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**Antimicrobial Resistance Pattern of Gram-negative Bacteria Causing Urinary Tract Infection.**Farjana Rahman<sup>1</sup>, Sadia Chowdhury<sup>1</sup>, Md. Majibur Rahman<sup>1</sup>, Dilruba Ahmed<sup>2</sup>, Anowar Hossain<sup>2</sup>Department of Microbiology, Stamford University Bangladesh<sup>1</sup>  
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**ABSTRACT**

Urinary tract infection (UTI) is a common and occasional recurrent bacterial illness with an increasing resistance to antimicrobials. Antibiotic resistance in UTI is a growing public health problem in the world including Bangladesh. The study objective was to examine the present incidence of UTIs in Bangladesh in a point period of time from January to December 2007. A retrospective data analysis of culture results of urinary pathogens was performed. The data was collected from the Clinical Microbiology Laboratory of International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B). The data included culture results of 9,854 urine samples and only Gram-negative isolates irrespective of age groups were analyzed. The prevalence of UTI was observed in 24.14%. It was observed that out of 2,379 uropathogens *Escherichia coli* (66.92%) was the most prevalent isolate followed by *Klebsiella* spp. (13.45%), *Proteus* spp. (6.77%) and *Pseudomonas* spp. (6.77%). The percentage of resistance to different antibiotics was higher in *E. coli*, *Klebsiella* spp. and *Pseudomonas* spp. isolates compared to that of others. Among the total number of isolates the resistant rate of *E. coli* and *Klebsiella* spp. to ampicillin was 86.09% and 83.33% and to cotrimoxazole was 67.61% and 59.81%, their resistance rate to nalidixic acid was 83.28% and 61.54%. All other isolates also showed above 80% resistance to ampicillin and above 50% to cotrimoxazole whereas imipenem was found to be the most effective against the uropathogens followed by amikacin.

**Key Words:** Urinary tract infection, Antimicrobial resistance, Uropathogens, Bacteriuria, Gram-negative bacteria

**INTRODUCTION**

Urinary tract infection (UTI) is one of the most common bacterial illnesses associated with leading cause of morbidity and health care expenditures in persons of all ages (Kunin CM, 1994). A variety of organisms entering the urinary tract establish bacteriuria often at levels more than or equal to 10<sup>5</sup> colony forming units of bacteria/ml of urine. It can affect both individual patients as well as in patients staying in hospital for long period especially in adult patients when they are some kind of incubations such as catheterization and venous shunt. Several studies reported that hospital acquired UTI is about 33% (Gupta et al., 2001). Majority of pathogens are gram-negative species, with predominance of members of *Enterobacteriaceae* (Neu, 1992). Increasing antimicrobial resistance in bacterial pathogens is a worldwide concern. The prevalence of antimicrobial resistance among UTI agents is also increasing (Mathai et al., 2001; Karlowsky et al., 2001) and its treatment has become more complicated due to increasing resistance and empirical therapy leading to treatment failures mostly associated with gram-negative bacteria (Blondeau et al., 1999). The present study investigated the pattern of gram-negative uropathogens and their antimicrobial resistance pattern among the clinical isolates to thirteen commercially available antibiotics that are often prescribed in UTI cases.

## METHODS AND MATERIALS

### *Study Samples and the site*

The culture results of urine submitted to Microbiology Lab of Clinical Laboratory Services of ICDDR, B was retrospectively analyzed from January 2007 to December 2007. Culture results showing colony count of  $\geq 1 \times 10^4$  cfu/ml of urine was considered for this analysis. However, patients with high number of pus cells in per high power field were also included in the study when associated with gram-negative bacteria for UTI.

### *Laboratory techniques*

In brief, one calibrated loopful urine samples were streaked on to MacConkey agar (MAC) and Blood agar media and incubated aerobically at 37°C for 24 hours for isolation and identification of urinary pathogens. The colony characteristics were then examined. The pink colonies on MAC were lactose-fermenters and most likely to be *E. coli*, *Klebsiella*, or other coliforms. If colonies were colorless, they were lactose-nonfermenters. The clinical isolates were characterized by gram-stain, oxidase test, motility, citrate utilization and biochemically for species identification (Cappuccino G. and Sherman N., 1996). The bacterial colony count was then determined following the defined formula.

### *Antibiotic susceptibility assay of bacterial isolates*

The standard agar-disc-diffusion method (Kirby Bauer technique) was used to determine the bacterial in-vitro susceptibility to different antibiotics towards gram-negative bacteria. Antibiotic and their potencies included were ampicillin (10µg), cotrimoxazole(23.75µg), nalidixic acid (30µg), nitrofurantoin (300µg), ceftriaxone (30µg), ciprofloxacin (5µg), gentamicin (10µg), ceftazidime (30µg), imipenem (10µg), mecillinam (25µg), amikacin (30µg), cefixime (5µg), and netilmicin (30µg).

### *Bacterial inoculums*

A suspension of test organisms was prepared using Muller-Hinton broth by adjusting the turbidity of the broth with normal saline to match the equivalent turbidity standard of McFarland (0.5 standards) and incubated for 2 hours. A sterile cotton swab was dipped into suspension and excess fluid was removed by pushing and rotating the swab firmly against the inside of the tube above the liquid level. The swab was then lawned evenly over the entire surface of a Muller-Hinton agar plate to obtain uniform inoculums. Antibiotic discs were applied aseptically to the surface of the inoculated plates at appropriate spatial arrangement by means of sterile needle within a distance of 5mm. The plates were then inverted and incubated at 37° C for 24 hours. After incubation, the plates were examined and the diameters of the zones of complete inhibition were measured in mm. The zone diameters for individual anti-microbial agents were translated into susceptible, intermediate and resistant categories according to Clinical Laboratory Standard Institute (CLSI) guideline.

## RESULTS

A total of 2,379 (24.14%) gram-negative isolates were yielded from 9,854 urine cultures. The detail background of the gram-negative isolates was included in Table-1. However, out of 2,379 isolates, the majority were *Escherichia coli* isolates (1592; 66.92%) followed *Klebsiella* spp. (320; 13.45%) and the equal numbers of *Proteus* spp. and *Pseudomonas* spp. (161; 6.77%). Less frequently isolated pathogens were *Acinetobacter*, *Enterobacter*, *Citrobacter* etc whose isolation rate in varied between 3.19 to 0.04%. Antibiotic susceptibility pattern of Gram-negative bacteria isolated from this study was shown in Table-2. Results showed that the majority (99%) of the isolates (*Escherichiae coli*, *Klebsiella*, *Proteus*, *Enterobacter*, *Pseudomonas*, *Acinetobacter* and *Enterobacter* spp.) were highly resistant to ampicillin, mecillinam, nalidixic acid, cotrimoxazole, nitrofurantoin, gentamicin, ciprofloxacin, cefixime, ceftazidime and ceftriaxone. Only a minor number of isolates (1%) were moderately resistance to imipenem, netilmicin and amikacin.

**Table 1. Frequency of bacteria causing urinary tract infection**

Bacteria	No of isolates	Frequency (%)
<i>Escherichia coli</i>	1592	66.92
<i>Klebsiella</i> spp	320	13.45
<i>Proteus</i> spp	161	6.77
<i>Pseudomonas</i> spp	161	6.77
<i>Acinetobacter</i> spp	76	3.19
<i>Enterobacter</i> spp	49	2.06
<i>Citrobacter</i> spp	04	0.17
<i>Moraxella</i> spp	04	0.17
<i>Salmonella typhi</i>	03	0.13
<i>Providencia</i> spp	03	0.13
<i>Serratia</i> spp	01	0.04
Other minor pathogens	05	0.21

*E. coli* showed highest resistance to ampicillin (86.09%), nalidixic acid (83.28%), ceftazidime (73.04%) and cotrimoxazole (67.83%). *Klebsiella* showed resistance to ampicillin (83.33%), mecillinam 70.59%), nalidixic acid (61.54), cotrimoxazole (59.80%). The *Proteus* had mecillinam resistance (86.21%), ampicillin (84.17%), nitrofurantoin 79.35%; while *Pseudomonas* had mecillinam resistance (93.55%), nitrofurantoin (87.50%), ampicillin (82.86%), nalidixic acid (81.82%). The *Enterobacter* had ampicillin resistance (97.87%), ceftazidime (85.71%), while *Acinetobacter* had ceftazidime resistance (94.44%), nitrofurantoin (93.33%) and mecillinam (63.64%). *Citrobacter* had ceftazidime resistance (100%), and ampicillin (66.67%). The *Providencia* had 100% resistance to ampicillin, netilmicin, amikacin and imipenem and 66.77% resistance to cotrimoxazole, mecillinam and nitrofurantoin.

**Table 2: Antibiotic resistance pattern of individual isolates\***

Bacterial spp.	Antibiotic Used												
	Ak	Amp	Caz	Cip	Cot	Cro	Gen	Imp	Mec	Nal	Net	Nit	CFM
<i>Escherichia coli</i>	16.45	86.09	73.04	67.83	67.6	49.75	37.44	1.05	43.01	83.28	29.06	12.19	50.63
<i>Klebsiella</i> spp	8.5	83.33	47.62	54.43	59.8	51.9	39.87	7.92	70.59	61.54	18.18	53.94	53.4
<i>Proteus</i> spp	7.4	84.17	27.45	16.56	52.3	10.83	13.55	5.88	86.21	55	17.31	79.35	23.85
<i>Pseudomonas</i> spp	30.66	82.86	46.66	49.68	52.3	53.85	48.72	18.88	93.55	81.82	30.03	87.5	69.34
<i>Enterobacter</i> spp	25	97.87	85.71	26.53	31.3	31.25	18.75	0	40.91	48.94	33.33	56.25	29.55
<i>Acinetobacter</i> spp	65.22	56.77	94.44	29.33	37.3	29.33	54.32	13.64	63.64	38.36	52.63	93.33	52.11
<i>Citrobacter</i> spp	0	66.67	100	50	50	25	50	0	50	50	0	25	25
<i>Moraxella</i> spp		0		0	50	0						0	0
<i>Typhi gr Salm</i>	0	50		0	67	0	0		33.33	100		0	33.33
<i>Serratia</i> spp		100		0	0	0	0		100	0		100	0
<i>Providential</i> spp	100	100	100	33.33	66.7	0	33.33	100	66.67	33.33	100	66.67	33.33
<i>Non-typhi Sal</i>		0		0	0	0	0		0	0		0	0

Abbreviations: Ak, amikacin, AMP, ampicillin, Caz, Ceftazidine, Cip, ciprofloxacin, Cot, cotrimoxazole, Cro, Ceftriaxone, Gen, gentamicin, Imp, imipenem, Mec, mecillinam, Nal, nalidixic acid, Net, netilmicin, Nit, nitrofurantoin, CFM, cefixime. \* Data are given as percentage of resistance.

The urinary isolates did not show any distinct seasonality (Figure 1). However, majority (66.46%) of the isolates were identified in the hot, moist and rainy season (April through October) and the rest (33.54%) were isolated in the dry winter season (November through March).

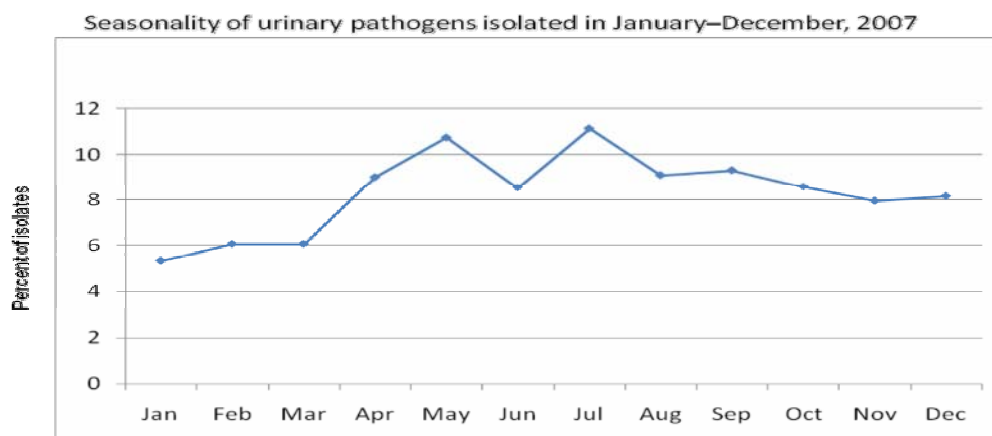


Figure-1: Seasonality of urinary pathogens in January-December, 2007

## DISCUSSION

Urinary tract infection results from urethral entry of enteric group of organisms into the urethra, bladder and kidneys. Recurrent and complicated urinary tract infections occur in patients with functionally, metabolically, or anatomically abnormal urinary tract. They are often associated with significant mortality and morbidity (Jarvis, 1996). A higher prevalence of UTI was reported in women than men, principally owing to anatomic and physical factors (Kumar et al., 2006; Khan et al., 2004). Even in developed country the average stay in hospital with UTI is on average 2.4 days with an associated additional cost at least between \$500 and \$700 (Jarvis, 1996). However, such cost estimated has not been found in our region. The present study mainly focuses the gram-negative isolates associated UTI in a segment of time for the period between January and December, 2007 and its seasonal pattern.

Antibiotic resistance is a major clinical problem in treating infections caused by microorganisms. The resistance to the antimicrobials has increased over the years. Resistance rates vary from country to country (Gales et al., 2001). Overall, isolates from Latin American countries show the high resistance rates to all antimicrobial agents followed by Asian-Pacific isolates and European strains; while the strains from Canada exhibit the lowest resistance pattern (Gales et al., 2001). In this study, it was accounted that majority of the organisms isolated were the members of Enterobacteriaceae family. This is consistent with reports where *E. coli* was the predominant pathogen isolated from patients with community acquired UTIs (Manges et al., 2006; Philippon et al., 1996). *E. coli* is the most important pathogen for uncomplicated and complicated UTI and has shown a slow but steady increase in resistance to several antibiotics over the past decade (Kahlmeter, 2003; Gales et al., 2002; Turnidge et al., 2002). In this study, the range of resistance of *E. coli* to ampicillin was 86.09% and that for cotrimoxazole was 67.83%. This resistance rates were higher than those in studies from developed countries; in the US (Vromen et al., 1999) the rates are 39.1 and 18.6%, and in the EU (Kahlmeter, 2003) they are 29.8 and 14.1%, respectively. On the other hand, similar rates have been found in other countries, such as Senegal (77%, 55%) (Dromigny et al., 2002); Spain (65%, 33%) (Daza et al., 2001); Taiwan (80%, 56%) (Lau et al., 2004); and Israel (66%, 33%) (Colodner et al., 2001). Therefore these drugs should no longer be prescribed as initial empirical therapy in our region. The susceptibility pattern of *E. coli* to imipenem and amikacin was very significant (98.95%, and 83.55%, respectively). There was also a significant susceptibility of *E. coli* to nitrofurantoin (87.81%), netilmicin (70.94%), and gentamicin (62.56%). The resistance rate of *E. coli* to extended spectrum cephalosporins (ceftazidime, ceftriaxone and cefixime) ranges from 60% to 75%, which is contrary to other community-acquired UTI studies in Europe, Israel and the US (Colodner et al., 2001; Mudur, 2000; Svetlansky et al., 2001; Hillier et al., 2002; Farrel et al., 2003). However, *Klebsiella pneumoniae* are rarely encountered in cases of community-acquired UTI (Kumar et al., 2006; Manges et al., 2006; Kunin, 1994). However, the present study indicated a significant association of *Klebsiella* spp. (13.45%) as UTI's pathogens, but due to data limitation it could not be ascertained to either community or hospital acquired infection. In this present study, *Klebsiella* spp. were shown high

sensitivity to amikacin (91.5%), imipenem (92.08%), and netilmicin (81.82%). The resistance rate to cephalosporins and fluoroquinolones (nalidixic acid, nitrofurantoin, ciprofloxacin) among *Klebsiella* spp. were moderate (40-60%). The isolates were highly resistant to ampicillin (83.33%) and mecillinam (70.59%). Isolates of *Pseudomonas* spp. were shown very high resistance to most antimicrobial agents. The rate of resistance to ampicillin, cotrimoxazole, mecillinam, nalidixic acid, nitrofurantoin and cefixime were 82.86%, 83.59%, 93.55%, 81.82%, 87.5%, and 84.38%, respectively. The resistance rate to ceftazidime, ciprofloxacin, ceftriaxone and gentamicin were moderate (49.46%, 49.68%, 53.85%, and 48.72%, respectively). Among antibiotics used in this investigation, *Pseudomonas* spp. isolates were very sensitive to imipenem (81.12%). Resistance rate to ampicillin, mecillinam and nitrofurantoin among *Proteus* spp. isolates was very high (84.17%, 86.21%, and 79.35%, respectively). These isolates were shown sensitivity to most of the antibiotics used in this study (ciprofloxacin, ceftriaxone, ceftazidime, gentamicin, netilmicin, and cefixime). They were shown high sensitivity rate to amikacin (92.96%) and imipenem (94.12%).

This study also showed that *Enterobacter* spp. isolates were very resistant to ampicillin and ceftazidime (97.87%, and 85.71%, respectively). The rate of sensitivity to imipenem among these isolates was 100% and above 65% isolates were sensitive to ciprofloxacin, ceftriaxone, cotrimoxazole, gentamicin, netilmicin, cefixime and amikacin (73.47%, 68.75%, 68.75%, 81.25%, 75%, and 70.45%, respectively). The resistance rate to mecillinam, nalidixic acid and nitrofurantoin were moderate (40-56%).

All the *Acinetobacter* spp. Isolates were shown high sensitivity to imipenem, ciprofloxacin, and ceftriaxone (86.66%, 70.67%, and 70.675%, respectively). The resistance rate of these isolates to ceftazidime and nitrofurantoin were high (94.44%, and 93.33%, respectively).

In this study, all the isolates were found to be sensitive to imipenem, netilmicin and amikacin. Imipenem exerts a bactericidal action by inhibiting cell wall synthesis in aerobic and anaerobic gram-negative bacteria, including most strains which are beta-lactamase producer. Inhibition of cell-wall synthesis is achieved in gram-negative bacteria by the binding of imipenem to penicillin binding proteins (PBPs). In the case of *E. coli* and selected strains of *Pseudomonas aeruginosa*, imipenem has been shown to have highest affinity for PBP-2, PBP-1a and PBP-1b, with lower activity against PBP-3. The preferential binding of imipenem on PBP-2 and PBP-1b leads to direct conversion of the individual cell to a spheroplast resulting in rapid lysis and cell death without filament formation. Imipenem is highly stable against  $\beta$ -lactamase and has an unusual property of causing a post antibiotic effect on gram-negative bacteria (Neu, 1992). Due to its small molecular size it can overcome the poor permeability of  $\beta$ -lactams for *Pseudomonas* by efficient penetration through the porin, OMPD (El Amin et al., 2005).

According to this study, all the isolates were shown differences in resistance between ampicillin, ceftazidime, ciprofloxacin, ceftriaxone, ceftazidime, cotrimoxazole, nitrofurantoin, nalidixic acid and gentamicin. Increasing resistance rate to all antibiotics used in this study with the exception of imipenem and amikacin may be explained as uncontrolled consumption of these antibiotics during the past decade in our region (Mudur et al., 2000; Svetlansky et al., 2001; Hillier et al., 2002).

Finally it can be concluded that the present study demonstrated that the uropathogens isolated have shown various trends in isolation rates and resistances to various classes of antimicrobial agents. In addition, multidrug-resistant *E. coli*, *Klebsiella* spp., *Pseudomonas* spp. can be expected to cause serious treatment problems. Therefore, it is essential to use the most appropriate antimicrobial management based on this study, in order to accurately assess the severity of patient's UTI, and to recognize the limits of conservative treatments.

## CONCLUSION

It is quite alarming to note that almost all of the isolates included in this study were found resistant to multiple drugs (four or more antibiotics). Antibiotic resistance has been emerged as a major problem in the management of hospitalized patients as well as those with chronic conditions and adds considerably to health care cost. It has been considered a threat to the public health problem worldwide. This important issue is to be addressed by the policy makers to formulate a strict antibiotics prescription policy in our country, which would aware the practitioners and care giver to make a prudent use antibiotics.

## REFERENCES

- Barrett SP, Savage MA, Rebec MP, Guyot A, Andrews N, Shrimpton SB. (1999) Antibiotic sensitivity of bacteria associated with community-acquired urinary tract infection in Britain. *J. Antimicrob. Chemother.* 44: 359-365.
- Blondeau JM, Tillotson GS. (1999) Formula to help select rational antimicrobial therapy (FRAT): its application to community and hospital-acquired urinary tract infections. *Int. J. Antimicrob. Agents.* 12:145-150.
- Cappuccino JG, Sherman N. (1996) Microbiology, A Laboratory Manual; 4<sup>th</sup> Ed. pp-186. The Benjamin-Cumming Publishing Company, Inc, Menlo Park, California.
- Colodner R, Keness Y, Chazan B, Raz R. (2001) Antimicrobial susceptibility of community-acquired uropathogens in Northern Israel. *Int. J. Antimicrob. Agents.* 18:189-192.
- Daza R, Grtierrez J, Piedrola G. (2001) Antibiotic susceptibility of bacterial strains isolated from patients with community- acquired urinary tract infections. *Int. J. Antimicrob. Agents.* 18: 211-215.
- Dromigny J A, Nebeth P, Perrier Gros Claude JD. (2002) Distribution and susceptibility of bacterial urinary tract infections in Darkar, Senegal. *Int. J. Antimicrob. Agents.* 20: 339-347.
- El Amin N, Giske CG, Jalal S, Keijsers B, Kronvall G, Wretling B. (2005) Carbapenem resistance mechanisms in *Pseudomonas aeruginosa*: alterations of porin OprD and efflux proteins do not fully explain resistance patterns observed in clinical isolates. *APMIS.* 113:187–96.
- Farrel DJ, Morrissey I, De Rubeis D, Robbins M, Felmingham D. (2003) A UK multi-center study of the antimicrobial susceptibility of bacterial pathogens causing urinary tract infection. *J. Infect.* 46: 94–100.
- Gales AC, Jones RN, Gordon KA, Sader HS, Wilke WW, Beach ML, Pfaller MA, Doern GV. (2000) The SENTRY Study Group (Latin America). Activity and spectrum of 22 antimicrobial agents tested against urinary tract infection pathogens in hospitalized patients in Latin America: Report from the second year of the SENTRY antimicrobial Surveillance program (1998). *J. Antimicrob. Chemother.* 45: 295-303.
- Gales AC, Sader HS, Jones RN. (2002) Urinary tract infection trends in Latin American hospitals: report from the SENTRY antimicrobial Surveillance program (1997-2000) *Diagn. Microbiol. Infect. Dis.* 44: 289-299.
- Gupta K, Sahm DF, Mayfield D, Stamm WE. (2001) Antimicrobial resistance among uropathogens that cause community acquired urinary tract infections in woman: a nationwide analysis. *Clin. Infect. Dis.* 33: 89-94.
- Hillier SL, Magee JT, Howard AJ, Palmer SR. (2002) How strong is the evidence that antibiotic use is risk factor for antibiotic-resistant, community -acquired urinary tract infection? *J. Antimicrob. Chemother.* 50:241–247.
- Jarvis WR. (1996) Selected aspects of the socioeconomic impact of nosocomial infections: morbidity, mortality, cost, and prevention. *Infect. Control Hosp. Epidemiol.* 17(8):552-557.
- Jones RN, Kugler KC, Pfaller MA, Winokur PL. (1999) The SENTRY Surveillance Group (North America). Characteristics of pathogens causing urinary tract infections in hospitals in North America: results from the SENTRY antimicrobial Surveillance program, 1997. *Diagn. Microbiol. Infect. Dis.* 35: 55-63.
- Kahlmeter G. (2003) Prevalence and antimicrobial susceptibility of pathogens in uncomplicated cystitis in Europe. The ECO. SENS study. *Int. J. Antimicrob. Agents.* (22): 49-52.
- Karlowsky JA, Jones ME, Thornsberry C, Critchley I, Kelly L, Sahm D. (2001) Prevalence of antimicrobial resistance among pathogens isolated from female outpatients across the US in 1999. *Int. J. Antimicrob. Agents.* 18: 121-127.
- Kataoka S, Tanimura M, Kondo K, Morioka M, Fujita Y. (1992) Pathogen occurrence and antimicrobial susceptibility trends among urinary tract infection-the second report. *Nishinohon J. Urol.* 54: 812-821.

- Khan AU, Musharraf A. (2004) Plasmid mediated multiple antibiotic resistance in *P. mirabilis* isolated from the UTI patients. *Medical Sci. Mon.* 10:598–602.
- Kumar MS, Lakshmi V, Rajagopalan R. (2006) Occurrence of extended spectrum beta-lactamases among Enterobacteriaceae spp. isolated at a tertiary care institute. *Indian J. Med. Microbiol.* 24:208–11.
- Kunin CM. (1994) Urinary tract infections in females. *Clin Infect Dis.* 18: 1-12.
- Lau SM, Peng MY, Chang FY. (2004) Resistance rates to commonly used antimicrobials among pathogens of both bacterial and non-bacterial community-acquired urinary tract infection. *J. Microbiol. Immunol. Infect.* 37: 185-191.
- Manges AR, Natarajan P, Solberg OD, Dietrich PS, Riley LW. (2006) The changing prevalence of drug-resistant *Escherichia coli* clonal groups in a community: evidence for community outbreaks of urinary tract infections. *Epidemiol. Infect.* 134:425–31.
- Mathai D, Jones RN, Pfaller MA. (2001) Epidemiology and frequency of resistance among pathogens causing urinary tract infection in 1,510 hospitalized patients: a report from the SENTRY Antimicrobial Surveillance Program (North America). *Diag Microbiol Infect Dis.* 40: 129-136.
- Meharwal SK, Taneja N, Sharma SK, Sharma M. (2002) Complicated nosocomial UTI caused by nonfermenters. *Indian J. Urol.* 18:123–128.
- Mudur G. (2000) Drug resistant cholera in India attributed to antibiotic misuse. *BMJ.* 321:1368–9.
- Murakami K, Aoki Y, Iwaoka K, Tsuka H, Saikawa S, Wada O, Gohbara M, Akino H, Mori H, Takahashi M, Ikeda H, Oyama N, Fujita T, Miwa Y, Moriyama N, Nakamura N, Suzuki Y, Kanamura H, Okada K. (1995) Statistical studies on organisms isolated from urinary tract infections during a ten-year period. *Nishinohon J. Urol.* 57: 1260-1264.
- Nasu Y, Yamada D, Ozawa H, Nishimura M, Hayashi H, Maki Y, Fujimoto H, Nishitani Y, Sakuramoto K, Tsugawa M, Kishi M, Mizuno A, Kumon H, Omori H. (1998) Statistical studies of the relationship between organisms isolated from urinary tract infections prescribed antimicrobial agents. *Nishinohon J. Urol.* 50: 557-566.
- Neu HC. (1992) Urinary tract infections. *Am. J. Med.* 92: 63-70.
- Phislippon A, Arlet G, Lagrange PH. (1996) *Escherichia coli*: Frequency de resistance et evolution a divers antibiotiques urinaires dont la fosfomycine en milieu hospitalier. *Med. Mal. Infect.* 26:539–541.
- Sader HS, Jones RN, Winokur PK, Pfaller MA, Doern GV, Barrett T, the SENTRY Study group (Latin America). (1999) Antimicrobial susceptibility of bacteria causing urinary tract infections in Latin American Hospitals: results from the SENTRY Antimicrobial Surveillance Program, 1997. *Clin. Microbiol. Infect.* 5: 478-487.
- Svetlansky I, Liskova A, Foltan V, Langsadt L, Krcmery V. (2001) Increased consumption of fluoroquinolones is not associated with resistance in *Escherichia coli* and *Staphylococcus aureus* in the community. *J. Antimicrob. Chemother.* 48: 457–458.
- Turnidge J, Bell J, Biedenbach DJ, Jones RN. (2002) Pathogen occurrence and antimicrobial resistance trends among urinary tract infection isolates in the Asia-Western Pacific Region: report From the SENTRY antimicrobial Surveillance program (1998-1999). *Int. J. Antimicrob. Agents.* 20: 10-17.
- Vromen M, van der Ven AJ, Knols AM, Stobberingh EE. (1999) Antimicrobial resistance patterns in urinary tract isolates from nursing home residents. Fifteen years of data reviewed. *J. Antimicrob. Chemother.* 44: 113-116.
- Wagenlehner FME, Niemetz A, Dalhoff A, Naber KG. (2002) A spectrum and antibiotic resistance of uropathogens from hospitalized patients with urinary tract infections: 1994-2000. *Int. J. Antimicrob. Agents.* 19: 557-564.
- Weber G, Riesenber K, Schaeffer F, Peled N, Borer A, Yagupsky P. (1997) Changing trends in frequency and antimicrobial resistance of urinary pathogens in outpatients clinics and a hospital in Southern Israel, 1991-1995. *Eur. J. Clin. Microbiol. Infect. Dis.* 16: 834-838.