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Prevalence of Urolithiasis in Adults due to Environmental Influences: A Case Study from Northern and Central Jordan

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Abstract

The Urinary stone disease, known as urolithiasis, is one of the most prevalent health problems around the world. It is considered as one of the most serious disease in humans in terms of continuity, repetitions, and symptoms. This study aims to determine the prevalence of urolithiasis , the incidences, and the risk factors of this disease among the population of northern Jordan. Moreover, it studies the effects of environmental, geographical, and biological factors that contribute to the occurrence of urolithiasis. More than 250 samples of urinary stones were collected from five hospitals in Jordan over the course of five years. They were used to assess the logistical and polynomial regression for each potential risk factor in order to determine the prevalence of urolithiasis through the demographic features. The processing of the climatic, geographic, and geochemical data revealed that there is a relationship between the environmental factors and the urolithiasis prevalence. Strong relationships were observed between the prevalence of urinary stones and the population distribution, gender, and age of the individuals in the study area. The local climatic condition is characterized by high temperatures in summer, excessive exposure to sunlight, and semiarid to arid conditions as well as a high concentration of bicarbonates and fluoride in water. These factors were observed to affect human health by their contribution to the formation and growth of urinary stones. It was noted that the urolithiasis disease prevails increasingly at the age >40 years and is found more significant in males than in females. This study investigates the impact of environmental factors on the formation and composition of stones through diet in addition of the effect of water hardness on the formation of oxalate stones which optimize their impact in bicarbonate concentration >300 gm/L. Moreover, geographical factors play a big role in the formation, prevalence, and composition of urinary stones. As will be observed in this study, the factors contributing to the high rate of the disease and its prevalence in regions with high temperature >20 ºC, feature increased exposure to sunlight, altitude >500 m, and soil of the Vertisols type.

Keywords: Urinary calculi, Urolithiasis, Environmental effects, Epidemiology, Jordan.

1. Introduction

The Urinary stone disease (urolithiasis) is one of the most prevalent medical problems occurring worldwide (Abboud, 2008a; Abboud, 2008b; Abboud, 2008c; Scales et al., 2012; Giannossi and Summa, 2013). Identifying the mineral composition of urinary stones helps in elucidating the impact of geo-environmental factors (Tasian et al., 2014; Fukuhara et al., 2016) and the nutrition behavior on the formation and growth of urinary stones (Alsheyab et al., 2007; Abboud, 2008a; Marickar and Vijay, 2009; Robertson, 2012).

Geological characteristics and climatic features seem to play an important role in the development of urolithiasis, its prevalence, recurrence, and the stone type (Basiri et al., 2010). Several environmental and geographical factors, such as temperature, height above mean sea level, daily and seasonal climate variability are known to have a direct or indirect impact on human health (Safarinejad, 2007; Tasian et al., 2014). Moreover, poor water quality due to the geological factors and/or anthropogenic pollutants is frequently concomitant with health problems (Abboud, 2014). These hazards may range from simple threats to harmful risks that may lead to the loss of life or damage in certain organs as is the case in the kidney stones which may lead to disruption in the daily work of the kidneys, among many other effects on human health.

In addition, the nutrition and lifestyle of many individuals may be a direct cause of the emergence of many hazards and diseases associated with the environmental, geographical, and geological factors (Marickar and Vijay, 2009), which make certain nutrients react with certain genetic factors in individuals thereby stimulating the emergence of some of these genetic diseases in some people. Scales et al. (2012) concluded in their study conducted on some population in the USA that diet and lifestyle are two of the most important factors that play an important role in the pathogenesis of kidney stones. However one can never rule out the impact of environmental and geographical factors on the prevalence of many diseases in some hot geographic regions in which people are totally dependent on aquifers (Chandrajith et al., 2006; Abboud, 2017).

The risk assessment of the environmental and geographical factors and their impact on human health are important to arrive at through disease maps that show where these diseases are prevalent and explore patterns and changes and their relationship with the environmental and geographical factors. The assessment of environmental and geographical health risks are part of the environmental epidemiology which plays

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an important role in the effectiveness of the environmental remediation programs (Nielsen and Jensen, 2005). In order to determine the consequences of the urinary stone disease at the level of the population and community, and to identify its risk factors on individuals and the possibility of the recurrence of the disease in many people, it is necessary to understand the epidemiology of the urinary stone disease accurately.

There are quite a number of epidemiological studies of urolithiasis conducted in several countries around the world, including Middle Eastern countries with the exception of Jordan. The current study is though to be be the first epidemiological study on urolithiasis in Jordan. The aim of this study is to highlight the environmental epidemiology in the Mediterranean region especially in Jordan. Moreover, it also aims at identifying the most pivotal factors that play an important role in the prevalence of environmental health risks in the region. Hopefully, this study will try to identify the main environmental and geographical factors that play an essential role in the prevalence of the urinary stone disease in Jordan and will provide and display additional information on this disease and how to prevent it and rehabilitate the infected population.

2. Materials and Methods

2.1. Urinary Stone Data

Over a five-year span (from 2007 to 2012) more than 250 samples of urinary stones extracted surgically from patients with urolithiasis were collected at five hospitals. (Namely: The Hussein Medical City, Hospital of Princess Basma, Al-Eman Hospital, Al-Mafraq Governmental Hospital, and Jerash Governmental Hospital) to study and determine the temporal changes in urolithiasis and link these factors to the gender and age groups of the infected individuals. The method of logistical and polynomial regression for each potential risk factor was used in order to assess the prevalence of urolithiasis through the demographic features. This method resulted from odds ratios (ORs), P-values, and 95 % of the members of a particular social group will submit a urolithiasis report for the reference group in the same region. This pattern of the variables which related a univariate association with urolithiasis through the p-value ($P < 0.05$) is statistically significant.

The urinary stone samples extracted from the patients were washed in H_2O_2 to get rid of any organic matter stuck on the outer surface and were dried for a month at the laboratory temperature for photographing. Visual observations of the urinary stone samples extracted from patients were listed; they include: size, color, shape, topography, and surface features. To determine the mineralogical composition of urinary stone samples , some samples were ground in an agate mortar to study the powder by X-ray diffraction (XRD: Philips type with X-Pert Pro XRD systems) at Al al-Bayt University labs.

2.2. Epidemiological Data

All epidemiological data in this study were collected from hospitals of the Jordanian Ministry of Health (JMH) for patients from northern and central Jordan. This study included residents of the territory of the governorates of Amman, Irbid, Mafraq, Ajloun, and Jerash. The current total population of Jordan amounted to 9.5 million people including 2.9 million inhabitants being non-Jordanians (DS, 2015; Ghazal, 2016). The population is distributed in the study area as follows: more than four million people or (42.05 %) live in Amman, 1,770,158 (18.8 %) in Irbid, 549,948 (5.8 %) in Mafraq, 237,059 (2.5 %) in Jerash and 176,080 (1.9 %) in Ajloun province (DS, 2015). These numbers equal 6,739,771 (70.6 %) people out of 9.2 total population of Jordan. Figure 1 shows the distribution of the population in the five governorates of Jordan, and the prevalence rate of the disease in these regions between the years 2007 and 2012. It also shows patients who were admitted to hospitals because they suffer from the urinary stone disease, whether from these provinces or from outside. Generally speaking, about 68 % of the Jordanian people have health insurance (DS, 2015). Therefore, in order to estimate the prevalence of the urinary stone disease and calculate the numbers of people infected accurately, all cases that were checked in to the hospitals in all provinces, were followed up. Also the archival records in the emergency rooms, or at the specialty physicians clinics were alos checked. A total of 525 questionnaires were distributed to urolithiasis patients, of which 285 were answered. The questionnaires included more than fifty questions covering the entire condition of the patient; marital status, the overall physical health, nutrition, and the disease recurrence; in addition to questions that may have a direct or indirect relationship with the prevalence of the urinary stone disease in humans.

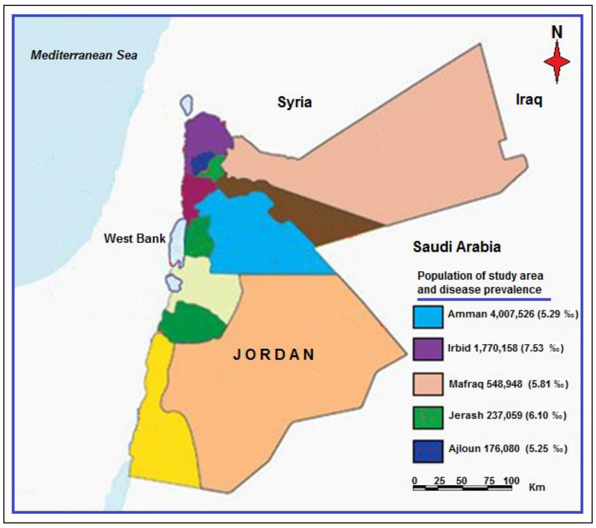

Figure 1. Distribution of population on five governorates of Jordan, and distribution of the specific prevalence rate of disease between 2007 and 2012

All these steps have been taken in order to attempt to verify the numbers of the infected patients and their conditions very accurately and to arrive at a correct diagnosis of the disease on a scientific basis and not by default, and in the end be able to suggest adequate health care by avoiding a wrong diagnosis of the disease usually provided only through some visible symptoms or the medical history without doing the necessary examinations Cases with kidney disease or the gallstone disease were separated from the cases of urolithiasis in order to arrive at an accurate distribution and certain prevalence of the disease. Finally, the personal data obtained from the patients were classified into the specified tables according to address, age, sex, social case, medical history, and diet, in order to compare the population infected with urinary stone disease with the total population and classify them based on their age and gender.

The data of the urinary stone disease patients were obtained from different hospitals and were processed through standard statistical methods and programs (Mendenhall, 1967), namely the Program of Epidemiological Statistics for Public Health (OPENEPI), version 2.2.1, and the easy-to-use-statistical software, MedCalc Program, version 16.8.4.

2.3. Climate, Water, and Soil Data

The major bulk of information on the annual and cumulative climate conditions such as temperature (Fig. 2), precipitation (Fig. 3), altitude (Fig. 4), sunlight, and the intensity of the brightness was obtained from the Jordan Meteorological Department (JMD) between 1999 and 2016 (Weather online, 2016).

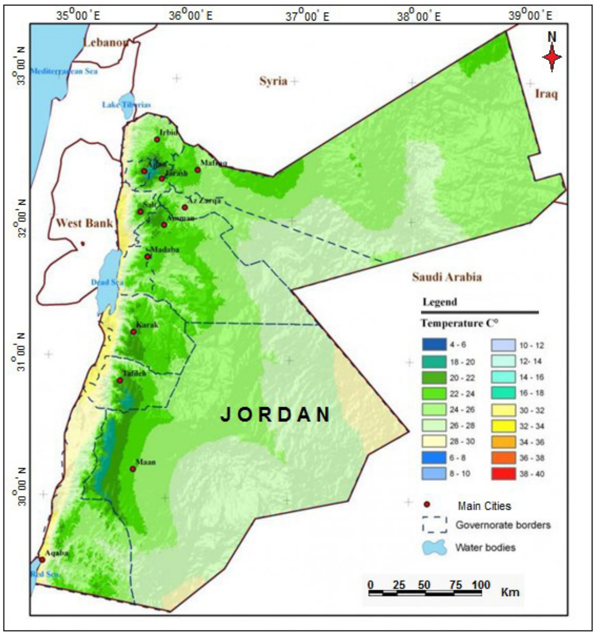

Figure 2. Mean annual maximum temperatures of study area between 1973 and 2012 (Map source: Jordan climate maps (Current climate) (2016). Map prepared by NCARE. Author: M. Saba; E. De Pauw; W. Goebel. Map source: http://www.icarda.org/jordan-climate-maps-current-climate)

It is found that the population in the study area use groundwater for drinking and other domestic uses. To determine the chemical composition of the groundwater in the study area 130 samples from all the provinces were analyzed (Abboud, 2017). Accordingly, ionic data to estimate the relationship between urolithiasis and the groundwater hardness was used in the study area. In order to determine the total hardness (TH) of the groundwater samples the contents of calcium, magnesium, and bicarbonate (Abboud, 2014; Abboud, 2017), were measured and expressed in units of milligrams per liter (mg/L). The classification of groundwater hardness was as follows: soft water (TH <75 mg/L), moderately hard water (75-150 mg/L), hard water (150-300 mg/L), and very hard water (>300 mg/L).

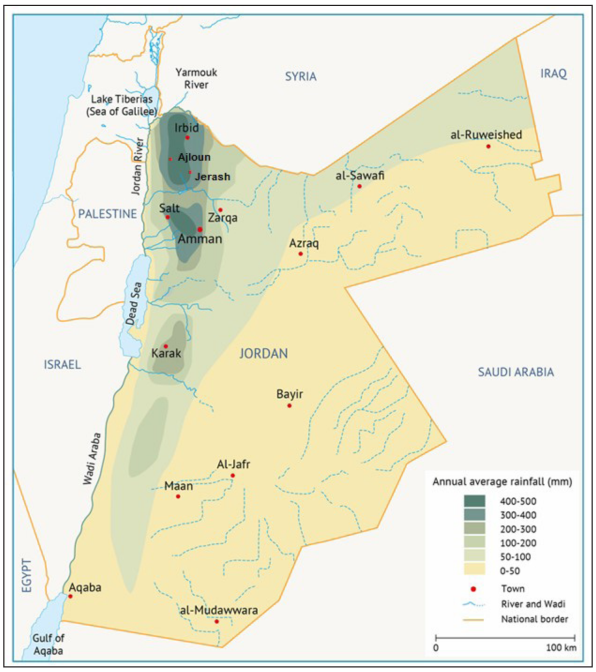

Figure 3. Distribution of the annual average rainfall (mm) in the study area between 1973 and 2012 (Map source: Annual average rainfall (mm) between 1973 and 2012 (2012). See link: https://water.fanack.com/wp-content/uploads/sites/2/2015/11/Jordan-Geography-and-Climate-Figure-5-Annual-average-rainfall-and-precipitation-Fanack-after-MWI.gif)

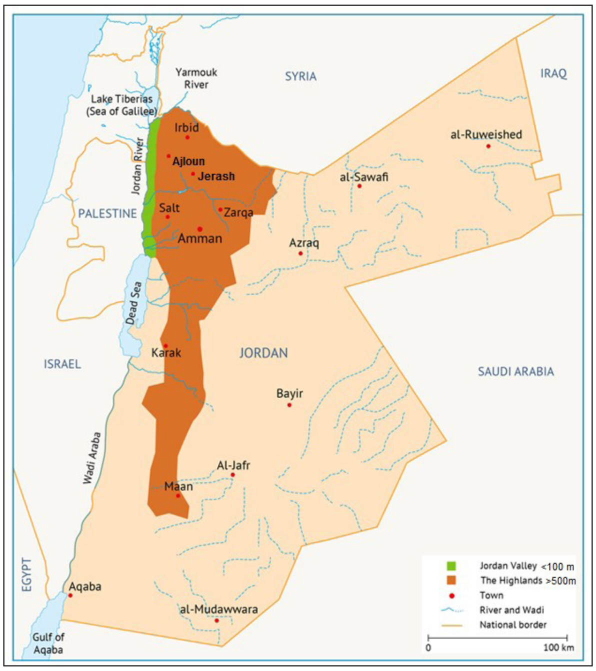

Figure 4. Mean altitude regions of study area (Map source: Fanack after Altz-Stamm, A., 2012. https://water.fanack.com/jordan/water-use/
https://water.fanack.com/wp-content/uploads/sites/2/2015/11/Jordan-Water-Use-Figure-13-Jordan%E2%80%99s-main-agricultural-regions-Fanack-after-Altz-Stamm-2012.gif

The types of soil in the study area have been identified depending on JOSCIS (2012). They are classified into macroscale, according to the the difference in their physical and chemical properties, (Fig. 5). So on the basis of the differences in the geology and lithology of study area rocks (Fig. 6), soil is classified into seven different classes (JOSCIS, 2012).

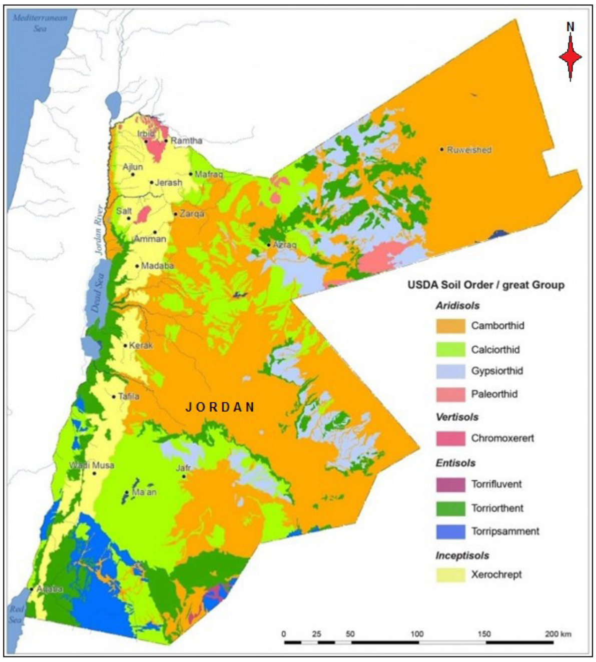

Figure 5. The main pedological regions of study area (Source: JOSCIS Database (2012). Conception: B. Lucke; A. Taimeh; F. Ziadat.. (Map source: Al-Hadidi M. M., Al-Kharabsheh A. A., Ta'any R. A. Impact of Over-Pumping on the Groundwater Quality of the Dead Sea Basin/ Jordan. Curr World Environ 2013; 8(3). doi : http://dx.doi.org/10.12944/CWE.8.3.04)

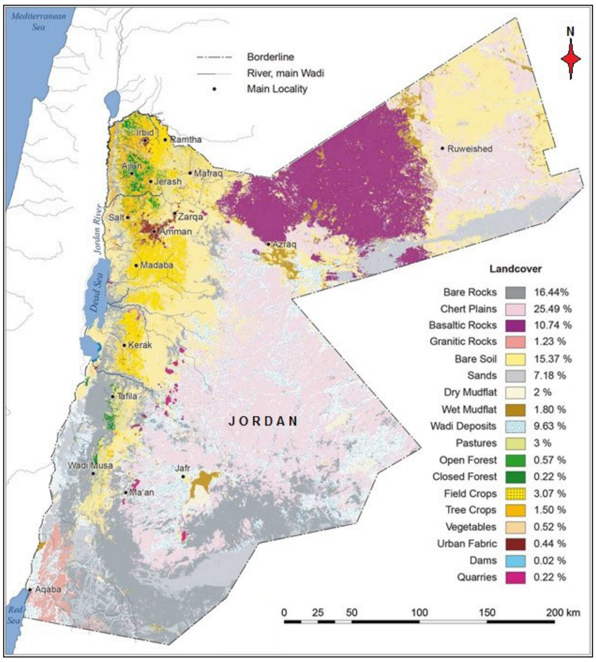

Figure 6. Geologically; the rocks distribution of Jordan land cover (Source: RJGC (2006). land cover map 1/250 000, 2006 and Conception and design: RJGC and M. Ababsa, IFPO 2010). See this link: http://books.openedition.org/ifpo/docannexe/image/4858/img-1.jpg and see; Myriam Ababsa (2014). Jordan's Land Cover. P.485. Chapter: A Land of Contrasts. p. 40-41. Éditeur: Presses de l'Ifpo. ISBN: 9782351593783, ISBN Multi-formats: 978-2-35159-438-4

3. Results and Discussions

Several medical and scientific studies have suggested that the epidemiological analysis research is very significant in order to identify the geoenvironmental factors that cause diseases and be able to control them. The processing of the climatic, geographic, and geochemical data of the study area revealed that there is a relation between the environmental factors and the epidemiology of urolithiasis. In other words, strong relationships were observed between the prevalence of the urinary stone disease and the public distribution, gender, and age of the infected individuals.

Climatic and geographical changes play an important role in the prevalence of urinary stone disease in hot and dry climates (Chen et al., 2000; Al-Eisa et al., 2002; Lee et al., 2002; Hesse et al., 2003; Komatina, 2004; Robertson, 2012; Giannossi and Summa, 2013; Tasian et al., 2014). The local environment in the study area is characterized by high temperatures in summer (30-38 ºC), excessive exposure to sunlight, semiarid to arid conditions (Jordan climate maps, 2016) as well as high concentration of bicarbonates and fluoride in the water of the study area (Abboud, 2014; Abboud, 2017). These factors were observed to affect the human health negatively by helping in the formation and growth of urinary stones and therefore increasing the number of infected cases (Tables 1 and 2). However, such effects were age dependent (>40 years) and were more evident in males than in females (61.03 %; Tables 1, 2). This finding was somehow reflected by Alsheyab et al. study (2007) where the incidence ratio was of 74.9 % in males and the most vulnerable ages were found to be between 30-50 years. Safarinejad (2007) found that the urolithiasis incidence in males was of (6.1 %) which is slightly higher than that in females (5.3%) and that it increases with age. In Abboud (2008c), the incidence of urolithiasis in males was (51.1 %) with the average age being 50 years and (44.3 %) in feamles. Basiri et al. (2010) showed a peak in the incidence of urolithiasis of (58 %) in males ranging in age between 55 and 65 years. Moreover, the prevalence of calculi stone among the Jordanian population is often similar to the global average. Accordingly urolithiasis in Jordan can be described as a prevalent local problem as is the case on a global scale.

As far as diet is concerened, eating green leaves, vegetables, red meat, chicken meat, and eggs all help to increase the concentration of Ca in the human body, which in turn helps in the formation of urinary stones. In addition, some kinds of vegetables, cheese, eggs, and milk increase the concentration of phosphorus in the human body which also contributes to the formation of urinary stones. Therefore, the nutritional factors, especially the non-medical diet system, play an important role in the formation of urinary stones through the lack of dietary fibers, the increased intake of animal protein and calcium (Robertson et al., 1979; Breslau et al., 1988; Holmes et al., 2001; Robertson, 2012), and the increased intake of green leaves and coffee (Abboud, 2008c). The results of the present study demonstrate that the impact of nutritional factors on the formation of urinary stones is age and gender specific. Whereas, these variables were more evident and influential in ages above forty, and were more prevalent in males than in females, 61.03 % (Tables 1 and 2).

Table 1. Urolithiasis prevalence in study area between 2007 and 2012 (Prevalence n and % calculated per year)

Region	Gender	**Population *n***		Population %		**Prevalence *n***		Prevalence %	Prevalence ‰	
Amman	Male	2,059,868	4,007,526	51.4	59.45	12,685	21,213	59.8	6.16	5.29
	Female	1,947,658		48.6		8,528		40.2	4.38	
Irbid	Male	911,631	1,770,158	51.5	26.25	8,165	13,320	61.3	8.96	7.53
	Female	858,527		48.5		5,155		38.7	6.01	
Mafraq	Male	301,921	548,948	55	8.2	2,107	3,188	66.1	6.98	5.81
	Female	247,027		45		1,081		33.9	4.38	
Jerash	Male	122,678	237,059	51.75	3.5	919	1,447	63.5	7.49	6.10
	Female	114,381		48.25		528		36.5	4.62	
Ajloun	Male	91,562	176,080	52	2.6	592	924	64.1	6.47	5.25
	Female	84,518		48		332		35.9	3.93	
Total	Male	3,487,660	6,739,771	51.75	100	24,468	40,092	61.03	7.02	5.95
	Female	3,252,111		48.25		15,624		38.97	4.81	

Table 2. Prevalence of urinary stones for 1,000 inhabitants: age and gender difference

Age	Study area (Amman, Irbid, Mafraq, Jerash, and Ajloun regions)									
	Gender	**Population *n***		Population %	**Prevalence *n***		Prevalence %		Prevalence ‰	
< 20	Male	1,579,758	3,065,334	23.4	1,744	2,847	4.35	0.093	1.104	0.93
	Female	1,485,576		22.0	1,103		2.75		0.74	
20-39	Male	1,129,679	2,175,389	16.8	7,165	12,589	17.87	0.579	6. 34	5.79
	Female	1,045,710		15.4	5,424		13.53		5.19	
40-50	Male	390,008	729,794	5.8	7,060	12,510	17.61	1.577	18.1	15.77
	Female	339,786		5.1	4,450		11.1		13.1	
51-60	Male	208,901	402,926	3.1	5,332	8,660	13.3	2.149	25.52	21.49
	Female	194,025		2.9	3,328		8.3		17.15	
> 60	Male	179,314	366,328	2.7	3,167	4,486	7.9	1.225	17.66	12.25
	Female	187,014		2.8	1,319		3.29		7.05	
Total	Male	3,487,660	6,739,771	51.75	24,468	40,092	61.03	0.595	7.02	5.95
	Female	3,252,111		48.25	15,624		38.97		4.81	

Table 1 shows that 40,092 people of the total population (6,739,771 people) in the study area suffer from the urinary stone disease, with the lifetime prevalence of urolithiasis being of 5.95 ‰ (Table 2). Moreover, most of the patients were males (24,468 (61.03 %) and/or older than forty years (Table 2). The prevalence and appearance of urinary stone disease increases with age.

The prevalence of the urinary stone disease in the average age of the residents of the study area was 5.95 ‰ with an average prevalence of 7.02 ‰ in male; which is higher than that in females (4.81 ‰, Table 2). These results are found to be in accordance with previous studies, and show that the relative risk of urinary stone disease in males is 1.46 times of the relative risk for females. They also reveal that the possibility of the formation and growth of lithiasis in males (being 45 %) is greater than that in females. This finding reflects other results in international studies such as Giannossi and Summa (2013) (1.2), Serio and Fraioli (1999) (1.25), Borghi et al. (1990) (1.5), and Basiri et al. (2010) (1.38) with a 58 % possibility in males.

On the whole the frequency_of urinary stone formation was observed more in males than in females as appeared from the field survey which lasted more than five years in the study area . The overall rate of the infection with the disease reached 5.95 ‰ with 7.02 ‰ of the cases occurring in males and 4.81 ‰ of them in female (Table 2). The data presented in Table 2 show that the lower prevalence of urinary stone disease was observed in the ages <20 years at a rate of 0.93 ‰, while the highest proportion of prevalence was noticed in the age group between 51-60 years with a rate of 21.49 ‰. It was also noted that the rate of prevalence of the disease in males is much higher than that in female ranging from 1.32 times in the ages between 20-39 years to 2.40 times in the age >60 years. These rates are considered high for a population that is characterized by a roughly equal number of males and females in all age groups: (1:1) ratio (Table 2).

It can be inferred that the urinary stone disease is scarce in children or adolescents under the age of twenty years, where the prevalence rate ranged from 0.74 ‰ in females to 1.104 ‰ in the males. This result is inconsistent with findings in several international studies, including Borghi et al. (1990) and Vahlensieck et al. (1982) where the prevalence of the disease among children ranging between 2 ‰ to 2.7 ‰ and in Giannossi and Summa (2013) where it was 1.2 ‰.

Tables 3 to 7 show the odds ratios acquired through the gathering and the prospect as a p-value, which signalizes how possible it is that the gathering visible is sufficient to opportunity. Tables 3 and 4 show a positive correlation between the risk factors and the disease, which become high when combined with many parameters such as age and sex. So these Tables show high and multi declines significant in all the cases that have been assembled, without any chance found or observed in the composition of the stones, leaving it to chance.

Table 3. Relation between potential risk factor of age group and urolithiasis

Risk factors of age group	Total no.	No. of cases	Odds ratio	95% confidence interval (CI)	Significance level (*p* value)
40 - > 60	1,499,048	24,656	19.9324	0.8119	0.0669
51- > 60	769,254	13,146	19.1714	0.7809	0.0705
> 60	366,328	4,486	26.8838	1.095	0.0438

Table 4. Relation between potential risk factor of Age group + Gender and urolithiasis

Risk factors of age group + gender	Total no.	No. of cases	Odds ratio	95% confidence interval (CI)	Significance level (*p* value)
40 - > 60 + male	778,223	15,559	16.3387	0.6655	0.0871
40 - > 60 + female	720,825	9,097	26.0778	1.0622	0.0458
51- > 60 + male	388,215	8,499	14.8917	0.6066	0.0982
51- > 60 + female	381,039	4,647	26.9961	1.0995	0.0436
> 60 + male	179,314	3,167	18.5370	0.755	0.0738
> 60 + female	187,014	1,319	46.9106	1.91	0.0185

Table 5. Relation between potential risk factor of Mean annual temperature (º C) and urolithiasis

Risk factors of mean annual temperature (º C)	Total no.	No. of cases	Odds ratio	95% confidence interval (CI)	Significance level (*p* value)
20 - 24 ºC	1,361,811	23,699	18.8205	0.7666	0.0723
20 - 24 ºC + male	708,008	14,927	15.4766	0.6304	0.0935
20 - 24 ºC + female	653,803	8,772	24.5096	0.9983	0.0501
20 - 24 ºC + 40 – 60 age	1,040,462	18,538	18.3748	0.7485	0.0747
20 - 24 ºC + 40 - 60 + male	550,922	11,419	15.7480	0.6415	0.0914
20 - 24 ºC + 40 - 60 + female	489,540	7,119	22.5869	0.92	0.0563

Table 6. Relation between potential risk factor of High altitude (m.a.s.l.) and urolithiasis

Risk factors of high altitude (m.a.s.l.)	Total no.	No. of cases	Odds ratio	95% confidence interval (CI)	Significance level (*p* value)
550 – 1200	1,167,143	19,197	19.9322	0.8119	0.0669
550 – 1200 + male	606,972	12,128	16.4874	0.6716	0.0861
550 – 1200 + female	560,171	7,069	10.5195	0.4285	0.1496
550 – 1200 + 40 - 60	838,605	15,358	17.8674	0.7278	0.0775
550 – 1200 + 40 - 60 + male	433,847	9,599	14.7316	0.6001	0.0995
550 – 1200 + 40 - 60 + female	404,758	5,759	23.0923	0.9406	0.0545

Table 7. Relation between potential risk factor of Water hardness (mg/L) and urolithiasis

Risk factors of water hardness (mg/L)	Total no.	No. of cases	Odds ratio	95% confidence interval (CI)	Significance level (*p* value)
150 – 300	827,474	13,610	19.9323	0.8119	0.0669
>300	646,089	10,626	20.6403	0.8407	0.0638
>300 + male	1,503,181	6,706	74.3794	3.0296	0.0083
>300 + female	1,401,659	3,921	118.8099	4.839	0.0034
>300 + 40 - 60	488,202	8,693	18.3857	0.7489	0.0746
>300 + 40 - 60 + male	258,129	5,341	15.7751	0.6425	0.0912
>300 + 40 - 60 + female	230,072	3,352	22.5424	0.9181	0.0564

Five governorates in northern Jordan were surveyed in order to determine the average rate of the entry of urinary stone disease in government hospitals (Fig. 1). The combination of the medical and scientific standards in collecting the samples determined the methodology of the study. It was observed that the governorate of Irbid exhibited the highest prevalence of the disease (7.53 ‰) followed by Jerash (6.10 ‰) and then Ajloun (5.25 ‰) (Table 1). Moreover, the prevalence of the disease was noted more in males than in females in all the provinces. It is also found significantly higher than the proportion of the regional prevalence of the disease, being 5.95 ‰ (Table 1). The provinces of the far north, especially Irbid and Jerash exhibited the highest rates of the sickness altitude (Fig. 1). The main reason behind the higher incidence of the urolithiasis disease among the population of the Irbid governorate than other places was water hardness.

There was no direct impact of the population number on the increase or decrease of the prevalence of the urinary stone disease. However there was a significant impact of age on the incidence of disease, especially in males (Table 2). The biggest prevalence of the disease was in the age group 20-39 years at 31.4 % followed by the age group 40-50 years 28.71 % and finally the age group 51-60 years at 21.6 %. The explanation of such an increase and distribution among the age groups is that the formation of urinary stones in humans takes a long period of time for the stones to reach the complete size and begin to affect the human health. Therefore, the emergence of the disease occurs in the later stages of life. In addition, the lifestyle of males in small towns may also help in the growth of urinary stones with the rate being higher than the urban regions.

The population of the study area was split into three geographic regions based on differences in geological, environmental, and climatic characteristics. The first zone consisted of the Amman, Irbid, and Jerash Governorates; the second zone included the Ajloun Governorate, and third zone included the (Mafraq Governorate. It was found that there is a significant correlation between the prevalence of the urolithiasis disease and the differences in some geographical, geological, environmental, and climatic features. The highest prevalence rate of the urolithiasis disease was in the first zone, followed by the third zone. The lowest prevalence rate was in the second zone (Table 1). The most important geological, environmental, and climatic differences that have affected the different proportions of the urolithiasis disease in the study area were summarized on the basis of the rock type (Fig. 6), soil type (Fig. 5), water hardness, the difference in temperatures (Fig. 2), the difference of annual rain ratio (Fig. 3), altitude (Fig. 4), the proportion of solar radiation, and the lifestyle of the population.

Based on the results of the utilization of X-ray diffraction (XRD) and the scanning electron microscope (SEM) on the samples collected for this study and on the basis of the results of the previous studies of Abboud (2008a, 2008b), 60 % of urinary stones composed of oxalates and are distributed in the following proportions: 26.7 % of pure calcium oxalate, 10 % of oxalate/cholesten, 10 % of oxalate/uric acid, 10 % of oxalate/cholesten/uric acid, and 3.3 % of oxalate/cholesten/cystine. Moreover, 13.3 % of the stones were cholesten stones, 23.4 % were cholesten/urate (uric acid) stones, and 3.3 % were cholesten/cystine stones. It was observed that the urinary stones that were extracted surgically from the male and female patients in the study area are of nine different groups.

The ratio of uric acid stones were more prevalent in males than in females. The reason for the abundance of these stones in males is the presence of a strong acid environment, which is a critical risk factor causing the crystallization of uric acid stones and turning them into precipitated crystals of various forms in the urinary liquid (Ferrari and Bonny, 2004). Struvite stones were more prevalent in females. In this context, Giannossi and Summa (2013) ascribed the presence of this type of stones to the medical history of the family. Then, the whewellite and weddellite stones prevailed semi-symmetrically or about equally in males and females. According to Giannossi and Summa (2013) cystine stone formation is caused primarily by the hyper cystinuria and is a genetic factor. Moreover, calcium oxalate stones may be produced directly from the body (Giannossi and Summa, 2013), or are diet-related (Abboud, 2008c) or hyperoxaluria-related (Brinkley et al., 1990; De Mendonca et al., 2003). The high temperature stimulates an increased urinary excretion of calcium, which causes the supersaturation of calcium oxalate and calcium phosphate increasing the probability of the risk of urinary stone formation (Marston et al., 1992). All the above –mentioned factors which help in the formation of urinary stones are linked strongly to the dietary habits and lifestyle of the people in addition to the water type and water consumption (< 2 L/d).

Another factor that affects the stone type is the age of patient. Uric acid stones were more evident in people older than fifty years of age, while calcium oxalate stones were prevalent in people aged between 30-50 years. In order to further understand the prevalence mechanisms of the urinary stone disease in the study area and link this distribution with the stone type and place, the surroundings of patients and their place of birth were considered. A concentration of urinary stones prevalence of oxalates was observed in the first zone, while uric acid stones were found to be more prevalent in the third zone.

To determine the most significant environmental risk factors that cause the formation of urinary stones in humans, it is necessary to evaluate the effect of annual average temperatures as it is of great significance. The annual average temperatures in Amman, Irbid, and Jerash range between 20-24 ºC. In the Ajloun region they range between 18-22 ºC, and in the Mafraq region they fall between 22-28 ºC.

Despite the possibility that there might be some climate variations in the region, whether seasonal or annual, the study attempted to determine the average annual temperatures in the study area, On this basis the study attempted to correlate the prevalence of urolithiasis and the temperature. The final results show that the high temperature in summer induces a rise in the dehydration levels in the human body, which helps in the formation of urinary stones. Al-Eisa et al. (2002) proved a strong correlation between the prevalence of urinary calculi in Kuwait and the high temperature. Brikowski et al. (2008) pointed out that generally speaking the increased temperature means an increase in the likelihood of the incidence of the nephrolithiasis risk. Boscolo-Berto et al. (2008) confirmed that the emergence of renal colic resulting from kidney stones has a direct relation with temperatures higher than 27 °C. Likewise, Safarinejad (2007) observed an increase in the prevalence of urinary stones in males and females through the increased average annual temperature and/or sunlight index. According to Akoudad et al. (2010) hydrological and climatic factors are instrumental in the formation and prevalence of urinary stones. Giannossi and Summa (2013) considered the range temperature T >13 ºC the critical line at which there might be the risk for humans to develop the urinary stone disease. Tasian et al. (2014) found that the incidence of nephrolithiasis rose with the increase in the average daily temperature in some USA cities (Atlanta, Georgia; Chicago, Illinois; Dallas, Texas; Los Angeles, California; and Philadelphia, Pennsylvania). Despite the slight difference in the length or short duration of temperature in the regions of the study area, the annual temperature average in all the regions of the study area will more likely to help develop urinary stones. The Mafraq area, located within an arid and semiarid climate zone, showed the longest period of high temperatures. The Ajloun area located within the wet Mediterranean climate showed the shortest period and of low temperatures

Table 5 shows the possibilities of odds ratio calculations. The increase in the chance of an infection with the disease was found to correlate with high temperature, being a male rather than a female, and with a specific age group. The annual average temperatures between 20-24 ºC, being a male and/or from the (40-60) age group make people more vulnerable to the risk of developing urinary stones (Table 5). However the link between the emergence of the disease among females from a certain age group and temperature was found less influential.

There are many studies in the world that confirmed the existence of a close relationship between urolithiasis and the increasing temperature (Marston et al., 1992; Al-Eisa et al., 2002; Basiri et al., 2004; Boscolo-Berto et al., 2008; Akoudad et al., 2010; Giannossi and Summa, 2013; Tasian et al., 2014), or/and rotate of seasons in the year (Fujita, 1979; Chauhan et al., 2004; Boscolo-Berto et al., 2008; Chen et al., 2008; Basiri et al., 2009; Lo et al., 2010; Tiu et al., 2010; Scales et al., 2012; Fukuhara et al., 2016), or/and temperature and the seasons rotations (Brikowski et al., 2008; Freeg et al., 2012; Fukuhara et al., 2016). The results of the current study concerning the relationship between temperature and the formation of urinary calculi are consistent with the results in the above-mentioned studies.

Like temperature, altitude also has a correlation with the formation and evolution of urinary stones. To elucidate the impact of altitude on urolithiasis, the relationship has been calculated over various periods at altitudes between 550 m to 1,200 m covering all the study regions (Table 6).

The process of the formation of urinary stones in humans is not an instantaneous process, but rather a cumulative process of different materials that increase the degree of saturation in the fluid leading to precipitation into a solid state. Therefore, it is difficult to set clear boundaries between the seasons in which the urinary stones are formed in the bladder or in any other organ of the human body. There is no specific geometric distribution found in the the numbers of patients who suffer from urinary stones seen at hospitals. During summer seasons, when the rise in temperature increases the proportion of water consumption per capita, and/or when there is a lack of hydration and not drinking enough water during the summer, there is more chance for the concentration of the nuclei of atoms to form urinary stones. In the winter seasons, the body does not naturally require the same amount of water for drinking, which also stimulates the formation of urinary stones. Based on the dehydration theory in (Embon et al., 1990; Pin et al., 1992; Borghi et al., 1993; Borghi et al., 1999; Basiri et al., 2004; Boscolo-Berto et al., 2008) who all propose that the increased crystallization of the stone in the urine is relevant to the lower volume of urine and the decrease in the amount of fluids in the body as a result of sweating in hot and dry climates. Also, the too much exposure to the sunlight increases vitamin D intake, which also helps in the formation of urinary stones in the body (Parry and Lister, 1995; Lo et al., 2010). The final results of this study show that the seasons of the year are to be considered indicative or relevant to the formation of urinary stones in all regions. Also, the rise in temperature needs to be taken as an important factor in the composition of urinary stones in certain areas.

Similarly, water hardness was reported as a relevant environmental factor in the formation of urinary stones in the human body (Sierakowski et al., 1979; Kohri et al., 1993; Abboud, 2008c; Abboud, 2017). The quality and quantity of water intake by individuals play an important role also as a risk factor in the formation of urinary stones. In particular, water containing high levels of calcium and magnesium and/or water characterized by water hardness i.e. more than 300 mg/L is another rsik factor for urolithiasis. Given the fact that water hardness in the study area is mostly higher than 300 mg/L, drinking hard water helps in the development of urolithiasis. Table 7 shows the strength of odds ratio values of the correlation between the urinary stone formation and the age group (40-60 year), being male, and also water hardness (>300 mg/L).

Table 1 shows that Irbid region is the highest in the prevalence rates of the urinary stone disease, followed by the Jerash, Mafraq, Amman, and Ajloun.: 7.53 ‰, 6.1 ‰, 5.81 ‰, 5.29 ‰, and 5.25 ‰ respectively. Therefore, the odds ratio of risk factors for people living in pedological of Irbid region was calculated in this study.

Figure 5 shows the most important classifications of soils spreading in the study area. The type of soil spreading in Irbid region is vertisols. It is a clay soil rich in the montmorillonite mineral and also of high thickness formed by the weathering processes of basaltic rocks in the region. The soil spreading in the regions of Amman, Jerash, and Ajloun are of the type xerochrept consisting of unconsolidated alluvium from the limestone source (Fig. 5). Soil in the Mafraq region is of the kind aridisols usually spread in arid and dry areas, and is often poor in organic matter. It was formed originally from carbonate and silicate materials (Fig. 5). It is expected that the different types of soil affect the ions dissolved and the concentration in the groundwater. Those soil types also affect the quality of the ions that are concentrated in the tissues of plants eaten by the people in those regions. All this leads in the end to the development of urinary stones of different types in individuals. In addition, the concentration of many chemical elements in the urinary stones extracted from the patients explains the origin of these elements either as coming from the drinking water or the diet style of individuals.

Magnesium, sodium, and calcium ions are concentrated in the soil of the Irbid region because they are composed of the montmorillonite mineral. Therefore, an increase in the concentration of these ions in the groundwater wells of the region was noticed as a result of the washing and leaching processes that occur in the soil dissolving these ions and transferring them into aquifer. The regions of Amman, Jerash, and Ajloun are rich in limestone. Therefore, we notice an increase in the concentration of Ca ion in the groundwater of the wells of these regions due to its solubility during the flow of water in the soil and its passage to the reservoirs of the groundwater. The Mafraq region is rich in Ca, Mg, Na, and Si ions because it contains mainly carbonate and silicate minerals. This is inevitably reflected on the quality of the groundwater in that region. The concentration of these ions in these soil types explains their increased concentration in the groundwater of these regions. This also shows their increased concentration in the vegetation of the area as a result of the plant absorption of the water directly through the soil or indirectly from the water contained in the soil particles. As a result of the consumption of the groundwater of the wells by the population of those regions or as a result of eating plants growing in those soils, an increase in the concentration of those elements in the tissues of the body occurs increasing the chances for the formation of urine stones.

The relationship between the prevalence of urolithiasis and altitude, soil type, and climatic features prevailing at Irbid region has been exmained in this study. Odds ratios showed a strong and absolute correlation between the prevalence of urolithiasis and the type of soil in Irbid region. The reason for this strong corrleation is the direct effect of some environmental and geological factors which play an important role in the formation of the soil and its minerals such as morphology, rock type and lithology, precipitation, drainage system, altitude, and temperature. The rock type and soil thickness profiles in the Irbid region play an essential role in the mineral type concentrated in the soil which has an impact on the quality of the chemical elements that are absorbed by crops. The population of this region depend on those crops in their diets which increases the likelihood and exposure to the urinary stone disease.

Conclusion

The epidemiological survey was carried out in this study to examine the prevalence of urolithiasis in five governorates in northern and central Jordan.The average prevalence rate found was 5.95 ‰. This study attempted to link the risk of developing urolithiasis and its prevalence to some geographic variables and several demographic, geological, and environmental factors in addition to some human habits. The highest prevalence of the urinary stone disease was found in the governorate of Irbid. Climatic conditions, relatively high temperatures, or high solar radiation, precipitation, as well as some environmental, geographical, and geological factors including water hardness being (>300 mg/L), relative altitude being higher than (500 m), rock type, and the mineral components of the soil, along with some human characteristics, such as gender and age being (>40) years, can all be very siginificant risk factors to the human health and provide sufficient explanation for the increased prevalence of the urinary stone disease among the population of the study area.

The epidemiological survey carried out in this study is considered the first of its kind in the region. It is the starting point in the expansion of knowledge about the mechanism of the disease distribution in the region among the population, their sexes and ages. It also provides sufficient details to help draw a clear picture about the impact of the disease on the community and its causes. Hopefully, the results of the current study will contribute to the design and implementation of comprehensive prevention projects to reduce the extent and prevalence of the disease as much as possible.

الملخص

أمراض الحصى البولية هي الأكثر انتشارا في جميع أنحاء العالم، وتعتبر واحدة من الأمراض الأكثر تأثيرا في الإنسان، من حيث استمرارية المرض، والتكرار، أو الأعراض. يتم التحكم في تشكيل ونمو الحصيّات البولية من قبل العديد من العوامل البيولوجية والبيئية والجغرافية. في هذه الدراسة، تم تحديد انتشار المرض، وحدوثه، وعوامل الخطر الناتجه عن التّحصّي البولي في سكان شمال الأردن. لذلك دُرس تأثير العوامل البيئية والجغرافية والبيولوجية التي قد تساهم في حدوث المرض. ولوحظ أن الانتشار المتزايد لمرض التّحصّي البولي يكون في عمر ٤٠ سنة، والذكور أكثر عرضة للإصابة بالمرض من الإناث. ولخص تأثير العوامل البيئية على تكوين الحصيّات البولية من خلال النظام الغذائي للأفراد، نمط الحياة، وكذلك تأثير عسر الماء بالذات في تكوين حصى الأوكسالات بسبب تركيز البايكربونات > ٣٠٠ غم/لتر. وأخيرا، لعبت العوامل الجغرافية دوراً هاماً في تكوين وانتشار وتكوين الحصيّات البولية. كما لوحظ في هذه الدراسة ارتفاع معدل المرض وانتشاره في المناطق ذات درجة الحرارة العالية > ٢٠ درجة مئوية، وزيادة التعرض لأشعة الشمس، والارتفاع > ٥٠٠ م، والتربة من نوع فيرتي سويلس.

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