The effect of climate temperature and daily water intake on the diversity of uropathogens causing urinary tract infections in adult hospital patients

Mohammad I Al-Berfkani (MSc)[1], **Muslim A Allu (**MSc)[2] and **Sherzad A Mousa (**MB ChB)[3]

Abstract

Background: The most frequent bacterium causing urinary tract infection is *Escherichia coli* followed by *Staphylococcus saprophytic*. These infections are more prevalent among pregnant women, particularly in summer, due to dehydration and insufficient uptake of drinking water.

Objective: To assess the effect of climate temperature on diversity of uropathogens causing UTIs, and investigate whether infection increases during specific months.

Patients and Methods: Seven hundred forty one patients aged 20 years or above in General Zakho Hospital was investigated for urinary tract infection status from January to December 2015, and the daily drinking water uptake was assessed. The monthly climate temperatures were analyzed. Urine samples were collected using mid-stream method, and the samples were cultured to isolate uropathogens identified by biochemical tests.

Results: The results indicate that 494 (66.66%) out of 741 patients were infected with UTIs, with seasonal trends of a peak plateau from June to July and a sharp decline after September. The percentage of UTI was 71% among patients who drank less than 2 liters of water per day, and 60% for other infections. Pregnant women had significantly higher prevalence of uropathogens due to the physiological changes during pregnancy. *E.coli* was the most common isolated pathogen (51.7%) in male and female patients.

Conclusion: The results support evidence suggesting that dehydration due to low water intake, especially in summer, leads to low urine output, which increases the occurrence of urinary tract infection.

Key words: Uropathogens, urinary tract infection, water uptake, climate temperature.

Corresponding Author: berfkani85@gmail.com

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[1] Department of Medical Laboratory Technology - Zakho Technical Institute - Duhok Polytechnic University - Duhok - Iraq.

[2, 3] Department of Nursing - Zakho Technical Institute - Duhok Polytechnic University - Duhok - Iraq.

Introduction

Urinary tract infection (UTI) is the second most common type of bacterial infection in humans, and it can manifest in all age groups, from neonates to the elderly [1]. The family of enterobacteriaceae are dominator bacterial uropathogens responsible for urinary tract infection, with a high predominance of *E.coli*, comprising approximately 75% of cases [2]. Other members of the family are less common, including *Proteus mirabilis*, *Klebsiella pneumoniae* and more rarely Gram positive bacteria, including *Staphylococcus saprophyticus* and *Streptococcus faecalis* [3]. The frequency of the uropathogens

varies depending upon their virulence factors, patient age, sex, catheterization and hospitalization [4]. *Streptococcus faecalis* is an infected agent of human infections, including UTIs and wound infections. *Streptococcus faecalis* is the second most common cause of UTIs, with around 110,000 cases per year acquired in hospitals and other healthcare facilities. Infections with *Streptococcus faecalis* can be difficult to treat due to their ability to resistance broad spectrum of antibiotics [5]. *Staphylococci saprophyticus* displays the strongest ability to attach and invade uroepithelium and more frequently cause infection in sexually active women and men [6]. *Staphylococci saprophyticus* has been isolated from homosexuals and elderly males with foley catheters [7]. Although *Proteus mirabilis* is not a common infection agent in UTI, it does complicate the latter, and cross-infection in catheterized patients can occur when the bacterium move to the urethra and urinary bladder and produce urease, which breaks down the urea in urine into ammonia, resulting in an alkaline environment and enhanced the formation of magnesium ammonium hydroxide stone called "struvite" [8]. *Pseudomonas aeruginosa* is the third most common uropathogen associated with uncomplicated urinary infection [9]. *Pseudomonas aeruginos*a pathogenesis could be related to virulence factors such as Adhesins, alginate, Endotoxin, Exotoxin, alkaline protease and Phospholipase C [10]. In addition, the remarkable ability of *P. aeruginosa* to form biofilms that attach to surfaces in many environments helped it develop resistance to a broad spectrum of antibiotics [11]. Lactobacillus are part of the vaginal microbiota and play important role in protecting the host from uropathogens [12]. *Lactobacillus* are part of vaginal microbiota and are considered as a strong probiotic that inhibits adhesion and growth of uropathogens, and which is able to colonize the epithelial cell of vaginal and intestine cells [13]. Fungal uropathogens can also be part of microbial populations that may associate with UTIs [14]. Candiduria refers to the presence of *Candida* yeast in the healthy urinary tract, and it is considered to be an opportunistic uropathogen that causes lower UTI, typically after antibiotic therapy [15]. Environmental conditions influence uptake of drinking water, along with factors such as physical activity, age and health. The total water intake by adult per day is 2.5 liters for adult man and 2.0 liters for adult woman [15]. Some evidence showed that low water intake leads to less outpouring of urine, resulting in increased occurrence of UTI [16]. Borghi *et al.* suggest that drinking a large amount of water daily ensures high urine output and prevents recurrent urolithiasis [17]. A research study by Evans et al. suggested that change in climate temperature leads to development of kidney stones, particularly with a deficiency of drinking water [18].

Patients and Methods

This research work was carried out over duration of one year, from January to December 2015. The aim of this research was explained to the subjects before their consent to participate was sought. A total of 741 patients aged 20 years or above were interviewed. Structured questionnaires were used as the study tool. The questions outlined in the data forms were explained to the subjects, and completed forms containing biodemographic information included subject age, sex, marital state, dietary intake of water (cups per day) and history of urinary stones.

Specimen collection and transportation

Seven hundred forty one urine samples were collected from patients suspected with UTIs visiting Zakho General Hospital. The first morning samples were collected by mid-

stream method in sterile plastic containers. The urine samples were labeled and transported to the Microbiology Laboratory of Zakho Technical Institute for bacteriological analysis.

Isolation and identification of uropathogens

Serial dilutions of urine samples up to 1:106 were made using one milliner of sample with sterile distilled water. 0.1 ml of diluted sample were cultured on the surface of Blood agar and MacConkey agar and incubated overnight at 37oC. Samples with a count of more than 105 colony forming unit (CFU)/ml were considered as positive UTI.

Single colonies were subcultured on the medium Eosin Methylene blue agar for Enterobacteriaceae species, Mannitol Salt agar for Staphylococcus spp., and Cetrimide-agar plates for Pseudomonas spp. For isolation of Lactobacilli, samples were cultured anaerobically on deMan Rogosa Sharpe (MRS) Agar. Identification of bacterium was undertaken using the following biochemical tests: IMViC tests, Oxidase Test, Gas and H2S production, Lysine Decarboxylase, Lactose and Mannitol fermentation tests, Urea Hydrolysis Test, Catalase Test, Tube Coagulase tests and Nitrate Reduction test [19]. The isolated strains were confirmed using the following tests: API 20 E, API Staph and API 20NE systems (bio Meraux, France). For isolation of Candida albicans, samples were inoculated on Sabouraud's Dextrose Agar for 72 hours at 37°C. Identification was achieved using germ tubes and carbohydrate utilization tests, confirmed by serological tests.

Assessment of drinking water intake

To assess water intake among patients, we used water frequency questionnaire, designed in the native language of participants (Kurdish) to be clearly understood, 741 patients responded to the question "how many cups of bottled/tap water do you drink each day?"

Meteorological data

Data on the monthly temperature in Zakho - Duhok City in 2015 were provided by the Iraqi Meteorological Organization (IMO).

Statistical analysis

The effect of climate temperature and daily water intake on the prevalence of Bacteriuria was assessed using chi-square test, whereby ($p<0.05$) was considered significant [20].

Results

A colony count of more than 105CFU/ml was displayed by 494 patients out of 741 (66.66%); 371 (75.1%) female patients and 123 (24.89%) male patients had a positive urine culture (Table 1). The frequency of UTIs related to sex and marital status is shown in Figure 1.

Table (1): Percentage of uropathogens among males and females

Uropathogens	Males	Females	Total
Escherichia coli	33 (27.5%)	84 (24.2%)	117(51.7%)
Staphylococcus saprophytic	30 (25%)	80 (23%)	110 (48%)
Streptococcus faecalis	22 (18.3%)	68 (19.5%)	90 (37.8%)
Klebsiella pneumoniae	19 (15.8%)	42 (12.1%)	61 (27.9%)
Candida albicans	7 (5.8%)	59 (17%)	66 (22.8%)
Proteus mirabilis	7 (5.8%)	9 (2.5%)	16 (8.3%)
Lactobacillus	1 (0.8%)	24 (6.4%)	25 (7.2%)
Pseudomonas aeroginosa	2 (1.6%)	5 (1.4%)	7 (3%)
Total	121 (24.5%)	371 (75.4%)	492 (100%)

The incidence of UTI in pregnant women (n=165, 33%) was higher than in married women (n=131, 27%), in agreement with earlier studies [21]. The lowest percentages were found among married males (n=88,

18%), single females (n=75, 15%) and single males (n=37, 7%) (Figure 1).

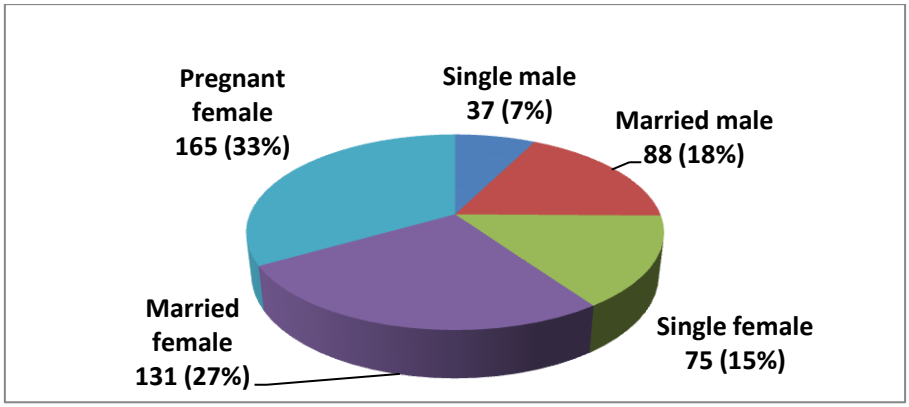

Figure (1): Percentage of urinary tract infections related to married status

Eight different microorganisms were isolated and identified from 494 urine samples with a positive culture, including Escherichia coli, Staphylococcus saprophytic, Streptococcus faecalis, Klebsiella pneumoniae, Candida albicans, Proteus mirabilis, Lactobacillus and Pseudomonas aeroginosa.

Escherichia coli was isolated in 117 cases (51.7%), followed by Staphylococcus saprophytic in 110 (48%), Streptococcus faecalis in 90 (37.8%), Klebsiella pneumoniae in 61 (27.9%), Candida albicans in 66 (22.8%), Proteus mirabilis in 16 (8.3%), Lactobacillus in 25 (7.2%) and Pseudomonas aeroginosa in 7 (3%), as shown in Table 1.

Survey data were used to study the effect of climate temperature on the prevalence of UTI. All patients were asked about their daily water intake, and it was found that for patients who reported drinking less than 2 liters of water per day there was a UTI prevalence of 71%, and of 60% for other infections (Figure 2).

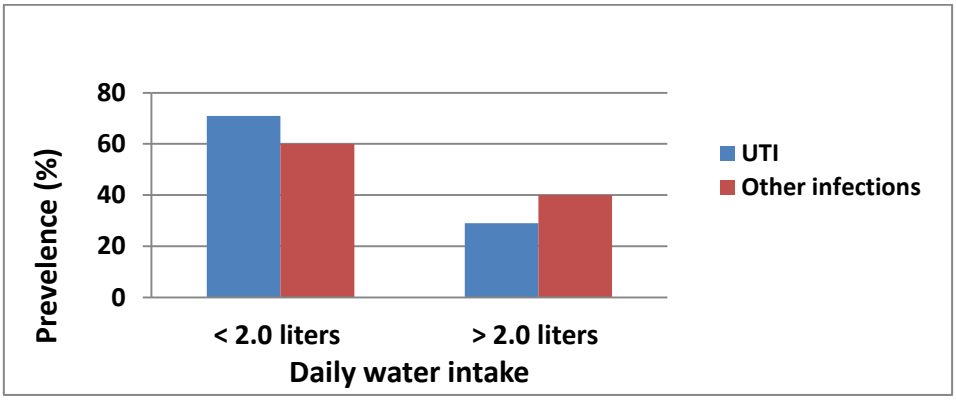

Figure (2): Risk of UTI associated with water intake

Based on the climate temperature of the Kurdistan Federal Region in Iraq, the year is divided into four astronomical seasons; winter (December, January and February), spring (March, April and May), Summer (June, July and August) and Autumn (September, October and November). The average temperatures in the winter, spring, summer and autumn were 5.1˚C, 14.7˚C, 27.5˚C and 17.3˚C respectively. The highest incidence rate of UTI was found among females during the Summer

(106 cases), followed by Autumn (97 cases), then Spring (88 cases) and Winter (82 cases), as shown in Figure 3.

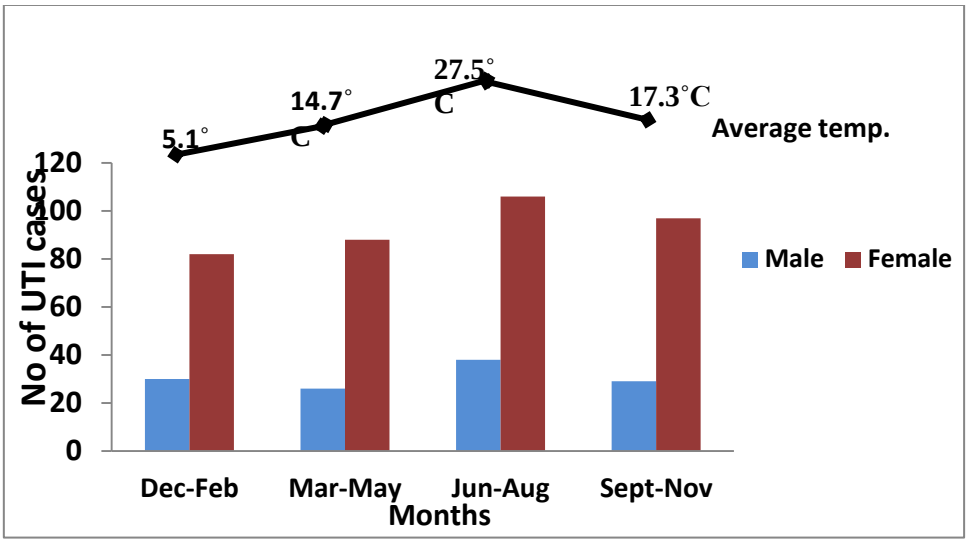

Figure (3): Incidence of UTIs by monthly average temperature

To assess the effect of climate temperature on the diversity of uropathogens, the months of 2015 were separated to high climate temperature (May to October) and low climate temperature (November to April), as shown in Table 2. The results showed that the majority of UTIs (272 cases) occurred in May to October. The vast majority of UTI cases were caused by the Escherichia coli and Staphylococcus saprophytic (60 cases), followed by Streptococcus faecalis (50 cases) and Candida albicans (35 cases). 220 UTI cases occurred in November to April, including 57 caused by Escherichia coli, followed by Staphylococcus saprophytic (50 cases), Streptococcus faecalis (40 cases) and Candida albicans (31 cases).

Table (2): Uropathogens distribution of UTIs in high and low temp. months (2015)

Uropathogens	High temp. months (May to October) Mean temp. 27.5˚C	Low temp. months (November to April) Mean temp. 13.1˚C
E. coli	60	57
Staphylococcus saprophytic	60	50
Streptococcus faecalis	50	40
Klebsiella pneumoniae	34	27
Candida albicans	35	31
Proteus mirabilis	12	4
Lactobacillus	18	7
Pseudomonas aeroginosa	3	4
Total	272	220

Discussion

The high incidence of UTI infections among women is largely related to the anatomy and physiology differences between the male and female genitourinary systems; the distance between urethra and anus of the female is shorter than in males, and the former have a lack of bacteristatic secretion of the prostatic gland [22]. The prevalence of UTI among pregnant and non-pregnant women varies due to changes during pregnancy such as increased rate of urine formation, dilation of the renal pelvis and ureters, decrease urethral peristalsis, reduced bladder tone and increased secretion of Relaxin and Progesterone hormones in the ovary, all of which promote urine stasis and

reduced defenses against the reflex of bacteria into the kidney [23]. Sexual activities may aid in introducing bacteria from the vagina into the urethra and increase the prevalence of bacteria.

Escherichia coli was the most prevalent bacterium isolated from the urine of females [27.5%] and males [24.2%], corroborating the findings of previous studies [24]. The sexual pressure during sexual intercourse and the close proximity of urethra of the female genitals and the rectum of anal region aids the easy transfer of E. coli from the anus to the vagina and transport to the urethra, where they then multiply and may cause considerable discomfort [25]. It is interesting to note that *Lactobacillus* load was low compared to other uropathogens [7.2%]. The prevalence of Lactobacillus in female patients was [6.4%] and in male patients was [0.8%]. The depletion of *Lactobacillus* in the vagina usually encourages the establishment of Staphylococci saprophytic and other uropathogens. *Staphylococci* are carried by humans as normal microbiota on the skin, hands, and nostril. *Staphylococci saprophytic* are the second most prevalent bacteria (48%) followed by *Streptococcus faecalis* (37.8 %). The presence of *Streptococcus faecalis* in urine samples was previously reported [26]. The frequency of *Streptococcus faecalis* in females (19.5%) was more than in males (18.3%), this may be due to their persistent presence in the female genital tract, since anatomy favors their existence in the environment [25]. Generally, *Klebsiella pneumoniae* was the third most frequently reported bacterium isolated in the urine samples of both genders (27.9%). The bacterium is considered to be part of microbial flora associated with skin, pharynx, colon and intestinal and biliary tract. They may colonize sterile wounds and urine [27]. The percentage of Proteus mirabilis was 8.3%, and the numbers of positive cultures among females and males were 7 and 9, respectively, which indicates that *P. mirabilis* is not a common bacterial uropathogen in normal hosts. This result agrees with previous reports [28]. *Pseudomonas aeroginosa* showed the lowest percentage (3%) among urine samples. This bacterium is widely distributed in soil, water, sewage, plants and animal surfaces, their presence in urine indicate contamination and formation of biofilms [25]. Among fungal uropathogens, *Candida albicans* strains dominate (22.8%) all UTI cases in hospitalized patients. UTIs by fungi are more common in immunocompromised and diabetic patients, and those with indwelling catheters [29]. In the present study, the percentage of *Candida albicans* in females (17%) was higher than in males (5.8%). The reason is due to use of douches or perfumed vaginal hygiene products and sexual intercourse with an infected partner [30].

The graph suggests a potential relation between the climate temperature and the incidence of UTI. It shows increased UTI cases in high climate temperature months (May to October). Therefore, risk is concentrated in summer (until September) and decreases in winter (to March) among both women and men. Although in winters it is common for people not to feel too thirsty, dehydration is more common in the summer. The summer peak was seen mainly among women. Younger people might also be more likely to experience dehydration if they are outside more.

The prevalence of infection among patients who drink less than 2 liters of water per day was 71% and 29% among patients who drink more than 2 liters per day. The results suggests that by increasing consumption of water, the chance of UTI can be reduced. The effect of water intake on incidence of UTI could be explained as follows: firstly, drinking lot of water leads to increased excretion of urine (dieresis) and flushes away bacteria that might have entered

the urethra during sex. Secondly, frequent voiding leads to less time for bacteria to grow in the bladder and minimizes the available surface area for bacterial growth. This is in addition to reducing factors in the formation of urinary stones associated with low amounts of citrate in the urine (hypocitraturia) and supersaturated urine with salt and minerals such as calcium, oxalate and uric acid [31].

In conclusion, the study reports a high prevalence of uropathogens in pregnant women. Escherichia coli were the most commonly isolated uropathogen. UTIs were more common in summer, due to dehydration and insufficient uptake of drinking water. We described the relationships between sex, UTI and climate temperature.

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