DOI: 10.4081/aiua.2024.12022

ORIGINAL PAPER

Occupational hazard in urolithiasis patients in Qatar: A single-center cross-sectional study

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Summary *Background: Urolithiasis is one of the most prevalent urological diseases and is associated with a substantial economic burden. Its prevalence varies according to geographical location. Qatar is a Middle Eastern country located in the Afro-Asian Stone Belt. It has a dry and hot climate, which may predispose individuals working in these environments to form kidney stones (KSs).*

Methods: A population sample of 4204 patients was categorized into five occupational classes. The frequencies and correlations of these occupations with KS formation were calculated.

Results: Among the total cases, 2000 presented with KSs, with the majority being of Asian descent (49%), followed by individuals of Middle Eastern descent (35.1%). Technicians accounted for 35.15% of KS cases followed by clerks (29.2%) and executives (14.6%). Among KS cases, 44% had a single stone, 30% had multiple stones, and 26% had two stones. In comparing both KS and non-KS groups, age, gender, occupation, and race were significantly associated with KS formation (p-value < 0.05), while BMI did not show any significant correlation (p-value > 0.05). Asian males aged 31-40, working as technicians, were significantly more prone to urolithiasis. In comparing age, BMI, and gender with stone characteristics, only age was found significantly associated with stone size (p-value < 0.05). Occupation showed an impact on all studied stone characteristics. Clerks and technicians presented more frequently with stones within the 11-15 mm range, while executives more frequently presented with smaller stones (p-value < 0.001). Stone density was more frequently < 500 HU in workers, technicians and housewives and > 500 HU in executives and clerks (p-value < 0.001).

Conclusions: Our findings revealed an elevated risk of urolithiasis among certain occupational groups, particularly technicians, who frequently work outdoors in high-temperature environments. Alternatively, the sedentary nature of clerical and executive positions can also contribute to the risk of urolithiasis.

KEY WORDS: *Urolithiasis; Occupational risk; Environmental factors; Geographic prevalence; Qatar.*

Submitted 24 October 2023; Accepted 9 January 2024

INTRODUCTION

Urolithiasis is the presence of stones inside the urinary tract. It is one of the most prevalent urological diseases, preceded only by urinary tract infections and prostate diseases (1).

Urolithiasis is a multifaceted condition and doesn't have a specific etiology. Risk factors for the development of *kidney stones* (KSs) are divided into intrinsic and extrinsic factors. Intrinsic factors are age, gender, ethnicity, and genetics. Extrinsic factors are climatic and environmental conditions, dietary habits, and occupation (2-4).

The prevalence of KSs increases with age in both men and women. Men are more susceptible to developing KSs than females, while in children, both sexes have the same probability of KS formation (2, 5). The prevalence of this condition differs across various geographical areas, with an estimated prevalence ranging from 1% to 5% in Asia, 5% to 9% in Europe, and a significantly higher at 13% in North America.

Additionally, it is important to highlight that the likelihood of recurrence for this condition is on the rise, exceeding 50% within a 5- to 10-year timeframe (6).

Occupations that involve dehydration, prolonged exposure to the sun and high temperatures, perspiration, prolonged sitting, and infrequent urination increase the likelihood of KS formation (7-11). The economic burden of KSs is substantial. The USA spent 1.83 billion dollars and 2.1 billion dollars in the years 1995 and 2000, respectively. The estimated cost of stone-related problems could reach 4.1 billion dollars by the year 2030 (12).

Qatar is a Middle Eastern country that is characterized by its dry and subtropical desert climate. It is situated within the Afro-Asian-Stone Belt region, and the workforce composition is marked by the presence of diverse nationalities (13, 14).

This study aims to investigate the role of occupation in urolithiasis in the Qatar population. Additionally, it seeks to examine the correlation of occupation and several intrinsic factors with KS characteristics.

Methods

Study design

This was a retrospective cross-sectional study of 4204 patients who visited Al-Khor Hospital over the past eight years. Specific information such as age, gender, BMI, occupation, race, smoking status, comorbidities, medical history, having KS or not, stone characteristics (in patients with KS), and any previous history of renal surgery (in cases with KS) were collected. The review of the data presented no risks to the subjects involved, as it entailed a comprehensive review of historical medical records without the implementation of any new or invasive measures.

Study population and setting

The study sample comprised medical records of 4204 patients, sourced from pre-existing data within the registry of Al-Khor Hospital, encompassing individuals who have either presented with renal or ureteric stones or visited the hospital for general check-ups over the preceding 8 years. The study population encompassed a diverse spectrum of occupational categories, including clerks, executives, technicians, workers, and housewives. Within this classification, technicians were engineers and skilled laborers who were engaged in tasks related to machinery and technology. Workers represented a broader category encompassing individuals involved in manual labor or strenuous physical activities, spanning various industries including construction, agriculture, and manufacturing. Clerks denoted employees fulfilling various roles within an office setting, while executives were supervisors primarily engaged in meetings and responsible for decision-making processes. The frequencies of these occupations were calculated in both groups of patients with or without KSs and compared against each other.

Inclusion and exclusion criteria

The study included adult patients who were admitted to Al-Khor Hospital with renal or ureteric colic or visited it for routine check-ups between January 1, 2014, and December 31, 2022. Individuals within the pediatric age group were excluded from this study.

Statistical analysis

The acquired data were inputted into the Statistical Package for the Social Sciences (*SPSS, v.25; IBM Corp.*), with optimization of variables for subsequent analysis. Descriptive statistics were then generated, followed by correlation testing, where the Chi-squared (χ^2) test was employed to identify associations among diverse parameters. The significance level was predetermined at $p \leq 0.05$.

Results

Among the total number of individuals included, 2000 presented with KS, with the majority being of Asian descent (49%), followed by individuals of Middle Eastern descent (35.1%). In both KS and non-KS cases, a higher proportion of subjects were male (84.1% and 80.6%, respectively), with male-to-female ratios of 5.3:1 and 4.1:1, respectively. The mean age of KS cases was 36.9 ± 9.1, concentrated in their thirties to forties, while non-KS cases were commonly distributed over thirty years with a mean age of 41.6 ± 13.4. The BMI of KS cases was 28.9 ± 3.6, compared to 29 ± 3.71 in non-KS cases.

Table 1.
The baseline characteristics of the patients.

Patients with KS (No., %)	Patients with no KS (No., %)	Overall (No., %)
Race		
Asian (979, 49.0%)	Asian (1081, 49.1%)	Asian (2060, 49.0%)
Middle Eastern (701, 35.1%)	Middle Eastern (843, 38.2%)	Middle Eastern (1544, 36.7%)
Unknown (184, 9.0%)	Unknown (0, 0.0%)	Unknown (184, 4.4%)
African (132, 6.6%)	African (245, 11.1%)	African (377, 8.9%)
American (3, 0.2%)	American (12, 0.5%)	American (15, 0.4%)
European (1, 0.1%)	European (23, 1.0%)	European (24, 0.6%)
Sex		
Male (1682, 84.1%)	Male (1776, 80.6%)	Male (3458, 82.3%)
Female (318, 15.9%)	Female (428, 19.4%)	Female (746, 17.7%)
Age (yrs.)		
18-23 (0, 0.0%)	18-23 (155, 7.0%)	18-23 (155, 3.7%)
24-30 (488, 24.4%)	24-30 (347, 15.7%)	24-30 (835, 19.9%)
31-40 (851, 42.55%)	31-40 (621, 28.2%)	31-40 (1472, 35.0%)
41-50 (330, 16.5%)	41-50 (557, 25.3%)	41-50 (887, 21.1%)
> 50 (331, 16.55%)	> 50 (524, 23.8%)	> 50 (855, 20.3%)
Mean age ± SD (36.9 ± 9.1)	Mean age ± SD (41.6 ± 13.4)	Mean age ± SD (39.3 ± 11.8)
BMI (kg/m^2) *		
Normal (209, 10.45%)	Normal (242, 11.0%)	Normal (451, 10.7%)
Overweight (1048, 52.4%)	Overweight (1109, 50.3%)	Overweight (2157, 51.3%)
Obese (743, 37.15%)	Obese (853, 38.7%)	Obese (1596, 38.0%)
Mean BMI ± SD (28.9 ± 3.6)	Mean BMI ± SD (29 ± 3.71)	Mean BMI ± SD (29 ± 3.67)
Smoking		
Yes (504, 25.0%)	Yes (327, 14.8%)	Yes (831, 19.8%)
No (1496, 75.0%)	No (1877, 85.2%)	No (3373, 80.2%)
Comorbidity		
None (1952, 97.6%)	None (1752, 79.5%)	None (3704, 88.1%)
Diabetes mellitus (26, 1.3%)	Diabetes mellitus (220, 10%)	Diabetes mellitus (246, 5.9%)
Hypertension (22, 1.1%)	Hypertension (232, 10.5%)	Hypertension (254, 6.0%)
Occupation		
Clerk (584, 29.2%)	Clerk (342, 15.5%)	Clerk (926, 22.0%)
Executive (292, 14.6%)	Executive (302, 13.7%)	Executive (594, 14.1%)
Housewife (87, 4.35%)	Housewife (392, 17.8%)	Housewife (479, 11.4%)
Technicians (703, 35.15%)	Technicians (416, 18.9%)	Technicians (1119, 26.6%)
Worker (334, 16.7%)	Worker (752, 34.1%)	Worker (1086, 25.8%)
Previous renal surgery		
Yes (1154, 57.7%)	-	-
No (846, 42.3%)	-	-
Number of stones		
One (879, 44.0%)	-	-
Two (522, 26.0%)	-	-
Multiple (599, 30.0%)	-	-
Location of stones		
Ureter (330, 16.5%)	-	-
Renal pelvis (512, 25.6%)	-	-
Upper Calyx (303, 15.15%)	-	-
Middle Calyx (411, 20.55%)	-	-
Lower Calyx (444, 22.2%)	-	-
Size of stones		
5-10 mm (551, 27.55%)	-	-
11-15 mm (935, 46.75%)	-	-
16-20 mm (514, 25.7%)	-	-
Laterality		
Right (958, 47.9%)	-	-
Left (1042, 52.1%)	-	-
Density of stones		
< 500 HU (1093, 54.65%)	-	-
> 500 HU (907, 45.35%)	-	-

Regarding occupations, technicians comprised the largest group (26.6%), accounting for 35.15% of KS cases and 18.9% of non-KS cases. They were followed by workers (25.8%), representing 16.7% of KS cases and 34.1% of non-KS cases, and clerks (22%), comprising 29.2% of KS cases and 15.5% of non-KS individuals (Table 1).
More than half of the KS cases (57.7%) had a history of previous renal surgery. Among KS cases, 44% had a single stone, 30% had multiple stones, and 26% had two stones, which were almost evenly distributed in terms of laterality. The most common locations were the renal pelvis (25.6%), lower calyx (22.2%), and middle calyx (20.55%). Stone sizes were commonly distributed between 11-15 mm (46.75%) with a density smaller than 500 HU in 54.65% (Table 1).
In comparing the two groups, age, gender, occupation, and race were significantly distributed in subjects with and without KS (p-value < 0.05), while BMI was not significantly different (p-value > 0.05).

Asian males aged 31-40, working as technicians, were the group significantly more prone to urolithiasis (Table 2).
In comparing age, BMI, and gender with stone characteristics (number, size, density), only stone size was differently distributed by age (p-value < 0.05). The 11-15 mm stone size was the most frequent in all age groups, although in patients between ages 31-40 years, the rate of 11-15 mm stones was higher (49%) than in the other age groups.
All three stone characteristics were significantly correlated with occupation; stones were mostly single in clerks, housewives, technicians, and workers, while in executives, stones were mostly multiple (p-value < 0.001).
The most common stone size among clerks and technicians was within the 11-15 mm range, while executives more frequently presented with smaller stone sizes in comparison to other occupations (p-value < 0.001). Stone density was more frequently < 500 HU in workers, technicians and housewives and > 500 in executives and clerks (p-value < 0.001).

Table 2.
The correlation of age, BMI, gender, and occupation with having KS.

Part. 1

Variables		Age (yrs.)							BMI			
		Total	18-23	24-30	31-40	41-50	> 51	P-value *	Normal	Overweight	Obese	P-value *
Having stone	Yes	2000	0	488	851	330	331	< 0.001	209	1048	743	0.401
	No	2204	155	347	621	557	524		242	1109	853	

Part. 2

Variables		Gender				Occupation						Race						
		Total	Male	Female	P-value*	Clerk	Executive	Housewife	Technician	Worker	P-value *	Total	African	American	Asian	European	Middle eastern	P-value *
Having stone	Yes	2000	1682	318	0.003	584	292	87	703	334	< 0.001	1816	132	3	979	1	701	< 0.001
	No	2204	1776	428		342	302	392	416	752		2204	245	12	1081	23	843	

* *Chi-square test. BMI: body mass index. KS: kidney ston.*

Table 3.
The correlation of age, BMI, gender, and occupation with stone characteristics.

Part. 1

Variables		Age (yrs.)						BMI			
		Total	24-30	31-40	41-50	> 50	P-value*	Normal	Overweight	Obese	P-value *
Stone number	One	879	215	366	147	151	0.867	90	471	318	0.474
	Two	522	124	232	89	77		59	278	185	
	Multiple	599	149	253	94	103		60	299	240	
Stone size	5-10 mm	551	109	249	102	91	0.027	58	304	189	0.55
	11-15 mm	935	250	401	139	145		97	476	362	
	16-20 mm	514	129	201	89	95		54	268	192	
Stone density	< 500 HU	1093	271	466	181	175	0.9	105	588	400	0.255
	> 500 HU	907	217	385	149	156		104	460	343	

Part. 2

Variables		Gender				Occupation					
		Total	Male	Female	P-value *	Clerk	Executive	Housewife	Technician	Worker	P-value *
Stone number	One	879	732	147	0.612	363	38	39	310	129	< 0.001
	Two	522	445	77		107	106	16	199	94	
	Multiple	599	505	94		114	148	32	194	111	
Stone size	5-10 mm	551	459	92	0.642	29	142	36	205	139	< 0.001
	11-15 mm	935	794	141		551	35	21	284	44	
	16-20 mm	514	429	85		4	115	30	214	151	
Stone density	< 500 HU	1093	920	173	0.923	266	56	62	465	244	<0.001
	> 500 HU	907	762	145		318	236	25	238	90	

* *Chi-square test. BMI: body mass index. Yrs: years, HU: Hounsfield units.*

Discussion

In the course of this study, we conducted an assessment of the role of occupation in urolithiasis and examined the correlation of occupation and other several intrinsic factors with KS characteristics in the population of Qatar. In this study, only validated studies were used for discussion (15).
Factors estimated to contribute to the pathogenesis of nephrolithiasis include genetic predisposition, gender, geographic location, dietary habits, insufficient fluid intake, and socioeconomic status (16).
It has been well established that males are more susceptible to nephrolithiasis than females due to exposure to risk factors (16-18).
A review study indicated an elevated prevalence of exposure to occupational hazards among men. These hazards include engaging in repetitive tasks, extended periods of sitting or standing at work, physically demanding labor involving lifting and manual material handling and exposure to occupational ultraviolet radiation from sunlight.
The review found no evidence in any study suggesting that women had a higher susceptibility than men to these specific occupational hazards, most of which are recognized as risk factors for the development of KS (18).
Another study indicated that the increased occurrence and prevalence of KS in men could be attributed to higher rates of obesity and alcohol consumption in men compared to women, leading to heightened production of oxalic acid in men (17).
Urolithiasis predominantly impacts adults in the third to fourth decade of life, with a generally observed male-to-female ratio ranging from 1.5:1 to 2.5:1 (19). Some studies, particularly in the United States, suggested a potential decline in this ratio to below 1.5:1 (20-22). Another study conducted in Morocco reported a male-to-female ratio of 2.03:1, while *Hossain et al.* documented a ratio of 2.68:1 in Japan (19, 23).
In Bouatia's study, the age group most susceptible to KS was between 31 and 60 years old, with a peak incidence observed at the age of 53 (19).
In addition to the intrinsic factors, some studies also mentioned high BMI or obesity as a factor for KS formation (17, 19, 24, 25).
In line with the literature, the findings of our study revealed that males were significantly more affected by nephrolithiasis. This association was attributed to the nature of the patients' work, which often involved exposure to sunlight, high temperatures, or a sedentary work style in the workplace. The male-to-female ratio among our KS cases was 5.3:1, significantly higher than the ratios reported in previous studies.
The mean age of KS cases was 36.9 ± 9.1, consistent with the literature.
While some authors have reported an association between BMI and KS formation, our findings, to the contrary, indicate no significant role of BMI in nephrolithiasis.
In our study, the races most significantly affected by KS were Asian, followed by Middle Eastern and African populations, underscoring the correlation between KS formation and geographical location, as indicated in the literature (16).
In terms of stone composition, most studies reported similar findings. In a renal stone clinic in Southampton, in a population of 2800 patients, the predominant stone composition was calcium oxalate (89%), with a ratio of 1:4 for calcium oxalate to mixed calcium oxalate phosphate stones. Pure calcium phosphate stones were infrequent, accounting for only 2% of cases. In Sweden, approximately 85% of urinary tract stones were classified as calcium stones, encompassing both calcium oxalate and calcium phosphate varieties (26, 27). In another study involving 888 cases, calcium oxalate and calcium phosphate were identified as the most common primary components of the stones (28). In a series of 802 patients with 828 KS, *Bouatia et al.* identified calcium oxalate as the main component, followed by uric acid and calcium phosphate (19).
Unfortunately, due to the nature of the study design, we could not represent any data regarding stone composition in our cases. However, the stone density in 54.65% of our cases was < 500 HU, and according to the literature, stones with < 500 HU were usually uric acid stones. Therefore, we estimate that stones in more than half of our cases were uric acid type (29).
Our findings revealed that the majority of patients at risk of KS formation were the technicians and the clerks. The technicians with KS accounted for 35.15% of our dataset. They may spend a significant amount of time outdoors, often exposed to adverse weather conditions, including high temperatures and direct sunlight. These environmental factors, notably high-temperature environments and prolonged sun exposure, are recognized as significant risk factors in the etiology of urinary stone formation, especially uric acid stones (30). Nevertheless, workers, akin to technicians, are exposed to elevated temperatures and sunlight. However, in this study, their association with KS formation did not reach the same level of significance as observed with technicians.
In 1945, *Pierce et al.* studied the effects of high-temperature exposure as a risk factor for the formation of urolithiasis in American troops in desert areas (31). Later on, multiple studies indicated the association between the incidence of stone and working in ambient temperatures, under the sun, and perspiration (10, 30, 31).
Better et al. studied the increased incidence of nephrolithiasis in lifeguards who are exposed to the sun more than the normal population (10). *Lu et al.* reported an increase in the prevalence of radiolucent stones among workers in a steel factory who were exposed to heat (11).The correlation between urolithiasis and ambient temperature, as well as heat exposure, can be attributed to several factors, including low urine volume with saturation of stone-forming salts in urine due to perspiration (32).
Perspiration also leads to acidic urine with a reduction of uric acid solubility, which also contributes to stone formation (31).
The incidence of urolithiasis peaks in the summer, which further supports the impact of ambient temperatures on stone formation (8).
This assumption aligns perfectly with our region, characterized by a dry and subtropical desert climate.
Another hypothesis for the development of stone in warmer climates is that sunlight leads to higher levels of Vitamin D (32), although it is not concretely supported (33-35).
A substantial portion of our dataset (43.8%) in the KS

group consisted of individuals employed in clerical and executive positions. This notable prevalence can be attributed to a myriad of factors. Executive professionals occupied pivotal roles within our dataset, characterized by their accountability for formulating high-level decisions and overseeing the management of organizations or departments. Their responsibilities encompassed strategic planning, leadership, and frequent engagement in meetings and office-based activities. Clerical personnel within our dataset primarily performed administrative functions such as data entry, record-keeping, and meticulous management of paperwork. They often worked indoors with executives. Staying indoors and the sedentary features of these occupations have the potential to place individuals in a vulnerable position regarding the development of metabolic syndrome, elevated BMI, and infrequent urination. Consequently, it is plausible to assert that such occupational pursuits may indirectly elevate the susceptibility of individuals to urolithiasis (8). Infrequent urination due to prolonged working hours and low urine volume are other occupational risks for the development of urolithiasis. Individuals in various professions such as taxi drivers, aviation personnel, teachers, and healthcare workers are at risk due to these factors (7, 8, 36).

On the other hand, the potential for urolithiasis development in factory workers is exacerbated by occupational exposure to metallic substances. *Jarup et al.* documented an increased prevalence of KSs in individuals exposed to Cadmium (37). Additionally, Liu and colleagues identified an association between KSs and the presence of heavy metals such as Arsenic and Cadmium, while Chromium, Mercury, and Lead did not manifest discernible associations with this condition (4).

In the present study, we were unable to explore any relationships between metallic substances and KS formation due to the absence of data regarding the extent of exposure among cases or workers.

Finally, there is insufficient knowledge on the correlation of stone characteristics with intrinsic and extrinsic factors for stone formation.

A study by *Krambeck et al.* reported no significant difference in stone size and location in relation to age. Nonetheless, older individuals were more likely to have stones with a larger diameter or staghorn calculi (28). A meta-analysis of 15 studies involving 13.233 patients found no significant correlation between BMI and stone size (25).

In the present study, all stone characteristics, including number, size, and density, were found to be significantly correlated only with occupation, whereas stone size showed a correlation with age. In contrast to the study by *Krambeck et al.*, the stone size of 11-15 mm was the most frequent in all age groups, particularly in patients aged 31-40 years; no evidence suggested that older patients had larger stone sizes. Furthermore, consistent with the meta-analysis by *Wang et al.*, BMI did not exhibit a significant impact on stone size.

Our study had several limitations. The primary constraints included the retrospective nature of the work, which may have omitted certain data that could directly or indirectly influence the results. Specifically, information about alcohol consumption status, urination volume, daily water intake, and the presence of kidney diseases or other diseases that could enhance KS formation may not have been adequately captured.

Conclusions

This study has provided insights into different working activities that may increase the risk of urinary stone formation in the Qatari population. Our findings suggested an elevated risk of urolithiasis among certain occupational groups, particularly technicians, who frequently work outdoors in high-temperature environments. Similarly, the sedentary nature of clerical and executive positions, characterized by prolonged indoor working hours can also indirectly contribute to the risk of urolithiasis. Implementing proactive measures and awareness plans targeted at these at-risk groups may significantly contribute to reducing the incidence of urolithiasis among the workforce.

Declarations

- ***Ethical approval***: This study does not involve any human or animal testing.
- ***Availability of data and material***: All data and materials are kept by the first and corresponding authors.
- ***Competing interests***: None.
- ***Funding***: No source to be stated.
- ***Authors' contributions***: *Kamran Hassan Bhatti, Rawa Bapir*, and *Nadeem Sohail* were major contributors to the study. *Hiwa O. Abdullah, Faaz Salah Gomha, Ahmed H.A. Shaat, Aftab Ahmed Channa, Nali H. Hama, Khalid Mohammed Abdelrahman*, and *Bryar Othman Muhammed* were involved in the literature review, the writing of the manuscript, and data analysis and interpretation. *Fahmi H. Kakamad, Berun A. Abdalla*, and *Jihad Ibrahim Hama* were involved in the design of the study, and the critical revision of the manuscript. All authors have read and approved the final manuscript.
- ***Acknowledgments***: None to be declared.

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Conflict of interest: The authors declare no potential conflict of interest.