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DIETARY AND ENVIRONMENTAL RISK FACTORS CONTRIBUTING TO THE ESCALATING INCIDENCE OF RENAL CALCULI: A CLINICAL STUDY

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ABSTRACT

Renal calculi, commonly known as kidney stones, have emerged as a significant urological disorder in Pakistan, particularly in urban regions such as Lahore where dietary imbalance, environmental heat exposure, and inadequate hydration contribute to increasing incidence rates. This clinical study investigates the dietary and environmental risk factors associated with renal calculi formation among patients admitted to tertiary care hospitals in Lahore. The study is grounded in the Multifactorial Risk Theory, which explains renal stone formation through the interaction of metabolic, nutritional, and environmental determinants. A quantitative cross-sectional methodology was employed using structured questionnaires and clinical reports collected from 150 patients diagnosed with renal calculi at Mayo Hospital, Sheikh Zayed Hospital, and Jinnah Hospital. Statistical analysis was conducted using SPSS to identify major contributing variables. Findings revealed that low water intake, excessive consumption of oxalate-rich foods, high sodium diets, carbonated beverages, and prolonged exposure to hot climatic conditions were strongly associated with stone formation. Male patients aged 25–45 years demonstrated the highest prevalence. The results further indicated that nearly 72% of participants consumed less than the recommended daily water intake, while 64% reported frequent intake of salty and processed foods. Measurable outcomes demonstrated a significant association between dehydration and recurrent renal calculi episodes, emphasizing the need for dietary modification and public health awareness programs. The study highlights preventive nutritional strategies as essential interventions for reducing renal stone burden in Pakistan.

Keywords: *Renal calculi, nephrolithiasis, dietary risk factors, dehydration, environmental exposure, Lahore hospitals, urolithiasis, kidney stones, clinical study, public health*

1. INTRODUCTION

1.1 Context and Background of the Study

Kidney stones (also known as renal calculi) are one of the most common urologic diseases among populations around the world. The disease is caused by the deposition of hard crystals of minerals or salts in the kidneys or urinary tract, as a result of urine supersaturation. They can be very large and of different composition and severity, and will frequently present with severe flank pain, urinary obstruction, haematuria, infection and renal dysfunction. However, renal calculi have become more common over recent decades, as

many dietary habits have changed, more people have become urbanised, the environment has changed, and lifestyle has become more sedentary (Worcester and Coe 955). Nephrolithiasis has been rising in prevalence and has become a major public health challenge, especially in the developing world, where awareness of preventive health care is low.

In the world, about 10-15% of the population suffer from kidney stone disease, and almost half of the individuals who develop kidney stones will experience another one in the next five years (Pearle et al. 317). Epidemiological data indicate a rise in the incidence of renal calculi in both industrial and developing countries, as a result of nutritional changes and climate change. Renal calculi are much more common in South Asian countries like Pakistan, India and Bangladesh as this is the "Afro-Asian stone belt", where there are high temperatures, dehydration risk, and dietary imbalances (Fakheri and Goldfarb 118).

Long summer season and high temperature in the environment are also contributing factors of dehydration and urinary concentration in Pakistan. Being one of the most densely populated metropolitan cities of Pakistan, Lahore witnesses extreme heat exposure in the summer months when the temperature often goes into the 40s which leads to the rise in circulatory rate and loss of fluids, which in turn decreases the volume of urine and raises the mineral supersaturation in urine. Fakheri and Goldfarb state that warmer climates greatly increase the likelihood of kidney stones developing, due to the increased concentration of urine caused by warmer temperatures, which increases the risk for calcium oxalate precipitation and crystal aggregation (119). Based on that, the exposure to ambient heat has emerged as an important epidemiological risk factor for nephrolithiasis in Pakistan.

In addition to climatic factors, dietary habits are a major factor in the formation of renal calculi. The Pakistani population has undergone many changes in the way they eat due to rapid urbanization and modernization. With traditional diets that are rich in hydration sources becoming more and more rare, they are being replaced by processed food, fast food, sugary drinks and an overabundance of sodium. The diets cause calcium to be excreted in the urine, increase the concentration of oxalates in the urine, and add to acidic urine that is conducive to stone formation (Taylor and Curhan 770). Diets containing high sodium causes calcium to pass out in the urine, which makes it more likely to form stones. Processed foods, pickles, canned foods, and meals at restaurants are the most common dietary sources of sodium.

Foods high in oxalate also play a major role in the formation of kidney stones. Spinach, chocolate, nuts, tea and beetroot, for instance, have high oxalate content, which can bind up urinary calcium to form calcium oxalate stones, the most prevalent type of renal calculi worldwide (Holmes and Kennedy 272). Excessive tea intake and consumption of spicy processed food exacerbates the metabolic disorders of the kidney stone disease in Pakistani dietary culture. Moreover, carbonated drinks and artificially sweetened beverages are on the rise among younger audiences, in lieu of healthier fluid consumption.

Remaining hydrated is one of the most important factors to avoid forming kidney stones. Drinking plenty of water prevents the minerals in urine from becoming concentrated, which means that the calcium, oxalate, uric acid and phosphate crystals found in urine are not concentrated. But, in urban Pakistan a lot of people have not adequate water consumption, even after an extended period of environmental heat exposure. Borghi et al. found that those who kept drinking a lot had significantly less reoccurring renal calculi than those who were dehydrated (841). Unfortunately, lack of knowledge about the need of hydration is still a cause of the rising prevalence of nephrolithiasis in Lahore and its surrounding areas.

Environmental exposure is compounded by occupational exposure. Dehydration and electrolyte imbalance are common in many occupations, such as labors, construction, factory workers, traffic wardens and outdoor vendors that work directly in the sun for long periods. These work conditions put the urine into a favorable physiological state for the formation of urinary crystals. Research has shown that the prevalence of

renal calculi is higher in outdoor workers than in indoor workers due to chronic heat stress and limited opportunities to drink water (Curhan 289).

The socioeconomic impact of renal calculi is also alarming. In addition to causing excruciating pain and frequent hospitalizations, kidney stones also cut down on workers productivity and quality of life. Prolonged diagnostic testing including ultrasonography, CT scans and laboratory testing is required in some patients, as well as surgical procedures such as lithotripsy, ureteroscopy and nephrolithotomy. For many families, long-term medical management and dietary interventions add psychological and financial strain during re-episode.For recurrent cases, long-term medical treatment and dietary restrictions add to the psychological and financial burden of the family during re-episode. With the increasing admission of patients for nephrolithiasis in hospital along with recurrent cases in emergency department, healthcare institutions are now under pressure in Pakistan.

Gender difference has also been consistently reported with regard to renal calculi epidemiology. Men are more likely to suffer from it than women due to the fact that they are more likely to be exposed to occupational heat, and have protein consumption patterns, hormones and dietary habits, that increase their risk of developing it (Stamatelou et al. 1819). However, recent evidence suggests a narrowing of the gender gap, and dietary changes and sedentary lifestyles are now impacting women too. Age also continues to be significant: prevalence is highest among adults aged 25 to 45 years, who are most likely to have active occupational exposure, lifestyle factors.

Recurrence is another great concern that goes along with renal calculi. Unfortunately, many patients develop another stone within a few years after treatment, if the preventive measures are not sufficient. Ongoing dehydration, inadequate dietary management, obesity, metabolic syndrome and ignorance of stone prevention are all involved in the recurrence. Worcester and Coe indicate that kidney stone recurrence rates could be over 50% if the patients cannot make lifestyle changes and increase fluid intake (960). Thus, it is crucial for preventive healthcare education to prevent future disease burden.

Although there is a vast amount of literature available on nephrolithiasis all over the world, there are not many studies that have investigated the contribution of dietary and environmental factors to nephrolithiasis among Pakistani population. Biochemical diagnosis and surgical management are stressed in most local studies, and preventive epidemiological analysis is ignored. Moreover, there are no datasets available that focus on the urban population of Lahore that are available in a hospital setting. This leaves a significant research gap in understanding localized dietary patterns, occupational exposures, patterns of hydration and environmental factors that may be involved in the development of kidney stones.

To fill the gap, the present study aims to investigate dietary and environmental risk factors of renal calculi patients admitted in pseudonymous to the Sheikh Zayed Hospital, Mayo Hospital and Jinnah Hospital, Lahore, tertiary care hospitals. The study is based on the Multifactorial Risk Theory to account for the interplay between nutrition, environmental, metabolic and lifestyle factors in renal stone disease. The quantitative clinical analysis looks for key determinants and suggests evidence-based recommendations for preventive health care interventions in the Pakistan context.

1.2 Research Gap

Though much work has been done in the field of renal calculi origin and management worldwide, yet there are some important lacunas in the Pakistani healthcare scenario. The majority of the work done to date has concentrated on the biochemical composition of kidney stones, surgical techniques or pharmaceutical treatment methods, but not on the public health aspects of prevention. There is little research done to explore the combined effect of dietary habits and environment on renal calculi formation among people of Pakistan with special reference to urban area like Lahore.

Previous research has also lacked a set of data that is derived from a single population-based resource that could assess all of these factors together at a

single location (localized hospital-based data). There are many climatic, dietary, socioeconomic, and health awareness differences in different countries that make it difficult to use most of the findings from abroad in Pakistan. The extreme weather conditions that are experienced in Lahore during summers, rising prevalence of fast food consumption, along with lack of public awareness about the need for water, provide the city with unique nutritional and environmental risk profiles suggesting the need for independent clinical studies.

Moreover, there were few Pakistani studies that included comparative analysis between the tertiary care hospitals and demographic factors like age, gender, occupation and lifestyle in one study. Limited attention is focused on recommendations for prevention of recurrence, which includes diet and environmental changes. Hence, this study fills a research gap by presenting a detailed clinical analysis of dietary and environmental factors which are associated with renal calculi among the patients admitted in hospitals of Lahore.

1.3 Research Objectives

The present study is designed to achieve the following objectives:

1. To investigate the major dietary factors contributing to renal calculi among patients in Lahore hospitals.
2. To examine the impact of environmental heat exposure and dehydration on kidney stone formation.
3. To analyze demographic patterns associated with renal calculi incidence, including age and gender distribution.
4. To evaluate the relationship between hydration practices and recurrent renal stone disease.
5. To assess the influence of sodium-rich and oxalate-rich diets on urinary stone formation.
6. To recommend preventive healthcare strategies for reducing renal calculi prevalence in Pakistan.

1.4 Research Questions

The study seeks to answer the following research questions:

1. What dietary habits significantly contribute to renal calculi formation among patients in Lahore?
2. How does environmental heat exposure influence the incidence and recurrence of kidney stones?
3. Which demographic groups are more vulnerable to renal calculi in Lahore-based hospitals?
4. What is the relationship between hydration practices and urinary stone recurrence?
5. How do sodium-rich and oxalate-rich foods affect renal calculi development?
6. What preventive interventions can reduce the burden of nephrolithiasis in Pakistan?

1.5 Scope of the Study

The study emphasizes on the dietary and environmental risk factors associated with renal calculi in patients of tertiary care hospitals in Lahore. The study focuses on patients with diagnosis of kidney stones at three hospitals, namely Mayo hospital, Sheikh Zayed hospital and Jinnah hospital, with pseudonymised identities. Hydration patterns, sodium intake, consumption of food that contains a high amount of oxalate, occupational heat exposure, and demographic factors are analyzed in the investigation.

The research is carried out quantitatively, cross-sectional clinical analysis, consisting of 150 cases of renal calculi. The dataset is based on laboratory diagnosis, questionnaires from patients and patient records. Advanced biochemical pathways of stone formation and genetic predisposition are not discussed in detail in the study. Rather, it focuses on lifestyle, dietary and environmental factors affecting the prevalence and recurrence of nephrolithiasis.

Significance of the Study

This study is important because it contributes to the research of preventive care of renal calculi in Pakistan. The results are clinically significant in terms of dehydration, dietary imbalance and environmental heat exposure as risk factors for kidney stone disease in urban areas of Lahore. The findings from this study can aid in the creation of nutrition awareness campaigns and hydration-

based preventative measures aimed at these key modifiable risk factors.

The study also provides public health policy implications as increased burden of nephrolithiasis in the health care system in Pakistan is highlighted. The results could be used by hospitals and health care providers to create patient counseling programs aimed at diet control and proper water consumption. Moreover, the study can support nutritionists and policy makers in developing education programs at the community level about how to stay hydrated during extreme weather events.

Dietary, environmental, and demographic variables were included in a single tool for analyzing the study and it has filled an important gap in localized clinical literature. The research also lays the groundwork for future studies on the long-term effects of preventive measures, workplace risks, and metabolic issues linked to the recurrence of renal calculi in Pakistan.

2. Literature Review

The growing prevalence and high recurrence rate of renal calculi (nephrolithiasis) have led to research in this area across various disciplines of nephrology, urology, nutrition science, and environmental health. In the literature, kidney stone disease has been firmly established as a multifactorial condition related to dietary composition, hydration status, metabolic disorders, genetic predisposition and environmental factors (Worcester and Coe 954). This part critically examines the previous studies done to provide a conceptual framework for the current study and identify the factors contributing to renal calculi formation.

2.1 Global Epidemiology of Renal Calculi

Kidney stone disease has become a serious problem all over the world in the last 30 years. Epidemiological studies have shown that renal calculi affect about 10-15% of the world population at least once during their lifetime, and can recur up to 50% of the time within 5 years (Pearle et al. 317). In the industrial countries like the USA, there has been an increase in the incidence trend, because people have changed their diets and become more sedentary. In the developing countries there are other issues that require attention, including climate, access to healthcare, etc.

Recent studies indicate that the rate of renal stones has consistently risen in both men and women over the years, and the rate for men has always been significantly higher than for women (1818). Now, however, there are some indications that the gap between men and women is becoming smaller, thanks to lifestyle convergence, especially eating habits and obesity trends.

2.2 Dietary Risk Factors in Renal Calculi Formation

Diet is a key factor in kidney stone formation. Dietary sodium is strongly correlated with urinary calcium excretion, a risk factor for calcium stone formation. Curhan et al have shown that calcium handling in the kidney is abnormal in persons with high sodium diets, resulting in a significant increase in the risk of nephrolithiasis (836). Urban populations are heavily reliant on processed foods, fast foods and salted snacks for their high sodium consumption.

Another important dietary factor is a diet containing animal protein. Eating too much red meat and animal protein raises uric acid in the urine and lowers citrate, which is necessary to prevent stones from forming (Taylor and Curhan 769). The normal concentration of citrate is an inhibitor of crystallization, so a reduction in citrate level contributes to stone risk.

Other foods that are also high in oxalates are also known to be strongly associated with calcium oxalate stones, including spinach, tea, chocolate, nuts and beetroot. Holmes and Kennedy highlight that dietary oxalate has a major effect on urinary oxalate concentration, particularly those with low calcium consumption and dehydration (271). The common tea drinking habit or vegetable oxalate in South Asian traditional dietary pattern, also plays a role in the metabolic imbalance.

Beverages containing carbon dioxide and excessive amounts of sugars have become the modern dietary risk factors. Research indicates that overconsumption of sodas leads to a rise in urinary calcium loss, and raises obesity-related metabolic

imbalances, which raise kidney stone rates (Taylor and Curhan 771).

How does the body use water and fluids? How are water and fluids used in the body?

There is general agreement that hydration status is the most important potentially modifiable risk factor for renal calculi. Dehydration causes a reduction in urine and an increase in the supersaturation of lithogenic substances. Borghi et al. reported that increasing water consumption by up to 1l per day did show a significant effect in the reduction of stone recurrence (840).

The people of hot climates are more susceptible to nephrolithiasis resulting from dehydration. Fakheri and Goldfarb point out that ambient temperature has a direct link to the formation of kidney stones, and higher temperatures are associated with higher rates of kidney stone formation because of excessive sweating and urine output (118). This correlation is especially significant in areas like South Asia and the Middle East.

2.4 Environmental and Climatic Factors

The effects of environmental heat exposure on the formation of kidney stones have recently become a well-recognized factor. High temperatures cause fluid loss, electrolyte imbalance and diminished urine output. In warmer climates, populations tend to have a higher incidence of renal calculi, because of the chronic dehydration and concentrated urine (120).

This risk is further amplified in urban settings like Lahore because of the heat intensity, urban heat island and occupational exposure. Laborers and other outdoor workers, such as traffic workers, are especially at risk because they are exposed to the sun for extended periods of time and have limited opportunities to drink fluids.

2.5 Metabolic and Physiological Factors

The metabolic abnormalities like hypercalciuria, hyperoxaluria, hyperuricosuria and hypocitraturia have significant role in kidney stone formation. Worcester and Coe state that the process of stone formation is mostly a physicochemical process (955). If the concentrations of citrate and other inhibitory substances are lowered, the likelihood of crystallization increases.

There is also a connection between obesity and metabolic syndrome and stone risk. Insulin resistance changes the composition of urine, leading to an increase in uric acid and calcium loss and lowering of urinary pH thus favoring stone formation.

2.6 Socio-economic and Lifestyle Factors

Changes in lifestyle due to urbanization such as sedentary lifestyle, eating of fast food, and lesser physical activity have been a factor in the increasing prevalence of kidney stones. People living in cities tend to have diets rich in calories and low in nutrients, thus contributing to the metabolic risk factors.

Stamatelou et al. point out that the socioeconomic context affects the composition of the stone, the amount of hydration and how it is distributed, as well as patterns of care-seeking and utilization of health services (1820). In developing countries, disease prevalence is further complicated by low levels of awareness of these issues related to hydration and dietary balance.

Summary of Literature Review

It is well established in the literature that renal stones formation is related to a combination of dietary, environmental, metabolic and behavioral factors. However, most studies are biochemical mechanisms or on the international population, while local clinical data in Pakistan is hardly discussed.

There is no integrated hospital based study that is found in the literature which investigates the dietary habits, environmental exposure and the hydration pattern at the same time on the urban population of Lahore. Further, comprehensive comparison between different tertiary care hospitals is still an unexplored area. The existing gap requires targeted clinical research to explore specific risk factors for renal stone in Pakistan.

3. Research Methodology

3.1 Research Design

This study adopts a quantitative cross-sectional research design to examine dietary and

environmental risk factors associated with renal calculi among patients in Lahore. A cross-sectional design is appropriate because it allows the simultaneous assessment of exposure variables (diet, hydration, environment) and outcome variables (presence and recurrence of kidney stones) within a defined population. Such designs are widely used in nephrology research to identify associations between lifestyle factors and stone disease without manipulating variables (Wang and Cheng 412).

The study integrates clinical diagnosis with self-reported behavioral data to ensure a comprehensive understanding of nephrolithiasis risk patterns in real-world hospital settings.

3.2 Study Population and Sampling Technique

The target population consisted of patients diagnosed with renal calculi in tertiary care hospitals of Lahore. A total of 150 confirmed patients were selected. A purposive sampling technique was applied to ensure inclusion of only clinically diagnosed renal calculi cases. This non-probability sampling method is commonly used in medical research when the study requires specific diagnostic confirmation rather than general population sampling (Kumar et al. 233).

Inclusion criteria included:

- Confirmed diagnosis of renal calculi through ultrasound or CT scan
- Patients aged 18 years and above
- Willingness to participate in the study

Exclusion criteria included:

- Patients with congenital kidney abnormalities
- Patients with incomplete clinical records
- Patients refusing consent

3.3 Study Setting (Hospital-Based Framework)

Data were collected from three major tertiary care hospitals in Lahore:

- Hospital A (Mayo Hospital Lahore)
- Hospital B (Sheikh Zayed Hospital Lahore)
- Hospital C (Jinnah Hospital Lahore)

These hospitals were selected due to their high patient turnover, advanced diagnostic facilities, and diverse patient demographics. Hospital-based clinical research provides reliable and validated datasets, especially in urological studies where diagnostic accuracy is essential (Pearle et al. 318).

3.4 Data Collection Instruments

Data were gathered using a combination of primary and secondary sources:

1. Structured questionnaires
2. Patient interviews
3. Hospital medical records
4. Laboratory diagnostic reports

The questionnaire included variables such as:

- Daily water intake
- Dietary habits (sodium and oxalate consumption)
- Frequency of carbonated beverage intake
- Occupational heat exposure
- Physical activity level
- History of renal calculi recurrence

Dietary assessment tools in clinical nephrology are considered reliable for identifying risk exposure patterns when combined with medical records (Taylor and Curhan 771).

3.5 Variables of the Study

The study identifies the following variables:

Independent Variables:

- Water intake level
- Sodium consumption
- Oxalate-rich food intake
- Carbonated beverage consumption
- Environmental heat exposure
- Occupational exposure

Dependent Variable:

- Presence and recurrence of renal calculi

3.6 Data Analysis Procedure

Data were analyzed using SPSS (Statistical Package for the Social Sciences). The analysis included:

- Frequency distribution
- Percentage analysis
- Cross-tabulation of variables
- Correlation analysis between risk factors and kidney stone incidence

Statistical methods in nephrology research are essential for identifying significant associations between lifestyle factors and disease outcomes

(Curhan 290). A significance level of $p < 0.05$ was considered statistically relevant.

4. Results and Statistical Interpretation

4.1 Demographic Profile of Respondents

The analysis of 150 patients revealed the following demographic distribution:

- Male patients: 68%
- Female patients: 32%
- Age group 25–45 years: 59%
- Above 45 years: 28%
- Below 25 years: 13%

These findings indicate that middle-aged males are the most affected group. This pattern aligns with global nephrolithiasis trends reported by Stamatelou et al., where males consistently show higher prevalence rates due to occupational and dietary differences (1819).

4.2 Dietary Risk Factors

The study identified strong dietary associations with renal calculi:

- Low water intake (<2 liters/day): 72%
- High sodium diet: 64%
- Frequent oxalate-rich food intake: 58%
- Carbonated beverage consumption: 55%
- High fast-food consumption: 61%

These findings strongly support Curhan et al., who identified sodium-rich diets and processed food consumption as major contributors to kidney stone formation due to increased urinary calcium excretion (836).

4.3 Environmental and Occupational Risk Factors

- Occupational heat exposure: 61%
- Prolonged outdoor work: 48%
- Lack of hydration during work hours: 66%

Environmental exposure significantly increased dehydration risk, supporting Fakheri and Goldfarb's findings that high ambient temperature is directly linked to increased nephrolithiasis incidence (120).

4.4 Recurrence Pattern

- Recurrent stone cases: 45%
- First-time cases: 55%

Patients with low water intake and high sodium consumption showed significantly higher recurrence rates. Borghi et al. similarly reported that increased fluid intake reduces recurrence probability by lowering urinary supersaturation (842).

4.5 Correlation Summary

- Strong positive correlation between dehydration and stone formation
- Moderate correlation between sodium intake and recurrence
- Significant association between occupational heat exposure and dehydration-related stones

5. Theoretical Analysis

The underlying theory for this study is the Multifactorial Risk Theory and its effect on the development of disease, which relates to the interaction between biological, environmental, dietary and behavioural risk factors rather than the single cause. This theory is especially applicable to the formation of renal calculi, which is a complex physiologic process that is affected by the urine chemistry, hydration status, dietary composition and environmental exposure (Worcester and Coe 955).

Based on this theory, renal calculi are formed when there is a disturbance in the ratio of urinary promoters (calcium, oxalate, uric acid, phosphate) and inhibitors (citrate, magnesium). In the event of dehydration, the volume of urine decreases resulting in an increase in their concentration of solutes, which is a supersaturation effect that leads to crystal nucleation and aggregation. This biochemical imbalance isn't just going to happen; it's a result of several interacting risk factors acting together.

The Multifactorial Risk Theory is more applicable to explain the primary triggering factor of environmental heat stress in the context of Lahore. Perspiration is increased by high ambient temperatures, causing substantial fluid loss. This decreases the urine output and increases the concentration of the solutes. Fakheri and Goldfarb point out that climatic conditions directly impact the epidemiology of kidney stones, especially in hot climates where chronic dehydration occurs (119).

This theoretical model is supported by dietary factors. Eating foods rich in sodium increases calcium losses in the urine by decreasing renal tubular reabsorption of calcium and oxalate rich foods increase the concentration of oxalate in the urine. These dietary factors, together with low hydration, can greatly promote calcium oxalate crystallization. They note that dietary sodium and protein are very closely linked with the risk of stones, because of their effect on urinary chemistry (770).

Behavioral and lifestyle aspects are also included in the theory. Lahore has experienced urbanization, and as a result, people consume more processed foods, fast foods as well as carbonated drinks all of which disturb the metabolic balance. Low levels of exercise and non-scheduled fluid intake exacerbate metabolic inefficiency. The multifactorial nature of renal calculi formation is created by these behavioural changes, which are influenced by environmental stressors.

Another key concept of the theory is its recurrence behavior. According to Multifactorial Risk Theory, if the initial stones were removed without altering the underlying risk factors, there is a strong likelihood of recurrances if the risk factors stay the same. Kidney stone recurrence has strong association with ongoing dietary and environmental exposures, as indicated by Worcester and Coe (960). This is why there are many patients that are recurring in Lahore even after undergoing clinical treatment.

Further, the theory endorses a proactive approach to health care. It doesn't just seek to treat with a drug or surgery, but looks at lifestyle factors such as hydrations, food and work exposures that can be modified. Borghi et al. have robust empirical evidence for this prevention-based model: They found that the more water they drank, the fewer recurrences they had, because they had lower supersaturations in their urine (841).

In conclusion, the Multifactorial Risk Theory can explain renal calculi formation in this study. It combines the effect of environmental heat exposure, dietary imbalance, hydration deficiency and lifestyle behaviors in a single framework. This theoretical framework is well applicable to the high prevalence of kidney stones in Lahore, where several risk factors are present and play a dynamic role in each other, thereby contributing to the burden of disease.

6. Discussion and Analysis

The results of this study show that the cause of renal calculi in Lahore is mainly due to the food imbalance, environmental heat exposure and poor fluid intake. This finding is similar to the findings in established nephrology literature, which has already shown that kidney stone disease is not caused by one single factor, but is a multifactorial condition influenced by lifestyle and environmental factors (Worcester and Coe 954).

The most notable result is the high number of individual patients whose water consumption is too low (72%). This confirms that dehydration has long been known to play a key role in the development of kidney stones. Loss of fluids results in decreased urine output and therefore more supersaturated with lithogenic materials like calcium and oxalate. By showing that stone recurrence is highly associated with water consumption, Borghi et al. bring up the idea that a higher water intake can significantly decrease stone recurrence rates by diluting the urine's concentration and improving the dilution of the solutes (840). This risk is further exacerbated in Lahore's hot climate because of the increased loss of fluid through sweat.

Other food habits noted in the study also have high correlation with renal calculi formation. Processed and packaged foods were widely consumed as 64% of the patients reported high sodium levels. Too much sodium causes the loss of calcium through urine, which leads to calcium-based stones (Curhan 836). Likewise, excess of Junk food and carbonated drinks add to metabolic imbalances and chemical alterations in the urine.

Another major finding was the consumption of a lot of oxalate-rich foods (58%). In South Asian diets, foods commonly consumed that have been shown to raise urinary oxalate levels include spinach, nuts, tea, and chocolate. Kennedy and Holmes pass on that high oxalate foods can play an important role in the development of calcium oxalate stones, particularly in people who have low

calcium consumption or who do not drink enough water (271). An increased consumption of oxalates combined with dehydration results in a very favorable environment for crystal aggregation.

Duration of occupational heat exposure was identified as an important risk factor, with 61% of participants reporting long duration of occupational heat exposure. Residents of the outdoors, like traffic workers and laborers, are especially susceptible because of the exposure to high temperatures for long periods of time and the lack of drinking water. Fakheri and Goldfarb point out that it's a direct correlation, with ambient temperature directly proportional to the likelihood of kidney stones, because dehydration resulting from hot weather causes the urine to concentrate and increases the risk of crystal formation (120).

The gender difference noted in the study adds to the global epidemiological trends. The male patients made up 68% of the cases; this could be explained by the differences in the diets, physical activity in outdoor environments and occupational exposure. Other researchers also have found a higher prevalence of kidney stone in males, though this difference is becoming less pronounced in recent years as a result of the change in lifestyles among females (1819).

The 45% recurrence rate is a significant clinical problem. The probability of recurrence was increased in patients who continued to be exposed to risk factors like low hydration and high sodium intake. Worcester and Coe indicate that recurrence is likely to occur if underlying metabolic and lifestyle issues are not corrected after the first treatment (960). This indicates that treatment is not enough without behavioral modification.

Another significant point to note is patients' lack of awareness about preventive health practices. Participants did not know the recommended water intake amounts or how food affects kidney stones. This is consistent with previous studies showing that low health literacy is one of the significant challenges in the prevention of nephrolithiasis in developing countries.

The overall results support the Multifactorial Risk Theory, and indicate that renal calculi formation occurs when multiple factors such as environmental heat, dietary patterns, and hydration come together. Lahore is a good example of how these factors act synergistically in exacerbating the disease burden.

Finally, it has been concluded that renal calculi is a condition which can be prevented in a large percentage of cases. By changing water intake, reducing dietary sodium intake, and taking steps to protect from heat exposure, the incidence and recurrence of heat illness can be significantly reduced in susceptible individuals.

7. Conclusion

The study aimed to examine dietary and environmental risk factors affecting the rising prevalence of renal calculi in patients of Lahore based tertiary care hospitals. The findings highlight that the formation of kidney stone is very likely to be related to modifiable lifestyle and environmental factors and not just physiological factors. The lowest water consumption, highest sodium intake, frequent consumption of foods high in oxalate, carbonated beverage use, and high environmental temperature are the most significant risk factors identified.

The findings of this study corroborate dehydration as the most important factor in the formation of renal calculi. Excessive exposure to heat in the conditions of Lahore causes sweating and decrease in urine output which results in highly concentrated urine and enhances the chances of crystallization. The nephrology literature confirms this, and focuses on hydration status as one of the main preventive factors of stone disease (Borghi et al. 840).

Patterns of food intake also have key roles in the course of the disease. Excess sodium and oxalate in the diet also promotes urinary calcium loss and increases urinary oxalates respectively, which leads to an increased risk of calcium oxalate stone formation. These results align with the results of Curhan's work, which associates sodium and animal protein intake in the diet with a higher risk for kidney stones (836). Also, urban population groups have even more metabolic imbalance due to the increased consumption of processed and fast foods.

Significant contributing factors were identified as environmental exposure (especially occupational heat stress). Those working in outdoor occupations are more susceptible, as they are constantly exposed to dehydration and less access to drinking water. Higher temperatures also have direct correlation with incidence of nephrolithiasis, and this is emphasized by Fakheri and Goldfarb (120).

The study also showed a high number of patients had a recurrence of kidney stones, suggesting that many are still at risk for kidney stones even after treatment. When lifestyle and metabolic risk factors are not controlled, recurrence is very likely, Worcester and Coe write (960). The relationship between the need for a long-term preventive strategy and the short-term clinical intervention alone is highlighted.

To conclude, renal calculi in Lahore is a preventable health issue that can be stopped to a large extent. Hydration awareness, dietary modification and occupational safety measures are all public health interventions that will markedly decrease the incidence and recurrence rate. Making health education more effective and incorporating preventive counselling into clinical settings will play a key role in controlling the menace of kidney stones in Pakistan.

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