American Journal of Microbiological Research, 2016, Vol. 4, No. 4, 122-125
Available online at http://pubs.sciepub.com/ajmr/4/4/3

DOI:10.12691/ajmr-4-4-3

Antimicrobial Sensitivity Pattern of *Escherichia coli* Causing Urinary Tract Infection in Bangladeshi Patients

Nayareen Akhtar[1,*], Rezwanur Rahman[2], Shahin Sultana[1]

[1]Department of Microbiology, Delta Medical College
[2]Department of Nephrology, Bangladesh Medical College & Hospital
*Corresponding author: nayareen07@gmail.com

Abstract **Objectives**: Urinary tract infection (UTI) is a common bacterial infection in the Bangladesh community. There has been an increasing resistance by *Escherichia coli* to the commonly available antibiotics. The aim of the present study was to determine the prevalence of UTI, the common causative bacteria & antimicrobial susceptibility patterns of *E. coli* responsible for urinary tract infections (UTIs) to currently used antimicrobial agents. **Methods and Results:** In this study, three hundred urine specimens from clinically suspected UTI patients were collected from both outpatient and inpatient department during the period of February 2015 to January 2016 from a tertiary level hospital in the central part of country. The inclusion criteria included patients presenting with symptoms suggestive of UTI at the study site and who gave informed written consent to participate in the study. The exclusion criteria included patients on antibiotics within the last 2 weeks, and those with recent history of instrumentation. The urine samples received were processed using standard methods. Antimicrobial sensitivity patterns were performed on all *E. coli* isolates obtained from urine samples by disc diffusion method. Among 300 urine samples, (59%) yielded significant bacteriuria; 123 samples (41%) showed no growth. Out of 177 urine samples which showed significant bacterial growth, 72 (40.7%) samples comprised of males and 105 (59.3%) of females. Females within the age group of 20–29 years(26.67%) and elderly males of ≥60 years(34.7%) showed higher prevalence of UTI. 75.7% of isolates were found to be *Escherichia coli*, 7.9% *Klebsiella pneumoniae*, 5.6% *Proteus mirabilis*, *Pseudomonas aeruginosa* 5.1%, 1.7% *Enterococci faecalis*, 2.8% *Staphylococci saprophyticus* and 1.1% were *Staphylococcus aureus*. *E. coli* as the predominant cause of UTI, showed the highest percentage of resistance to co-trimoxazole, nalidixic acid and amoxicillin. The isolates were most sensitive to Imipenam, Meropenam, Nitrofurantoin and Amikacin. *Klebsiella pneumoniae* was the second most prevalent pathogen. **Conclusion:** *E. coli* was the most frequent isolate. Imipenam, Meropenam, Nitrofurantoin and Amikacin were shown to be very effective against *E. coli* organisms.

Keywords: *Urinary Tract Infections, Causative agents, Escherichia coli, Antimicrobial resistance*

Cite This Article: Nayareen Akhtar, Rezwanur Rahman, and Shahin Sultana, "Antimicrobial Sensitivity Pattern of *Escherichia coli* Causing Urinary Tract Infection in Bangladeshi Patients." *American Journal of Microbiological Research*, vol. 4, no. 4 (2016): 122-125. doi: 10.12691/ajmr-4-4-3.

1. Introduction

Urinary tract infections (UTIs) are one of the most common infectious diseases, and nearly 10% of people will experience a UTI during their lifetime. [1,2] The prevalence is increased by several factors. Poor socioeconomic status is reported to be a major risk factor with indigent patients having a fivefold increased risk. [3] Other risk factors include increased age, high parity, poor perineal hygiene, history of recurrent UTI, diabetes mellitus, neurogenic bladder retention, anatomic or functional urinary tract abnormality, and increased frequency of sexual activity. [4,5] UTI affect patients in all age groups and both sexes. [6] Neonates, girls, young women, and older men are most susceptible to UTIs. In women, bacterial cystitis is the most common bacterial infection. Every woman has a 60% lifetime risk of developing bacterial cystitis, which develops mostly before the age of 24. [7] The infections may be symptomatic or asymptomatic, and either type of infection can result in serious sequelae if left untreated. [8]

Although several different microorganisms can cause UTIs, including fungi and viruses, bacteria are the major causative organisms and are responsible for more than 95% of UTI cases. [9] Organisms that cause UTI are those from the normal vaginal, perineal, and fecal flora. [10,11] The vast majority of uncomplicated UTIs are caused by the Gram negative bacillus *Escherichia coli*, with other pathogens including *Enterococci*, *Staphylococcus saprophyticus*, *Klebsiella spp*. and *Proteus mirabilis*. [12] *Escherichia coli* is the most prevalent causative organism of UTI and is solely responsible for more than 80% of these infections. [12,13] An accurate and prompt diagnosis of UTI is important in shortening the disease course and for preventing the ascent of the infection to the upper urinary tract and renal failure. [13]

There have been reported cases of resistance to antibiotics by these UTI causing organisms. [14,15] The

extensive and inappropriate use of antimicrobial agents has invariably resulted in the development of antibiotic resistance which, in recent years, has become a major problem worldwide. [16] Following frequent use of broad spectrum antibiotics, the prevalence of these resistant bacteria is mainly due to widespread use of antibiotics in people and animal feeds. [14,17] These resistance properties are easily transferred between bacteria of different genera through plasmids and other means. To ensure appropriate treatment, knowledge of the organisms that cause UTI and their antibiotic susceptibility is mandatory. [18]

Therapy is based on information determined from the antimicrobial resistance pattern of the urinary pathogens. However, because of the evolving and continuing antibiotic resistance phenomenon, regular monitoring of resistance patterns is necessary to improve guidelines for empirical antibiotic therapy. [13,19,20]

The pathogens causing UTIs are almost always predictable [21], with *Escherichia coli* being the primary etiologic agent among both outpatients and inpatients accounting for 75 to 90% of urinary tract infection isolates. [22] Therefore, constant monitoring of drug resistance is required because only limited data describing multidrug resistance among UTI isolates is available. [21]

2. Methods

This prospective study was carried out in Centre for kidney disease & Urology Hospital, Dhaka during the period of February 2015 to January 2016. The study was conducted after due ethical approval which was subjected to the hospital administrations. After providing written informed consent, every patient was asked about symptoms suggestive of UTI (e.g., urgency, dysuria, urinary frequency, loin pain, and nausea). Midstream urine specimens from three hundred clinically suspected UTI patients that fulfilled the above criteria were selected. The participants were also selected on the basis of inclusion and exclusion criteria. The patients comprised both sexes and all age groups. Samples were collected using a sterile container that was refrigerated (4°C), and processed within 1 hour of collection. These samples were subjected to routine microscopy, culture, and sensitivity according to standard practice. A loopful urine sample was inoculated on MacConkey agar and blood agar plates and incubated aerobically at 37°C overnight and for 48 h in negative cases and read to assess growth of significant bacteriuria. A specimen was considered positive for UTI if an organism was cultured at a concentration of at least 10_5 single bacteria colonies per mL of urine and>5 pus cells per high-power field were observed on microscopic examination. [23] Then isolates were Gram-stained. Bacterial identification was based on standard culture and biochemical characteristics of isolates. *E. coli* was identified as medium, pink-to-red colonies and confirmed by positive indole test, whereas *K. pneumonia* were large, pink-to-mauve colonies, which were confirmed by negative oxidase and indole tests. *P. mirabilis* was assessed as small pale-to-colorless colonies testing negative to indole and oxidase and positive to urease. *Enterococcus faecalis* identified by the presence of small, turquoise colonies with coccoid morphology, which tested negative for catalase and positive for bile esculin. *Pseudomonas aeruginosa* can be isolated as clear colonies which will test positive for oxidase. Confirmatory tests include production of the blue-green pigment pyocyanin. *Staphylococcus aureus* was identified with the corresponding laboratory tests: catalase, coagulase, and mannitol test. Identified and pure isolates were maintained in nutrient agar slants and incubated at 37°C for 24 hrs. *S. saprophyticus* was identified as catalase positive, coagulase-negative and novobiocin-resistant species.

The disc diffusion method was used to determine the antimicrobial susceptibility of isolates. Standard inoculums were inoculated on Muller-Hinton agar and incubated at 37°C for 24 h. After 24 h, antimicrobial susceptibility and resistance was determined by isolate growth zone diameter.

3. Results

Of the 300 tested samples, total 177(59%) urine samples showed significant bacterial growth The majority 105(59.3%) of the isolates were from female while the remaining were from male. The highest prevalence of UTI in females was found in the age group of 20-29 years (26.67%); however in males the highest susceptible age group to UTI was ≥60years (34.7%). (Table 1).

Table 1. Age and sex distribution of patients with positive UTI

Age (years)	UTI group(Male) (n=72)		UTI group (Female) (n=105)	
	n	%	n	%
0-9	6	8.3	2	1.9
10-19	3	4.2	9	8.57
20-29	6	8.3	28	26.67
30-39	9	12.5	27	25.71
40-49	9	12.5	12	11.43
50-59	14	19.5	15	14.29
≥60	25	34.7	12	11.43

Table 2. Distribution of organisms isolated from patients with urinary tract infection

Bacterial pathogens	Frequency (%)
Escherichia coli	134(75.7%)
Klebsiella pneumoniae	14 (7.9%)
Pseudomonas aeruginosa	9(5.1%)
Proteus mirabilis	10(5.6%)
Enterococci faecalis	3 (1.7%)
Staphylococcus saprophyticus	5 (2.8%)
Staphylococcus aureus	2 (1.1%)

75.7% of isolates were *Escherichia coli*, 7.9% *Klebsiella pneumoniae*, 5.6% *Proteus mirabilis*, *Pseudomonas aeruginosa* 5.1%, 1.7% *Enterococci faecalis*, 2.8% *staphylococci saprophyticus* and 1.1% *Staphylococcus aureus*.

Table 3. Anti-microbial sensitivity pattern of Escherichia coli

Antibiotics	E.coli(134)	
	Sensitive	Resistant
Imipenam	121(90.3%)	13(9.7%)
Meropenam	120(89.6%)	14(10.5%)
Nitrofurantoin	119(88,8%)	15(11.2%)
Amikacin	117(87.3%)	17(12.7%)
Levofloxacin	96(71.7%)	38(28.4%)
Ceftazidime	86(64.2%)	48(35.8%)
Netilmicin	84(62.7%)	50(37.3%)
Mecillinam	79(58.9%)	55(41.1%
Ceftriaxone	72(53.7%)	62(46.3%)
Gentamycin	70(52.2%)	64(47.8%)
Cefuroxime	68(50.8%)	66(49.3%)
Ciprofloxacin	43(32.1%)	91(67.9%)
Amoxycillin	19(14.2%)	115(85.8%)
Nalidixic acid	17(12.7%)	117(87.3%)
Cotrimoxazole	3(2.2%)	131(97.8%)

E. coli isolates showed resistance to co-trimoxazole, nalidixic acid and amoxicillin in larger percentage respectively. *E. coli* isolates were highly sensitive to Imipenam, Meropenam, Nitrofurantoin and Amikacin

4. Discussion

Our study showed a high prevalence of UTI in females (59.3%) than in males (40.7%) which correlates with other findings which revealed that the frequency of UTI is greater in females as compared to males. [24,25] The reason behind this high prevalence of UTI in females is due to close proximity of the urethral meatus to the anus, shorter urethra, sexual intercourse, incontinence, and bad toilet. [26,27]

Females of the age group 20–29 years were found more susceptible (26.67 %) to UTI. These findings correlate with other reports which showed that females are more prone to UTIs than males during adolescence and adulthood. [28,29] The factors of this increasing incidence of UTI in young age females are associated with high sexual activity, recent use of a diaphragm with spermicide, and a history of recurrent UTIs. [30]

In our study it was found that the elderly males (≥60 years) had a higher incidence of UTI (34.7%) when compared with the elderly females. This finding is similar to a study conducted at a tertiary care hospital in Jaipur, Rajasthan, India. [31] The main cause behind this increasing incidence of UTI with advancing age in males is due to prostate enlargement and neurogenic bladder. [25] This factor is also reported by other authors whose studies showed that the prostate disease in males is responsible for the increase in incidence of UTI and decrease in female: male ratio in patients above 50 years. [32]

Of the 300 tested sample, 177 samples showed growth of pathogens among which the most prevalent were *E. coli* 134(75.7%) followed by *Klebsiella pneumoniae* 14(7.9%). Other isolated bacteria from UTI cases were *P.aeruginosa* (5.1%), *Proteus mirabilis* (5.6%), *S.aureus* (1.1%), *Enterococci faecalis*(1.7%) and *S.saprophyticus* (2.8%). Our study, as with previous studies, shows that *E. coli* is the predominant etiology of UTI. [33,34,35] The reason of the highest rate of *E.coli* is that they are normal fecal flora and uropathogenic strains of *E.coli* have an adherence factor called P fimbriae,or pili,which mediate the attachment of *E.coli* to uroepithelial cells. [36]

Our results also correlates with others in which *Klebsiella pneumoniae* was reported as the second most frequently isolated organism in UTI. [37,38] The results of our study show that among the heterogeneous causative organisms of UTI, Enterobacteriaceae are the predominant pathogens, followed by Gram-positive cocci. These findings are consistent with reports published from other countries. [39,40]

The highest percentages of resistance of *Escherichia coli* causing urinary tract infections were found for cotrimoxazole (97.8%), nalidixic acid (87.3%), amoxicillin (85.8%), whereas the highest percentages of sensitivity were seen for imipenem (90.3%), meropenem (89.6%), nitrofurantoin (88,8%) and amikacin (87.3%). These results correlates with a study done in Comilla Medical College, Bangladesh. [41] Khotaii et al. reported resistance rates of 87.5% to ampicillin, 67.5% to trimethoprim—sulfamethoxazole. [42] This significantly higher bacterial resistance to antibiotics in our region may be due to a higher rate of antibiotic usage, even in the absence of a prescription. Reducing the number of prescriptions of a particular antibiotic can lead to a decrease in resistance rates. [43,44] Another study conducted in India showed that meropenem was highly sensitive against Gram negative bacilli. [45] In other study, meropenem and imipenem were found to be 98% and 100% sensitive, respectively, against highly resistant gram negative bacilli. [46] A study done in King Fahd Hospital, Saudi Arabia showed that meropenem was 95.8% sensitive followed by amikacin (93.7%) and imipenem (91.71%) against extended spectrum β lactamase producing *E. coli*. [47]

5. Conclusion

It is concluded that most of the urinary tract infections in human are caused by *E. coli*. Regular monitoring of antimicrobial susceptibility for E.coli is recommended to improve treatment.

Acknowledgements

We would like to thank all the staffs who helped at the Microbiology lab in Centre for kidney disease & Urology Hospital. The authors also wish to thank Prof. Kamrul Islam, Prof. Rafiqul Alam, Prof. Dr. Syed Mukarram Ali, Prof. Dr. Zahedul Karim Ahmad and Prof. Dr. S. M. Fazlul Karim.

References

[1] Levi ME, Redington J, Barth L. The Patient With Urinary Tract Infection. Manual of Nephrology 6th Edition. Lippincott Williams & Wilkins. 2005; 7: 91.

[2] Delanghe J, Kouri TT, Huber AR, Hannemann-Pohl K, Guder WG, Lun A, et al. The role of automated urine particle flow cytometry in clinical practice. Clin Chim Acta 2000; 301: 1-18.

[3] Johnson EK, Wolf JS. Urinary Tract Infections in Pregnancy. [Accessed October 12, 2013]; Medscape. Available from: http://emedicine.medscape.com/article/452604-overview.

[4] Patterson TF, Andriole VT. Bacteriuria in pregnancy. Infect Dis Clin North Am. 1987;1(4):807-822.

[5] Schieve LA, Handler A, Hershow R, Persky V, Daris F. Urinary tract infection during pregnancy: its association with maternal morbidity and perinatal outcome. Am J Public Health. 1994; 84(3): 405-410.

[6] Gupta KAD, Hooton CL, Wobe, Stamm WE, 1999. The prevalence of antimicrobial resistance among uropathogens causing uncomplicated cystitisin young women. International Journal ofAntimicrobial agents 11: 305-308.

[7] Nicole W, Jon DM. Deciphering Dysuria. Emerg Med. 2008; 40(9): 29.

[8] Pezzlo M. Detection of urinary tract infection by rapid methods. Clin Microbiol Rev 1988;3:268-80.

[9] Bonadio M, Meini M, Spetaleri P, Gilgi C. Current microbiological and clinical aspects of urinary tract infections. Eur J Urol 2001;40:439-45.

[10] Cunningham FG, Gant NF, Leveno KJ, Gilstrap LC, III, Hauth JC, Wenstrom KD. Renal and Urinary Tract Disorders. In: Andrea Seils, Noujaim SR, Daris K., editors. Williams Obstetrics. 21st ed. New York: McGraw-Hill Medical Publishing Divsion; 2001. pp. 1251-1272.

[11] Arias F. Abnormalities of the urinary system during pregnancy. In: Daftary SN, Bhide AG, editors.Practical Guide to High Risk Pregnancy and Delivery. A South Asian Perspective. 3rd ed. New Delhi: Elsevier; 2008. pp. 489-505.

[12] Blondeau JM. Current issues in the management of urinary tract infections: extended-release ciprofloxacin as a novel treatment option. Drugs. 2004; 64(6): 611-28.

[13] National Committee for Clinical Laboratory Standards. Performance standards for antimicrobial disc susceptibility tests. 7th ed. Wayne, Pennsylvania, USA: NCCLS; 2000. M2-A7.

[14] Abdul IF, Onile BA. Bacterial isolates from urine of women in Ilorin and their antibiotic susceptibility patterns. Trop J Obstet Gynaecol. 2001;18(2):61-65.

[15] Arias F. Abnormalities of the urinary system during pregnancy. In: Daftary SN, Bhide AG, editors.Practical Guide to High Risk Pregnancy and Delivery. A South Asian Perspective. 3rd ed. New Delhi: Elsevier; 2008. pp. 489–505.

[16] Goldstein FW. Antibiotic susceptibility of bacterial strains isolated from patients with community-acquired urinary tract infections in France. Multicentre Study Group. Eur J Clin Microbiol Infect Dis. 2000; 19:112-7.

[17] Ezechi OC, Fasubaa OB, Dare FO. Antibiotic sensitivity patterns of microbial Isolates from urine of pregnant women with urinary tract infections. Trop J Obstet Gynaecol. 2003;20(2):113-115.

[18] Ashkenazi S, EvenTov S, Samra Z, et al. Uropathogens of various childhood populations and their antibiotic susceptibility. Pediatr Infect Dis J. 1991; 10: 742-6.

[19] Grude N, Tveten Y, Kristiansen BE. Urinary tract infections in Norway: bacterial etiology and susceptibility, a retrospective study of clinical isolates. Clin Microbiol Infect 2001;7:543-7.

[20] Kripke C. Duration of therapy for women with uncomplicated UTI. Am Fam Physician 2005;72:2219.

[21] Daniel F. Sahm, Clyde Thornsberry, David C. Mayfield,Mark E. Jones, James A. Karlowsky, 2001.Multidrug-Resistant Urinary Tract Isolates of *Escherichia coli:* Prevalence and Patient Demographics in the United States. Journal of Antimicrobial Agents Chemotherapy Vol. 45;5: 1402-1406.

[22] Nicolle LE, 2001. Epidemiology of urinary tract infection, Journal of Infection Medicine,18:153-162.

[23] J. G. Collee, R. S. Miles, and B. Watt, "Tests for the identification of bacteria," in Mackie and Mc Artney Practical Medical Microbiology, J. G. Collee, A. G. Fraser, B. P. Marmion, and A. Simmons, Eds., p. 433, Churchill Livingstone, London, UK, 1996.

[24] V. Rajalakshmi and V. Amsaveni, "Antibiotic susceptibility of bacterial pathogens isolated from diabetic patients," International Journal of Microbiological Research, vol. 3, no. 1, pp. 30-32, 2012.

[25] S. Sood and R. Gupta.Antibiotic resistance pattern of community acquired uropathogens at a tertiary care hospital in Jaipur, Rajasthan. Indian Journal of Community Medicine. 2012. 37(1): 39-44.

[26] O. A. Aiyegoro, O. O. Igbinosa, I. N. Ogunmwonyi, E. Odjadjaro, O. E. Igbinosa, and A. I. Okoh, "Incidence of urinary tract infections (UTI) among children and adolescents in Ile-Ife, Nigeria," African Journal of Microbiological Research, vol. 1, pp. 13-19, 2007.

[27] K. C. Arul, K. G. Prakasam, D. Kumar, and M. Vijayan, "A cross sectional study on distribution of urinary tract infection and their antibiotic utilization pattern in Kerala," International Journal of Research in Pharmaceutical and Biomedical Sciences, vol. 3, no. 3, pp. 1125-1130, 2012.

[28] B. A. M. Adedeji and O. A. Abdulkadir. Etiology and antimicrobial resistance pattern of bacterial agents of urinary tract infections in students of tertiary institution in Yola metropolis. Advances in Biological Researchno. 2009.3. (4): 67-70.

[29] I. Shaifali, U. Gupta, S. E. Mahmood, and J. Ahmed. Antibiotic susceptibility patterns of urinary pathogens in female outpatients. North American Journal of Medical Sciences. 2012. 4(4): 163-169.

[30] T. M. Hooton, D. Scholes, J. P. Hughes et al.A prospective study of risk factors for symptomatic urinary tract infection in young women. The New England Journal of Medicine.1996. 335. (7): 468-474.

[31] Jawetz, E. and Melnick, 1995. Clinical correlations: urinary tract in Medical Microbiology, 20th Ed. London, UK, PrenticeHall Intl Inc. p. 634.

[32] S. Shankel, Urinary Tract Infections Genitourinary Disorders, The Merck Manuals Online Medical Library, 2007.

[33] K. Shigemura, K. Tanaka, H. Okada et al., "Pathogen occurrence and antimicrobial susceptibility of urinary tract infection cases during a 20-year period (1983-2002) at a single institution in Japan,"Japanese Journal of Infectious Diseases, vol. 58, no. 5, pp. 303-308, 2005.

[34] M. Dash, S. Padhi, I. Mohanty, P. Panda, and B. Parida, "Antimicrobial resistance in pathogens causing urinary tract infections in a rural community of Odisha, India," Journal of Family and Community Medicine, vol. 20, no. 1, pp. 20-26, 2013.

[35] O. Omigie, L. Okoror, P. Umolu, and G. Ikuuh, "Increasing resistance to quinolones: a four-year prospective study of urinary tract infection pathogens," International Journal of General Medicine, vol. 2, pp. 171-175, 2009.

[36] E. M. Abubakar, "Antimicrobial susceptibility pattern of pathogenic bacteria causing urinary tract infections at the Specialist Hospital, Yola, Adamawa State, Nigeria," Journal of Clinical Medicine Research, vol. 1, no. 1, pp. 001-008, 2009.

[37] Johnson JR.Virulence factors in Escherichia coli urinary tract infection.Clin Microbiol Rev.1991;4(1):80-128.

[38] M. Sharifian, A. Karimi, S. R. Tabatabaei, and N. Anvaripour, "Microbial sensitivity pattern in urinary tract infections in children: a single center experience of 1,177 urine cultures, Japanese Journal of Infectious Diseases, vol. 59, no. 6, pp. 380-382, 2006.

[39] E. M. Abubakar, "Antimicrobial susceptibility pattern of pathogenic bacteria causing urinary tract infections at the Specialist Hospital, Yola, Adamawa State, Nigeria," Journal of Clinical Medicine Research, vol. 1, no. 1, pp. 001-008, 2009.

[40] J. C. Uwaezuoke and N. Ogbulie, "Antibiotic sensitivity pattern of urinary tract pathogens in Port-Harcourt, Nigeria," Journal of Applied Sciences and Environmental Management, vol. 10, no. 3, pp. 103-107, 2006.

[41] Majumder MI, Ahmed T, Hossain D, Begum SA. Bacteriology and antibiotic sensitivity patterns of urinary tract infections in a tertiary hospital in Bangladesh. Mymensingh Med J. 2014 Jan; 23(1):99-104.

[42] Khotaii Q, Mamishi S, Saligeh RN. Antibiotic resistance of germs isolated from urinary tract infections. Iran J Pediatr 2002;12:28-32.

[43] Garau J, Xercavins M, Rodriguez-Carballeira M, Gomez-Vera JR, Coll I, Vidal D, et al. Emergence and dissemination of quinoloneresistant Escherichia coli in the community. Antimicrob Agents Chemother 1999; 43: 2736-41.

[44] Natsch S, Conrad C, Hartmeier C, Schmid B. Use of amoxicillin-clavulanate and resistance in Escherichia coli over a 4-year period. Infect Control Hosp Epidemiol 1998;19:653-6.

[45] N. Goel, U. Chaudhary, R. Aggarwal, and K. Bala, "Antibiotic sensitivity pattern of gram negative bacilli isolated from the lower respiratory tract of ventilated patients in the intensive care unit," Indian Journal of Critical Care Medicine, vol. 13, no. 3, pp. 148-151, 2009.

[46] M.-L. Joly-Guillou, M. Kempf, J.-D. Cavallo et al., "Comparative in vitro activity of Meropenem, Imipenem and Piperacillin /tazobactam against 1071 clinical isolates using 2 different methods: a French multicentre study," BMC Infectious Diseases, vol. 10, article 1471, 2010

[47] A. J. Al-Zahran and N. Akhtar, "Susceptibility patterns of extended spectrum beta-lactamase (ESBL)-producing Escherichia coli and Klebsiella pneumoniae isolated in a teaching hospital," Pakistan Journal of Medical Research, vol. 44, pp. 64-67, 2005.