O R I G I N A L A R T I C L E

UDC: 615.03:616.6-022.7-085
DOI: 10.2298/VSP150122218D

Community-acquired urinary tract infections: causative agents and their resistance to antimicrobial drugs

Vanbolničke infekcije urinarnog trakta: uzročnici i njihova rezistencija na antimikrobne lekove

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Abstract

Background/Aim. Urinary tract infections (UTIs) are among the most common infections in outpatients. The aim of this study was to define the causative agents of urinary tract infections and their resistance to antimicrobial drugs in the urban area of central Serbia, as well as to evaluate eventual differences associated with age and gender of the patients. **Methods.** This retrospective study analysed data taken from routine, consecutively collected urine cultures of outpatients with symptomatic UTIs, collected from the Department of Microbiology, Institute of Public Health in Kragujevac, Serbia, from January 2009 to December 2013. **Results.** There were 71,905 urine cultures, and 24,713 (34.37%) of them were positive for bacterial pathogens. The most common pathogen was *Escherichia coli* (*E. coli*) (56.56%), followed by Klebsiella spp. (16.20%), *Proteus* spp. (14.68%), *Enterococcus* spp. (5.29%) and *Pseudomonas aeruginosa* (3.74%). *E. coli* and *Enterococcus* spp. isolation rates were lower in males ≥ 60 years old (23.71% and 4.87%, respectively), while *Klebsiella* spp. was more prevalent in this group (32.06%). The most common causative agents isolated from 15–29 years old male patients were *Enterococcus* spp. and *Pseudomonas aeruginosa* (13.28% each). Among women, the isolation rate of *E.coli* was high in all age groups (around 70%). *Proteus spp.* was frequently isolated from females ≤ 14 years old (13.27%), while *Klebsiella* spp. was the most frequent in the oldest age female group (10.99%). **Conclusion.** Choice of antibiotics for treatment of UTIs should be governed not only by the local resistance patterns, but also by gender and age of patients.

Key words:
urinary tract infections; urine; bacteria; drug resistance, microbial; outpatients; serbia; age factors; sex factors.

Apstrakt

Uvod/Cilj. Infekcije urinarnog trakta jedne su od najčešće prisutnih infekcija u vanbolničkoj praksi. Cilj ovog istraživanja bio je da se identifikuju uzročnici infekcija urinarnog trakta i stepen njihove rezistencije na antimikrobne lekove u urbanom području centralne Srbije, kao i njihova povezanost sa starošću i polom bolesnika. **Metode.** Studija je bila sprovedena kao retrospektivna analiza podataka prikupljenih tokom rutinskog rada na obradi urinokultura vanbolničkih pacijenata sa simptomatskom infekcijom urinarnog trakta u periodu od januara 2009. do decembra 2013. godine. **Rezultati.** Ukupno je bilo analizirano 71 905 kultura, od kojih je 24 713 (34,37%) bilo pozitivno na prisustvo bakterijskih patogena. Najčešće izolovani uzročnik urinarnih infekcija bila je *Escherichia coli* (*E. coli)* (56,56%), zatim vrste *Klebsiella* (16,20%), *Proteus* (14,68%), *Enterococcus* (5,29%) odnosno *Pseudomonas aeruginosa* (3,74%). *E. coli* i *Enterococcus* izolati bili su manje zastupljeni kod muškaraca starosti ≥ 60 godina (23,71%, odnosno 4,87%), dok su uzročnici *Klebsiella* vrsta preovladavali u toj starosnoj grupi (32,06%). Najčešće izolovani uzročnici kod osoba muškog pola starosti 15–29 godina bili su pripadnici vrsta *Enterococcus* i *Pseudomonas aeruginosa* (13,28% svaki). Među ženama, učestalost izolacije *E. coli* bila je visoka u svim starosnim grupama (oko 70%). *Proteus* vrste često su bile izolovane kod pripadnica ženskog pola starosti do 14 godina (13,27%), dok je *Klebsiella* bila najčešće zastupljena u najstarijoj grupi žena (10,99%). **Zaključak.** Izbor antibiotske terapije za urinarne infekcije treba da bude baziran na lokalnim obrascima rezistencije i usklađen sa polom i životnim dobom bolesnika.

Ključne reči:
urinarni trakt, infekcije; mokraća; bakterije; lekovi, rezistencija bakterija; bolesnici, vanbolničko lečenje; srbija; životno doba, faktor; pol, faktor.

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Introduction

Urinary tract infections (UTIs) are among the most common infections in outpatients. They are associated with a significant morbidity and mortality in general population and impose substantial financial burden to the society. About 150 million people worldwide are affected by UTIs every year, spending about 6 billion US dollars [1]. According to the 2007 National Ambulatory Medical Care Survey and National Hospital Ambulatory Medical Care Survey, UTIs are responsible for nearly 7 million office visits and 100,000 hospitalizations [2]. In Serbia, over 350,000 people is diagnosed with acute cystitis in primary care annually, and UTIs are the fourth leading cause of visits to general practitioners [3].

Earlier studies indicated that 50–80% of uncomplicated UTIs are solely due to *Escherichia coli (E. coli)*, while the remaining cases are caused by other *Enterobacteriaceae* (*Proteus, Klebsiella, Enterobacter*) together with *Pseudomonas* spp and gram-positive bacteria such as *Enterococci, Streptococci* and *Staphylococci* [4, 5]. The host risk factors as well as the virulence of a pathogen determine clinical course of UTI. Well-known risk factors for UTIs are female gender (especially pregnancy), diabetes mellitus, spinal cord injuries, multiple sclerosis, anatomic abnormalities of the urinary tract, incontinence, urinary bladder catheterization and advanced age [6, 7].

According to the guidelines of the European Association of Urology (EAU), treatment of UTIs includes fosfomycin trometamol, pivmecillinam or nitrofurantoin as the first-line therapy; alternative therapy includes fluoroquinolones, cefpodoxime proxetil, and combination of sulfamethoxazole and trimethoprim, if the local resistance of *E. coli* to the latter is less than 20% [8]. However, local and regional adjustments of these recommendations are necessary, since there are significant local differences in frequency of urinary pathogens, emergence of new agents or susceptibility to antimicrobial drugs [9]. Two recent studies from Serbia [10] and Bosnia and Herzegovina [11] support these recommendations, since isolated gram-negative causative agents of UTIs were highly resistant to beta-lactam antibiotics (> 25%), especially to ampicillin, amoxicillin and cephalosporins.

The aim of this study was to define the causative agents of UTIs and their resistance to antimicrobial drugs in outpatients in the urban area of central Serbia, as well as to evaluate eventual differences associated with age and gender of the patients.

Methods

This retrospective study included data taken from routine, consecutively collected urine cultures of outpatients with symptomatic UTIs, collected from the Department of Microbiology, Institute of Public Health in Kragujevac, Serbia, from January 2009 to December 2013. For each outpatient, the following data were extracted: the date of the sample obtaining, age, gender, urine culture results, identification of the bacterial strain responsible for an UTI and results of the corresponding antimicrobial susceptibility test (AST).

The Department of Microbiology has internal quality control procedures and participates in the external program for quality assurance by The United Kingdom National External Quality Assessment Service (UK NEQAS) for Microbiology and by Institute of Public Health of Belgrade, Serbia. The Institute of Public Health in Kragujevac is the competent UTI diagnostic center for 6 municipalities of the Šumadija region with 240,000 inhabitants.

The study was approved by the Ethics Committee of the Clinical Centre, Kragujevac, Serbia.

Before giving the urine sample, the outpatients received instructions for avoiding contamination with antimicrobials and for appropriate sampling technique, as a part of the routine procedure. The urine sample was collected early in the course of the disease, by midstream clean-catch technique after usual daily hygiene of genital area. The initial and the end portion of the micturition stream were discarded and the middle part was collected directly into a sterile recipient. In children up to two years of age urine samples were collected by collection bags taped to the skin surrounding the urethral orificium. Urine samples were transported to the laboratory and analyzed within the two hours after collection. When this procedure was not possible, urine samples were stored at 4°C and processed within the 24 hours after collection.

Identification of microorganisms was made by plating on chromogen coagulase positive *staphylococci* (CPS) agar (BioMerieux, France) and by incubation for 18–24 h at 35 ± 2^0C.

The exclusion criteria were contamination (growth of two or more bacterial species) and negative samples [bacterial growth lower than 10^3 colony-forming units (CFU)/mL of urine]. The inclusion criterion was monomorphic bacterial growth higher than 10^5 CFU/mL of the culture. All isolates were subjected to antimicrobial susceptibility testing AST.

The AST was made by the disk-diffusion method on Mueller-Hinton Agar (Biomerieux, France) and interpreted according to the guidelines of the Clinical and Laboratory Standards Institute [12] by measuring the diameter of the zones of inhibition. The following antibiotics were analyzed: penicillin (10 µg/mL), ampicillin (25 µg/mL), cephalexin (30 µg/mL), cefaclor (30 µg/mL), cefotaxime (30 µg/mL), ceftriaxone (30 µg/mL), meropenem (10 µg/mL), tetracycline (30 µg/mL), gentamicin (10 µg/mL), amikacin (30 µg/mL), ofloxacin (5 µg/mL), ciprofloxacin (5 µg/mL), trimethoprim-sulfamethoxazole (2.5 µg/mL) and nitroxolin (20 µg/mL).

Primary analysis of collected data was made by descriptive statistics. The difference between females and males in the frequency of positive samples to each of the agents was analyzed by $\chi 2$-test. Statistical hypotheses were considered true if probability of null-hypothesis was less than 0.05. All calculations were performed by the statistical software SPSS (SPSS Inc, ver.18, Chicago, IL).

Results

During the study period, there were 71,905 urine cultures, and 24,713 (34.37%) of them were positive for bacterial pathogens. Generally, the most common pathogen was *E. coli* (56.56%), followed by *Klebsiella* spp (16.20%), *Proteus* spp (14.68%), *Enterococcus* spp (5.29%) *and Pseudomonas aeruginosa* (3.74%), all accounting for over 95% of total isolates (Table 1). Gram-negative agents consisted 93.28% of urinary pathogens.

The isolates were obtained from 24,713 patients, 1 to 94 years of age (median 58.1 years). Nearly 70% of all isolates were from women [female to male ratio (F/M) was 2.21 (17,015/7,698)] (Table 2). The isolates frequency according to the age distribution of the patients is presented in Table 3. Female to male ratio was the highest in 15–29 years age group (F/M = 13.0) and the lowest in the oldest one (F/M = 1.5). There were significant gender differences in the isolation rates for four of the top five causative agents (the difference was not significant only for *Enterococcus* spp.): *E. coli* was isolated more frequently in females (11,953/17,015; 70.25%), whereas *Klebsiella* spp. (2,305/7698; 29.94%), *Proteus* spp. (1,970/7698; 25.59%) and *Pseudomonas aeruginosa* (646/7,698; 8.39%) were more common in men (Table 2).

All five the most prevalent bacterial isolates differed in regard to the isolation rate between the age groups (Table 3). *E. coli* was less prevalent in the oldest subjects (7,676/14,816; 51.81%) and more prevalent in the age groups 15–29 (1,268/1,797; 70.56%) and 30–59 years (3,798/6,071; 62.56%).

The data stratification according to both gender and age showed significant differences in regard to frequency of isolation between females and males throughout all age groups (Table 3). Furthermore, *E. coli* and *Enterococcus* spp were less frequently isolated in males ≥ 60 years old (1,407/5,935; 23.71% and 289/5,935; 4.87%, respectively), while *Klebsiella* spp was more prevalent in this group (1,903/5,935; 32.06%). The most common causative agents isolated from 15–29 years old patients were *Enterococcus* spp. and *Pseudomonas aeruginosa* (17/128; 13.28% each). Interestingly, *Proteus* spp. and *E. coli* were the most prevalent (170/477; 35.64 % each) isolates in young males ≤ 14 years old.

Among women, the isolation rate of *E. coli* was high in all age groups (around 70%). *Proteus* spp. was frequently isolated from females ≤ 14 years old (206/1,552; 13.27%), while *Klebsiella spp.* was the most frequent in the oldest age group (976/8,881; 10.99%) (Table 3).

The pattern of resistance to antibiotics of main isolated uropathogens is shown in Table 4. Isolates of *E. coli* showed moderate degree of resistance to trimethoprim-sulfamethoxazole (40.1%), while resistance to fluoroquinolones was lower (32.6% ofloxacin and ciprofloxacin 26.1%), as well as the resistance to aminoglycosides (23.0% for gentamicin, and 6.1% for amikacin). Percentage of the isolates resistant to the 1st and 2nd generation of cephalosporins was the same, 32.1%, while that to the 3rd generation was 10.7%.

Isolated uropathogen *Klebsiella* spp. showed high degree of resistance to fluoroquinolones (64.4–66.6%), trimethoprim-sulfamethoxazole (69.1%) and cephalosporins of the 1st, 2nd and 3rd generation (57.7–72.5%).

Table 1
Distribution of bacterial isolates from urine samples

Microorganism	n	%
All gram-negative	23,056	93.28
Escherichia coli	13,977	56.56
Klebsiella spp.	4,004	16.20
Proteus spp.	3,629	14.68
Pseudomonas aeruginosa	924	3.74
Acinetobacter spp.	270	1.09
Pseudomonas spp.	203	0.82
Providencia spp.	49	0.19
All Gram-positive	1,657	6.72
Enterococcus spp.	1,307	5.29
Streptococcus beta-haemolyticus group B	272	1.10
Coagulase-negative staphylococci	47	0.19
Staphylococcus aureus	27	0.12
Staphylococcus saprophiticus	4	0.02
Total	24,713	100.0

Table 2
Distribution of the most common bacterial isolate from urine samples by gender of the patients

Microorganism	Isolates, n (%)			*p*-values
	All (n = 24,713)	Males (n = 7,698)	Females (n = 17,015)	
Escherichia coli	13,977 (56.56)	2,024 (26.29)	11,953 (70.25)	< 0.001
Klebsiella spp.	4,004 (16.20)	2,305 (29.94)	1,699 (9.99)	< 0.001
Proteus spp.	3,629 (14.68)	1,970 (25.59)	1,659 (9.75)	< 0.001
Enterococcus spp.	1,307 (5.29)	411 (5.34)	896 (5.27)	0.708
Pseudomonas aeruginosa	924 (3.74)	646 (8.39)	278 (1.63)	< 0.001
All other Gram-negative	522 (2.11)	295 (3.83)	227 (1.33)	< 0.001
All other Gram- positive	350 (1.42)	47 (0.61)	303 (1.78)	< 0.001

Table 3

Distribution of the five most common bacterial isolates from urine samples by gender and age groups of the patients

Microorganism	≤ 14 years	15–29 years	30–59 years	≥ 60 years	*p*-values
Total, n					
males	477	128	1,158	5,935	
females	1,552	1,669	4,913	8,881	
all	2,029	1,797	6,071	14,816	
Escherichia coli, n (%)					
males	170 (35.64)	37 (28.91)	410 (35.41)	1,407 (23.71)	0.002[a]
females	1,065 (68.62)	1,231 (73.76)	3,388 (68.96)	6,269 (70.59)	
all	1,235 (60.87)	1,268 (70.56)	3,798 (62.56)	7,676 (51.81)	< 0.001[b]
Klebsiella spp, n (%)					
males	99 (20.75)	21 (16.21)	282 (24.35)	1,903 (32.06)	< 0.001
females	98 (6.31)	100 (5.99)	525 (10.69)	976 (10.99)	
all	197 (9.71)	121 (6.73)	807 (13.29)	2,879 (19.42)	< 0.001
Proteus spp, n (%)					
males	170 (35.64)	29 (22.66)	215 (18.57)	1,556 (26.22)	< 0.001
females	206 (13.27)	133 (7.97)	460 (9.36)	860 (9.68)	
all	376 (18.53)	162 (9.02)	675 (11.12)	2,416 (16.31)	< 0.001
Enterococcus spp, n (%)					
males	28 (5.87)	17 (13.28)	77 (6.65)	289 (4.87)	< 0.001
females	89 (5.73)	129 (7.73)	276 (5.61)	402 (4.53)	
all	117 (5.77)	146 (8.12)	353 (5.81)	691 (4.66)	< 0.001
Pseudomonas aeruginosa, n (%)					
males	6 (1.26)	17 (13.28)	105 (9.07)	518 (8.73)	< 0.001
females	57 (3.67)	6 (0.36)	74 (1.51)	141 (1.59)	
all	63 (3.1)	23 (1.28)	179 (2.95)	659 (4.45)	< 0.001

a – analysis of distribution of isolat rates among age groups by gender of patients or b – in all patients.

Table 4

Resistance pattern (%) of the most common bacterial isolates from urine samples

Microorganism	Antibiotic													
	PEN	AMP	CFL	CFC	CET	CTR	MER	TR	GEN	AMC	OFX	CIP	SXT	NTX
Escherichia coli	-	57.8	32.1	32.1	10.7	10.7	9.8	-	23.0	6.1	32.6	26.1	40.1	2.7
Klebsiella spp	-		72.5	72.5	57.7	58.0	11.2	-	59.8	30.2	66.6	64.4	69.1	3.6
Proteus spp	-	79.5	72.8	70.2	50.4	49.3	10.4	-	63.6	44.5	63.9	60.2	74.7	2.1
Pseudomonas aeruginosa	-	98.8	98.9	98.8	78.1	78.0	29.2	-	81.5	47.5	82.6	78.3	98.1	-
Acinetobacter spp	-	85.8	77.8	77.5	57.7	58.6	18.2	-	57.7	25.1	69.4	63.7	44.5	-
Pseudomonas spp	-	87.2	76.3	77.2	51.2	45.1	23.9	-	55.8	36.4	56.1	60.4	81.9	-
Enterococcus spp	7.0	7.5	-	-	-	-	-	84.4	69.9	-	-	43.1	9.1	-
Streptococus beta-haemolyticus group B	5.1	4.1	11.9	15.4	11.1	6.3	-	49.3	25.0	50.0	-	16.5	37.4	-

PEN – penicillin, AMP – ampicillin, CFL – cephalexin, CFC – cefaclor, CET – cefotaxime, CTR – ceftriaxone, MER – meropenem, TR – tetracycline, GEN – gentamicin, AMC – amikacin, OFX – ofloxacin, CIP – ciprofloxacin, SXT– trimethoprim-sulfamethoxazole, NTX – nitroxolin; -: not tested.

Proteus spp. isolates were highly resistant to trimethoprim-sulfamethoxazole (74.7%), ampicillin (79.5%) and the fluoroquinolones (63.9% ofloxacin and 60.2% ciprofloxacin). The other gram-negative bacteria also showed high degree of resistance to tested antimicrobial drugs.

The most commonly isolated uropathogen from the gram-positive group, *Enterococcus* spp. showed a low grade of resistance to ampicillin (7.5%), and trimethoprim-sulfamethoxazole (9.1%), but a high grade of resistance to tetracyclines (84.4%).

Discussion

Knowledge of the local or regional etiology of UTIs and antimicrobial resistance can be very useful as a guide for empirical therapy, because the frequency of pathogens and their features vary according to time and geographical area. As these infections are very common, adequate treatment have an important role in regard to the patients' health, development of antibiotic resistance and health care costs [1]. A large number of bacterial isolates included in this study (obtained from routine urine analyses), allowed stratification of data according to gender and age, and evaluation of association of these variables and UTI etiology, as well as determination of susceptibility of uropathogens to commonly prescribed antimicrobial drugs.

In our study, over 90% of all isolates were gram-negative pathogens. As it was expected, *E. coli* was the most frequent isolate (56.56%). It was also the most frequent uropathogen associated with the community-acquired UTIs (being implicated in more than a half of all the UTIs) in other studies [5, 13]. *E. coli* generally belongs to normal flora of human colon and therefore may easily colonize the urinary tract. The other gram-negative pathogens found in this study were *Klebsiella* spp. *Proteus* spp. and although they were isolated in small percentages, they play substantial role in UTIs due to their pathogenicity and high resistance to antibiotics [14, 15].

In our study the obtained isolation rate of gram-positive bacteria was relatively low (6.72%) and among them, *Enterococcus* spp was responsible to 5.28% of UTIs. The other studies show similar results, confirming that these bacteria have minor role in UTIs [16]. However, true frequency is still unknown, since the studies published about the topic differ in design, sample size, inclusion and exclusion criteria and presentation style.

Women are more likely to experience UTIs than men. Nearly 70% of all isolates in our study were obtained from women. This could be explained by anatomical differences: the urethra is shorter and closer to the anal orifice in women than in men. Furthermore, women are more likely to get an infection after sexual activity or when using a diaphragm for birth control. Pregnancy and menopause also increase risk from UTIs [6].

In our study, significant difference was also found in frequency of certain uropathogens in relation to gender: *E. coli* was isolated more frequently in females, whereas *Klebsiella* spp., *Proteus* spp. and *Pseudomonas aeruginosa* were more common in men, which is consistent with the results of other authors [4]. Previous studies have indicated that some uropathogens, especially *Pseudomonas aeruginosa*, were strongly associated with particular host characteristics, including male gender, recent antibiotic therapy, prior urinary tract procedures and neurogenic bladder [17].

In our study significant differences in etiology of UTIs among different age groups were observed, too. Besides, frequencies of urinary pathogens were different across both age- and gender-stratified groups. *E. coli*, for example, was less prevalent in the oldest males (23.71%), but highly frequent in female patients from all age groups (approximately 70%). *Klebsiella* spp. was the most common in the oldest age group in both men and women (32.06% and 10.99%, respectively), and *Proteus* spp. frequency was highest in younger age groups of both males and females (35.64% and 13.27%, respectively). Age of the patients was linked to etiology of UTIs in several recent publications [18–20]: the study similar to our with the data stratification according to both age and gender showed lower *E. coli* isolation rate in both males ≥ 60 years old (52.2%) [*Escherichia faecalis* and *Pseudomonas aeruginosa* were frequent in this group (11.6% and 7.8%, resp.), and in those ≤ 14 years old (51.3%) (*Proteus mirabilis* was highly prevalent in this group: 21.2%]. On the other hand, Linhares et al. [21] in a ten-year study did not find differences in uropathogen isolation rates among age groups of patients with an UTI. However, when the age groups were stratified according to gender, the isolation rate increased with the age.

Proteus mirabilis is the most frequent uropathogen in boys [22], which should be borne in mind when prescribing antimicrobial drugs to boys. On the other hand, the results of our study indicate that *Proteus* spp. is an important urinary pathogen in young females, in spite of its low frequency in the preadolescent female genital tract flora [23].

The misuse of antibiotic drugs in medicine has led to an alarming increase of the microbial resistance [24] and the consequent spread of antibiotics-resistant strains is a serious public health problem. Approximately 15% of all community-prescribed antibiotics in the USA [25] and some European countries [26] are dispensed for UTIs. Prudent use of available antibiotics is the only option to delay the development of resistance [27] and the urological community has a responsibility to contribute to these efforts. Therefore, it is necessary to follow the guidelines of EAU in treatment of UTIs. Also, it must be noted that the recommended antibiotic for the first-line therapy pivmecillinam is not registered in Serbia and that the fosfomycin and nitrofurantoin are not frequently used, so it was not possible to draw some conclusions about their effectiveness in treatment of UTIs.

In our study, 40.1% of isolates of *E. coli* were resistant to trimethoprim-sulfamethoxazole, while the percentage of resistance to fluoroquinolones was lower (32.6% ofloxacin and ciprofloxacin 26.1%), but still relatively high and in line with other European countries [28, 29]. This is probably due to extensive utilization of these antibiotics in treatment of community-acquired UTIs over the past decade in this region. Although values may vary among reports, resistance rate of recently community-isolated of *E. coli* to trimethoprim-sulfamethoxazole in Europe tends to be higher than 30% [30, 31].

According to the international Antimicrobial Resistance Epidemiological Survey on Cystitis (ARESC) conducted from 2003 to 2006, *E. coli* showed a high resistance to sulfonamides (29.4%) and to fluoroquinolone ciprofloxacin (8.1%) in nine European countries and in Brazil [32], thus limiting use of these antibiotics in empirical therapy. It is necessary that entire community makes significant effort to maintain sensitivity of urinary pathogens to antibiotics which could be given for treatment of UTIs. What was encouraging from this study is relatively low level of resistance to second-line antibiotics for UTIs, aminoglycosides (gentamicin and amikacin, 23.0% and 6.1%, respectively) and third generation cephalosporins (cefotaxime and ceftriaxone, 10.7% both). However, some of these drugs do not exist in the oral form and are more expensive for the treatment of UTIs.

The isolates of *Klebsiella* spp. in our study showed a high degree of resistance to fluoroquinolones (64.4–66.6%), trimethoprim-sulfamethoxazole (69.1%) and second- and third-generation cephalosporins (57.7–72.5%), which is 2–3 times higher than in other recent European studies [21]. This result is worrisome due to a high proportion of UTIs caused by *Klebsiella* spp. in our community (16.2%).

The resistance rate to uropathogens *Proteus* spp. isolated in our study was generally high for all tested antibiotics. The resistance rate of this isolate to trimethoprim-sulfamethoxazole is 74.7%, 79.5% to ampicillin, 63.9% to ofloxacin and 60.2% to ciprofloxacin, which is much higher than the rates shown in other similar studies [20].

Conclusion

The results of our study are a useful tool for doctors who should prescribe antibiotics to patients with UTIs, as well as for regional health authorities who intend to formulate recommendations for rational antibiotic use and define standard treatment guidelines. When prescribing drugs for UTIs, Serbian physicians should be aware of a high resistance rate of urinary pathogens not only to semi-synthetic penicillins and cephalosporins (> 30%), but also to fluoroquinolones (> 25%) and trimethoprim-sulfamethoxazole (> 40%), and choose among the antibiotics with still low resistance rates. Choice of antibiotics for treatment of UTIs should be governed not only by the local resistance patterns, but also by gender and age of patients.

Acknowledgements

This study was partially financed by Research grant No. 175007 given by Serbian Ministry of Education, Science and Technological Development. The authors have no conflict of interests concerning its content or conclusions.

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Received on January 22, 2015.
Revised on December 27, 2015.
Accepted on January 19, 2016.
Online First July, 2016.