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ORIGINAL ARTICLE

Epidemiology and risk factors for staphylococcal urinary tract infections in the Moroccan Casablanca area

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Abstract

Purpose This study aimed to ascertain the prevalence and risk factors for developing staphylococcal urinary tract infections (UTIs) in the Casablanca area of Morocco.
Methods In Casablanca, Morocco, a retrospective evaluation of 772 UTIs patients was conducted between January 2020 and December 2022. The research included two groups of patients: those with staphylococcal UTIs and those without. Sex, age, chronic illnesses, antibiotic exposure, urinary catheterization, urological surgery, and UTIs history were the risk variables assessed. We employed a logistic regression model to identify the characteristics that were predictive of staphylococcal UTIs.
Results Eight staphylococcal species were responsible for 16.84% of UTIs in 772 non-repeating individuals. Patients infected with *S. saprophyticus* (35.38%) were the most common, followed by those infected with *S. epidermidis* (24.61%), *S. aureus* (13.85%), and *S. hemolyticus* (10.78%). Multivariate logistic regression analysis revealed that male sex (95% CI: 0.261–0.563), immunosuppression and immunosuppressive treatments (95% CI: 0.0068–0.64), chronic diseases (95% CI: 0.407–0.965), previous UTIs (95% CI: 0.031–0.228), frequency of urination more than 8 times a day (95% CI:1.04–3.29), frequency of urination once or twice a day (95% CI: 1.05–2.39), and urinary catheterization (95% CI: 0.02–0.22) were the most likely predictors of staphylococcal UTIs. In addition, a larger proportion of patients with staphylococcal UTIs were made aware of the risk factors associated with staphylococcal UTIs (52.31%, $\chi 2=4.82,=0.014$).
Conclusions This is the first global study to evaluate the predictive factors for acquiring UTIs caused by staphylococci. Monitoring these factors will enable medical authorities to devise effective strategies for managing UTIs and combating antibiotic resistance.

Keywords Urinary tract infection · Staphylococci · Epidemiology · Predictive factors · Morocco

Introduction

Urinary tract infections (UTIs) are the second most common infectious diseases in hospitals and communities. They are associated with high morbidity, mortality, and economic costs in terms of treatment and health care [1].

In the past few years, the epidemiology of UTIs has been influenced by the emergence of staphylococcal UTIs. These species have developed a variety of virulence factors that maintain their pathogenicity and have a high affinity for urinary tract epithelial cells [2, 3].

The prevalence of uropathogenic staphylococci is difficult to assess accurately. Data from the most recent investigation in worldwide showed that UTIs caused by *Staphylococcus aureus* were accounting for 7–12% of UTIs [3, 4]. In addition, *Staphylococcus saprophyticus* is the most common

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cause of UTIs in sexually active young females [5]. Species-level identification of other coagulase-negative *Staphylococcus* (*CoNS*) isolated from UTIs is infrequent, making it difficult to determine their roles in UTIs [6]. The treatment of UTIs is becoming increasingly challenging due to the rising antibiotic resistance of these bacteria [7]. As a result, clinicians are facing a limited number of therapeutic options [8]. By employing preventive strategies, recognizing the epidemiology of UTIs, implementing surveillance, and being informed about trends in antibiotic resistance, clinicians can effectively reduce the incidence of UTIs and optimize their antibiotic treatment decisions for patients [9].

To prevent UTIs, individuals who are at high risk of developing UTIs must be identified. This study aimed to determine how often UTIs caused by staphylococci occur in the general population of Casablanca, Morocco, and what factors are associated with an increased risk of developing these infections.

Materials and methods

Study design

This is a cross-sectional study and was conducted between January 2020 and December 2022 in the capital economic region of Morocco (Greater Casablanca). The total area of Greater Casablanca is 1,615 km^2, making it the largest region in terms of population (6 million people), accounting for 20.3% of the country's total population [10]. The high number of immigrants in Greater Casablanca, coming from diverse areas of Morocco leads to a significant heterogeneity in terms of socio-economic status. Consequently, the population of this region can be viewed as a fair representation of the Moroccan population.

Sample size

The sample size was determined through the use of Epi-Info® software, with an anticipated prevalence of UTIs at 18%, a confidence level of 95%, and a tolerated margin of error of 5%. The minimum number of participants required for this study was calculated to be 273. To ensure the reliability of the study results, the final sample size was increased by more than 75% as a precautionary measure, resulting in a final sample size of 772 participants.

Inclusion and exclusion criteria

According to the Medical Microbiology Reference [11], the inclusion and exclusion criteria for this study were defined as follows:

The patients included in this study exhibited symptoms indicative of UTIs, such as fever above 38 °C, suprapubic pain, dysuria, and pollakiuria. Moreover, these patients had no history of antibiotic treatment for more than two weeks before sample collection and had a pure bacterial culture (bacteriuria greater than 10^5 CFU/mL) and a leukocyte count of more than 10^4/mL. Finally, patients with endo-urinary devices showed bacteriuria greater than 10^5 CFU/mL and a maximum of two different types of microorganisms.

Patients excluded from this study were those with colonization with or without an endo-urinary device, asymptomatic bacteriuria, leukocyturia without bacteriuria, or those who were taking antibiotics in the week prior to sample collection.

Data collection

The organization and structuring of data for patients suffering from UTIs were carried out by extracting data from medical records, biological data provided by medical analysis laboratories (21 medical laboratories of Casablanca), as well as by collecting other data through patients and their urological doctors.

For this extraction and collection of data, a questionnaire was carefully crafted based on the outcomes of the literature review. The questionnaire consisted of both closed-ended and open-ended questions and was divided into three parts. The first part collected information on sociodemographic characteristics, while the second part focused on capturing data about UTIs clinical risks, and the third part covered topics related to history of UTIs and urinary incontinence.

Microbiological analysis

White blood cell and red blood cell counts were quantitatively determined using a Urised mini (77 Elektronika Kft, Budapest, Hungary). Cystine Lactose Electrolyte Deficient (CLED) agar (Biokar Diagnostics, Beauvais, France) was used to inoculate 10 µL of urine according to the usual techniques in medical microbiology. After incubation at 35 ± 2 ℃ aerobically overnight.

Clinical isolates of *Staphylococcus* species were identified using medical microbiological techniques, including biochemical reactions: catalase, coagulase and Mannitol Salt

Agar (Biokar Diagnostics, Beauvais, France) fermentation. The VITEK2®COMPACT 15 system (BioMérieux, Marcy-l'Étoile, France) was used for identification according to standard criteria.

Results

Descriptive analysis of the study population

The study enrolled 772 patients diagnosed with UTIs, including 483 women (63%) and 279 men (37%), with a sex ratio of 0.58. The average age of the participants was 44.8 years. Most patients (62.18%) lived with a partner, whereas 37.89% were single. The urban population accounted for 60% of the patients, whereas 40% were from rural areas.

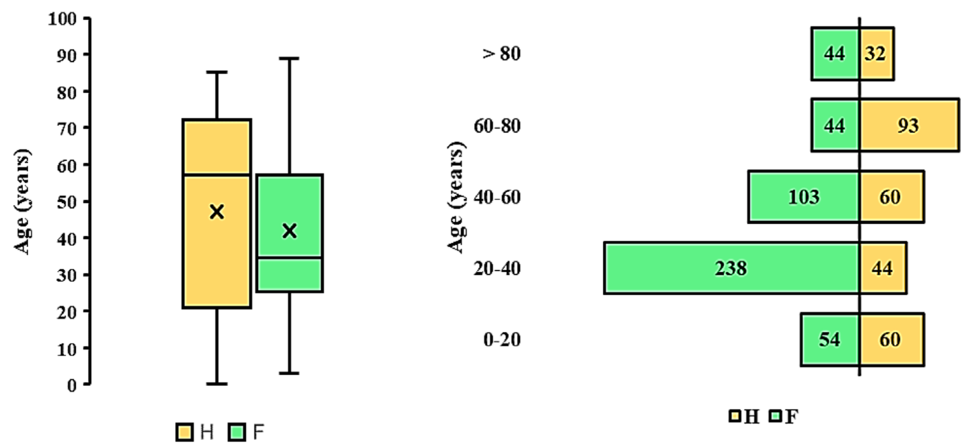
The peak incidence of UTIs was observed in the 20–40 age group with 49.21%. Women were more susceptible to UTIs in the 20–40 and 40–60 age group. In contrast, among men, the peak incidence was observed in the 60–80 age group, with 33.3% (Fig. 1).

Prevalence and risk factors for staphylococcal UTIs

Eight staphylococcal species were responsible for 16.84% of UTIs in 772 non-repeating individuals. The most common kind of patients was found to be infected with *S. saprophyticus* (35.38%), which was followed by *S. epidermidis* (24.61%), *S. aureus* (13.85%), and *S. hemolyticus* (10.78%) (Fig. 2).

The sex ratio of patients with staphylococcal UTIs was 0.49, with 57 women (43.85%) and 87 men (57.15%). Men accounted for a significantly higher proportion of

Fig. 1 Descriptive analysis of the study population. **H**: Men, **F**: Women



A: Distribution of the study population by age and sex.

B: Age pyramid of the study population.

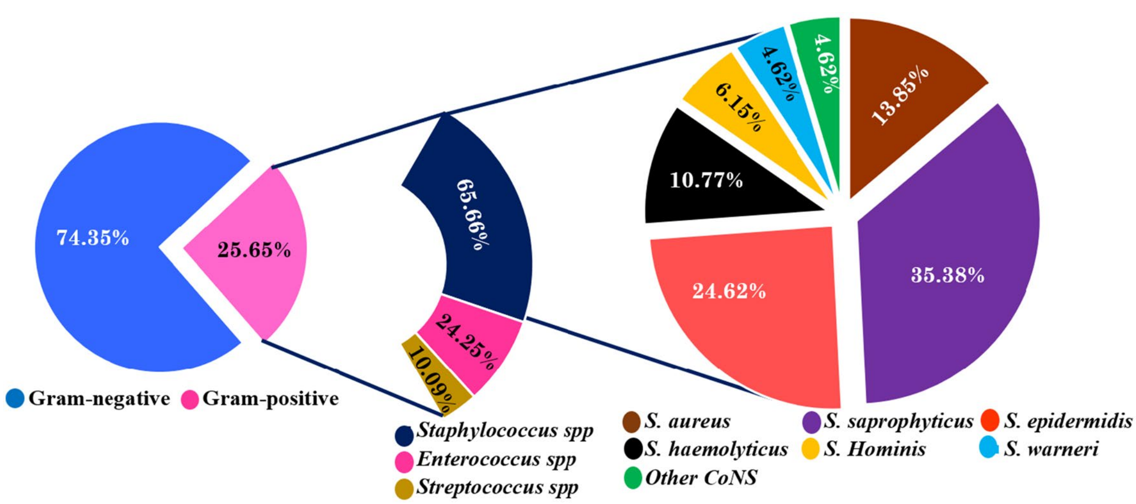


Fig. 2 Prevalence of uropathogenic bacteria

staphylococcal UTIs than women ($p < 0.001$). The mean age of patients was 32.3 years, with extremes ranging from 1 to 84 years. The majority of patients were in the 0–20 age group, while 25.38% were aged 20–40 and 21.54% were aged 40–60 years. The majority of these patients resided in urban areas (60.77%). Furthermore, 65.38% of the patients were married, whereas 34.62% were single (Table 1).

There was a significant age difference between patients with staphylococcal UTIs and those with non-staphylococcal UTIs ($p < 0.001$). Furthermore, the association between staphylococcal UTIs and chronic illness was found to be statistically significant between patients with and without chronic diseases ($p = 0.01$). The risk factors for staphylococcal UTIs were diabetes (22.06%), renal failure (10.29%), renal calculi (7.35%), bladder catheterization (19.12%), and previous UTIs (19.12%). Furthermore, bladder catheterization was the main risk factor for staphylococcal UTIs ($p = 0.25.10^6$) (Table 1).

Assessment of patient knowledge of the risk factors associated with staphylococcal UTIs

In this study, a larger proportion of patients with staphylococcal UTIs were made aware of the risk factors associated with staphylococcal UTIs (52.31%; $p = 0.014$). Our investigation revealed that patients could acquire information about the risk factors associated with staphylococcal UTIs primarily from healthcare staff (40.63%), social networks (31.25%), and academic training (32.81%). In contrast, 47.7% of patients were unaware of any risk factors.

Multivariate logistic regression analysis of factors predictive of staphylococcal UTIs

The multivariate logistic regression analysis of factors that are predictive of staphylococcal UTIs revealed that male sex (AOR = 0.38; 95%CI: 0.261–0.563), immunosuppression and immunosuppressive treatments (adjusted OR = 0.066; 95% CI: 0.00682–0.64), chronic diseases (AOR = 0.626; 95% CI: 0.41–0.97), previous UTIs (AOR = 0.085; 95%CI: 0.03–0.23), frequency of urination more than 8 times per day (AOR = 1.85; 95% CI: 1.04–3.29), and urinary catheterization (AOR = 0.077; 95% CI: 0.027–0.223) were the most likely to predict staphylococcal UTIs (Table 2).

Prevalence and risk factors of *S. aureus* and *CoNS* UTIs

Eighteen patients with *S. aureus* UTIs were studied, including six women (33.33%) and twelve men (66.67%). There was no significant difference between *S. aureus* UTIs and sex ($p = 0.322$). The average age of the patients was 32.9 years, with a range of 1 to 84 years.

A total of patients with *CoNS* UTIs, 46 (41.07%) were aged 0–20, while 31.25% were between 20 and 40 years, and 20.54% were between 60 and 80 years. The age range of 0–20 and 60–80 years was found to be at a higher risk for *S. aureus* UTIs than for *CoNS* UTIs.

Our study suggests that the incidence of *S. aureus* UTIs in pregnant women is similar to that of *CoNS* UTIs ($p = 1$). The majority of patients having *S. aureus* UTIs in urban areas (72.22%) compared to 27.78% in rural areas. Furthermore, almost all patients (83.33%) were married couples, whereas 16.67% were single.

Urinary catheterization was identified as the primary risk factor for *S. aureus* UTIs (31.82%; = 0.0305). The study found no significant difference in the incidence of *S. aureus* UTIs between patients with chronic diseases and those without ($p = 0.354$).

Discussion

To our knowledge, this is the first in Morocco and Africa to evaluate predictive factors for acquiring UTIs caused by Staphylococci. UTIs are much less commonly caused by *Staphylococcus* spp. Among the isolated *CoNS*, 41.07% were *S. saprophyticus*, 12.50% were *S. haemolyticus*, and 25.89% were *S. epidermidis*. These outcomes are comparable to those reported in previous research [31, 32]. The prevalence of *S. aureus* (13.85%) is lower than the values reported in studies conducted in Saudi Arabia [12] and in Rwanda [13]. The disparities in epidemiological data may be partly due to differences in the study design, setting, and participant population.

In our study, the factors associated with Staphylococci-related UTIs included age, sex, diabetes, renal insufficiency, kidney stones, immunodepression, catheterization surgery, and previous UTIs.

First, a history of UTIs is commonly recognized as a significant factor in predicting staphylococcal-related UTIs, as patients with such a history are more likely to experience recurrent UTIs than those without [14, 15]. Our research indicates that patients with diabetes are more likely to develop UTIs than those without diabetes. Multiple factors may contribute to this increased risk, including diabetic nephropathy [16]. Diabetic nephropathy can result in several complications, including high levels of protein and glucose in urine, leading to an increased risk of UTIs [16]. Diabetes impairs blood flow and depresses the immune system, which can be alleviated by regulating certain cytokines and other anti-inflammatory cytokines in a patient with diabetes. Furthermore, hyperglycemia can impair the function of white blood cells responsible for fighting infection, which can weaken the immune system [16].

Table 1 Prevalence and socio-demographic and clinical factors associated with staphylococcal UTIs

Demographic and clinical-biological characteristics	Prevalence of staphylococcal UTIs (n=130)		P value
	Yes (n, %)	No (n, %)	
Genre			
Woman	57 (43.85)	426 (66.36)	<0,001
Man	73 (57.15)	216 (33.64)	
Age			
0-20	50 (38.47)	64 (9.97)	<0,001
20-40	33 (25.38)	249 (38.79)	
40-60	13 (10)	150 (23.36)	
60-80	28 (21.54)	109 (16.98)	
Over than 80	6 (4.61)	70 (10.90)	
Residence			
Rural	51 (39.23)	259 (40.34)	0.81
Urban	79 (60.77)	383 (59.66)	
Marital status			
Single	45 (34.62)	247 (38.47)	0.408
Married	85 (65.38)	395 (61.53)	
Pregnant women			
No	46 (80.7)	326 (76.53)	0.481
Yes	11 (19.3)	100 (23.47)	
Chronic diseases			
No	98 (75.38)	419 (65.26)	0.025
Yes	32 (24.62)	223 (34.74)	
Comorbidities			
Hypertension	1 (1.47)	12 (5.13)	0.1
Renal insufficiency	7 (10.29)	44 (18.8)	0.047
Diabetes	15 (22.06)	83 (35.47)	0.018
Kidney stones	5 (7.35)	41 (17.52)	0.017
Immunodepression and immunosuppressive treatments	3 (4.41)	1 (0.43)	0.019
Urinary catheterization	13 (19.12)	5 (2.14)	0.0000025
Prostate problems	4 (5.88)	6 (2.56)	0.107
Previous UTIs	13 (19.12)	7 (2.99)	0.000016
Urinary incontinence	2 (2.94)	15 (6.41)	0.219
Malformative uropathy	2 (2.94)	6 (2.56)	0.41
Obesity	1 (1.47)	6 (2.56)	0.507
Bladder and kidney tumours	2 (2.94)	8 (3.42)	0.6
Urological surgery			
No	94 (20.94)	355 (79.06)	0.210
Yes	19 (17.3)	90 (82.57)	
Types of urological surgeries			
Cystectomy	4 (14.29)	24 (22.86)	0.238
Prostatectomy	1 (3.57)	13 (12.38)	0.157
Extracorporeal lithotripsy	1 (3.57)	6 (5.71)	0.545
Catheterization	13 (46.43)	5 (4.76)	˂ 0.01
Appendectomy	1 (3.57)	6 (5.71)	0.545
Cholecystectomy	3 (10.71)	20 (19.05)	0.2306
Renal malformation	1 (3.57)	7 (6.67)	0.467
Surgery for benign prostatic hyperplasia	2 (7.14)	12 (11.43)	0.398
Orchidopexy, orchiectomy and embolization of varicocele	1 (3.57)	6 (5.71)	0.545
Revascularization of renal arteries	1 (3.57)	6 (5.71)	0.545

Table 1 (continued)

Demographic and clinical-biological characteristics	Prevalence of staphylococcal UTIs (n=130)		P value
	Yes (n, %)	No (n, %)	
Frequency of urination			
3-5	67 (51.54)	248 (38.63)	0.022
More than 8	17 (13.08)	117 (18.22)	
Once or twice	46 (35.38)	277 (43.15)	

Table 2 Multivariate analysis of factors predictive of staphylococcal UTIs

Variables	AOR (95% CI)	P value
Genre		
Woman	*Ref.*	<0.001
Man	0.384 [0.261-0.563]	
Chronic diseases		
No	*Ref.*	0.034
Yes	0.626 [0.407-0.965]	
Immunosuppression and immunosuppressive treatments		
No	*Ref.*	0.019
Yes	0.066 [0.007-0.64]	
Urinary catheterization		
No	*Ref.*	< 0.001
Yes	0.0772 [0.027-0.223]	
Prior UTIs		
No	*Ref.*	< 0.001
Yes	0.0849 [0.032-0.228]	
Cathétérisme		
No	*Ref.*	< .001
Yes	0.0772 [0.027-0.223]	
Frequency of urination		
3-5	*Ref.*	–
More than 8	1.85 [1.04-3.29]	0.036
Once or twice	1.58 [1.05-2.39]	0.029

The most common healthcare-associated infection globally is catheter-associated UTIs, which poses a four-fold higher risk of UTIs compared to those who do not have a urinary catheter [17, 18]. The use of an indwelling urinary catheter for extended periods carries a risk of developing UTIs of 3–10% per day [17]. In our multivariate regression analysis, indwelling urinary device use was a dependent predictor of UTIs. Consequently, to prevent catheter-associated UTIs with staphylococci, it is advisable to insert a urinary catheter only when necessary and for a brief period, as per international guidelines [19].

Furthermore, our findings suggest that renal dysfunction may be a reliable indicator of increased vulnerability to staphylococcal UTIs. Other studies have also confirmed that any urinary drainage system that is damaged is susceptible to infection [20, 21]. Therefore, it is crucial to treat and prevent UTIs in hemodialysis patients.

In addition, our research suggests that patients with kidney stone disease commonly present with staphylococcal UTIs, other studies have also confirmed the association between UTIs and kidney stone disease [22, 23]. When stones are present, the urine cannot flow freely through the ureter, this can lead to inflammation and narrowing of the ureter or injuries caused by stones as they move down the ureter, making it easier for bacteria to penetrate and cause UTIs [24]. The severity of the risk of UTIs was influenced by the composition of the stones, with a stronger association observed in patients with calcium oxalate and urate stones than in those with other stone compositions [22, 23].

The patients with compromised immune systems or taking immunosuppressive medication after surgery were at a higher risk of developing staphylococcal UTIs than the general population. The justification for our results may lie in the fact that immunocompromised individuals are more susceptible to microorganisms penetrating the urothelium and causing an infection without exhibiting any typical symptoms of a UTIs.

This study has several limitations. As with any cross-sectional survey based on a questionnaire, there is no way to verify the accuracy of the answers given by the participants. Furthermore, the study was only conducted in a region of Casablanca; therefore, the results cannot be extended to the entire country.

Conclusions

This is the first global study to evaluate the predictive factors for acquiring UTIs caused by staphylococci. By regulating these factors, the yearly incidence of staphylococcal UTIs can be minimized, thus facilitating the selection of suitable antimicrobial therapy for patients suspected of having these infections, which in turn helps to prevent the development of antimicrobial resistance in pathogens.

Author contribution R.A., and D.A. and R.H, collected and analyzed the data, and drafted the manuscript. R.A, and B. A, conceptualized,

designed the study, guided data analysis and interpretation, T.M., B.A., and N. K. supervised, validated the study, and critically reviewed the manuscript. All authors have read and agreed to the published version of the manuscript.

Declarations

Conflict of interest The authors declare that there are no actual or perceived conflicts of interest.

Ethical approval This study was approved by the Ethics Committee for Biomedical Research of the Faculty of Medicine and Pharmacy of Oujda of Mohammed I University, Oujda, Morocco, approval number: 15/2023.

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