makes obstacle of stone inhibitory factors (citrate, GAGs) by binding with them [86]. Other events like bone resorption, renal leakage take a positive part in implicating hypercalciuria manifestation [87]. By reducing calcium intake, heights of calcium excretion are manageable at a certain level [88]. So, dietary management should be required for the regulation of hypercalciuria. A diet based study demonstrated that lower intake of animal proteins and salts with optimum calcium intake have great impact on reducing the chances of stone recurrence [52, 66]. Overtaking salts and proteins increase urinary calcium excretion nearly 23% and the outcome of it kidney stone formation [52]. Fructose also has a significant role on it and it was noticed in rat model experiment with elevated urinary calcium excretion [89].

3.1.2 Uric Acid

Uric acid stones record of nearly 5-10% of urinary stones [90]. Low urine pH is very much familiar to this type of stones [22]. Urinary uric acid solubility decreases approximately 185 mg/dL when urine pH dropped from 7 to 5. At higher pH 95% of uric acid is in its soluble urate form and at lower pH solubility is decreasing in most of the uric acid [91]. Excess uric acid excretion through urine, hyperuricosuria is caused by purine rich diet, precursor of uric acid (Figure 3) [90]. Foods containing high protein especially animal protein like poultry things eggs, meat, seabish and some plants products like seeds, nuts are the highest source of purines [92]. It was reported that daily increase of animal protein significantly increased 48% in the uric acid excretion [93]. Another factor sweet drinks containing high fructose level are in relation with increased risk for renal stones. In one study it was shown that over consumption of fructose results in a rapid rise of serum uric acid through increased purge synthesis [89]. In the metabolism pathway fructose breaks into insonine and xanthine with the help of energy driver ATP. This xanthine ultimately promotes uric acid formation by using ADP as a substrate [94].
3.1.3 Cystine Stone

Cystine stones are very rare nearly 1–2% of urinary caliculi [95]. These are formed in those people who have tendency of excessive cystine leakage from the kidneys into the urine [96]. Maintaining cystine concentration in urine below 200 to 300mg/L is the best medical care this type of stone [97]. High liquid substance is required for producing at least 3 litres volume urine during a day to decrease the high level of urinary cysteine [98]. In addition potassium citrate is usually taken as a drug for reducing renal acidosis [99]. In food, animal proteins containing methionine like meat break down into cystines which increase urinary cystine level in the body [100]. In a study it was shown that urinary cysteine excretion reduced to 34% by consuming very low protein diet nearly 20g/day [101]. Overtaking sodium has high impact in this disease manifestation by promoting excretion of cysteines (Figure 4) [102].
Figure 4. Cystine stone formation with food habits.

4. Food Diversity and Nutritional Effects In Indian Population:

Over nourishment and undernourishment are both great burdens for society. At one point over taking protein, carbohydrate, oxalate rich foods enhance the occurrence of renal stone [23, 59, 61, 62, 72]. Whereas raised protein break down and protein undernutrition are familiar in chronic kidney disease (CKD) patients [103]. So the vital factor protein has an observable influence on these two kidney disease by its presence or absence. Several studies have suggested CKD is a recognized issue among stone formers [104-106]. Renal stone is a result of an impaired kidney function and an important clinical parameter serum creatinine level should be monitored in the follow up [107]. It is reported in a population study from US that elevated serum creatinine levels cause nearly 25-44% increased risk for CKD in stone formers [108]. Protein rich diet may increase serum creatinine levels, which has an impact on the changes of glomerular filtration rate [109]. Interestingly there are multiple reports on protein–energy malnutrition which occur during the CKD especially in the mature stages(3-5) and the risks of mortality is high due to the occurrence of protein malnutrition at the time of dialysis [110]. Many studies have also shown that CKD patients have much resting energy expenditure in comparison to normal individuals and during dialysis this expenditure is increased more [111,112]. For this reason they require more energy given food especially protein. In a conclusion food management is very important tool for maintaining the health of kidney.

In Indian scenario, where mostly there are people under the poverty line, income plays a major role in determining the status of life and food intake in general [101]. This poor socioeconomic position is associated with chronic malnutrition since it inhibits purchase of essential nutritious foods for growth and development as the price rates are not increasing with income proportionately [113]. So, there are many indirect pathways which constitute poor healthcare, malnutrition, abstemious food intake that leads to a CKD and many others (Figure 5) [114]. In prenatal cases where calcium intake and nutritional levels need to properly maintained are frequently been underprivileged. In this section, we have given an introductory causality model that very much exists in India in the realm of nutrition, food intake and their impact in human lives.
5. Concluding Remarks

KSD is a rising concern, major healthcare burden and associated with hematuria, renal failure. The risk of renal stone varies from 1-5% in Asia, 5-9% in Europe, 10-15% in USA and 20-25% in the middle-east [115]. Dietary therapy can be one of the promising solutions to minimize the cases of recurring kidney stone formation and hence better quality of life. So, an awareness of health concern and optimized food therapy can potentially curtail the cost of hospitalization and enhance compliance in general. Vis-à-vis to dietary control, insufficient understanding of molecular, genetic basis of pathogenic mechanisms remains a critical barrier to early detection, treatment. Mostly stone formation attributes two mechanisms– 1) renal calcium leak, excessive absorption, bone resorption/formation imbalance 2) mineralization. Dietary factors have been widely recognized one of the prime risk factors of kidney stone formation [59]. On the other hand, parathyroid hormone primarily modulates calcium balance. It increases calcium excretion in kidney. VDR regulates calcium homeostasis by affecting bone resorption, calcium absorption. CLDN-14, tight junction protein, decreases Ca2+ permeability whereas MGP regulates calcification [76]. SPP1 prevent renal stone formation by decreasing aggregation of crystals and binding to renal epithelial cells [116]. These are the reason of stone formation initially in the form of insoluble calcium oxalate or calcium phosphate crystals. Most of these genetically inspired reports support the relation between food habit and kidney stones whereas stratified contradictory reports are also there. So conclusively, there is a high demand to understand better the correlation between food intake and CKD and hence quantified researches, aligned case studies need to establish in near future.

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