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Research Article

ASSESSMENT OF ANTIBIOTIC SENSITIVITY PATTERN OF MICROORGANISMS AND THEIR COST-EFFECTIVENESS AT A PRIVATE CORPORATE HOSPITAL IN SOUTH INDIA

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ABSTRACT

Objectives: Wide reports in the literature from different parts of the world revealed that antibiotics are used both widely and indiscriminately. Antibiotics are prescribed unnecessarily and empirically for complaints where no antibiotic is required or where culture and sensitivity results could be safely awaited. The current study was designed to assess the antibiotic sensitivity pattern of microorganisms and to analyze the antibiotic usage pattern and to conduct a cost-effectiveness analysis for the antibiotics prescribed.

Methods: The retrospective study of 6 months duration was conducted in 500 bedded multi-specialty private corporate hospital of South India, including all the inpatients in the Department of General Medicine and Pulmonology for whom at least one antibiotic was prescribed.

Results: In the sensitivity pattern study, a total of 796 documented records was analyzed and it was found that Escherichia coli was the major organism identified in 36.4% of the isolated specimens, followed by Klebsiella, Streptococcus pneumoniae, Staphylococcus aureus and Pseudomonas. The sensitivity pattern data revealed that E. coli were highly sensitive to Amikacin, followed by Klebsiella to amikacin, and Pseudomonas to meropenem. In the study, lower respiratory tract infection was found to be the most common disease in 51 patients. Cephalosporins (73%), in particular ceftriaxone (63.5%) was highly prescribed. ceftriaxone was found to be more cost-effective antibiotic in comparison to levofloxacin.

Conclusion: The study concluded that pharmacist's role in assisting prescribers on antibiotic prescribing is vital in achieving rational drug use and reducing resistance.

Keywords: Antibiotics, Observational study, Prescribing pattern, Rational drug use, Cost effective analysis.

INTRODUCTION

Anti-microbial resistance patterns can vary regionally and even among different hospitals within the same community. Overuse of antibiotics contributes to antimicrobial resistance and puts the patients at greater risk of carrying and becoming infected with resistant bacteria. Infections are the most common reasons for patients to seek medical advice and for antibiotics to be prescribed [1].

Inappropriate or indiscriminate use of antibiotics can increase the cost of care by increasing drug cost, increasing toxicity, increasing resistance, and increasing laboratory costs. Prophylactic antibiotic use in some hospitals remains a problem [2].

The majority of deaths result from respiratory tract infections occurs in developing countries with high poverty rates and inadequate medical care. The rise in anti-microbial resistance among the pathogens has been documented in many regions and now possesses a major challenge worldwide. Combinations of antibiotics are often used to broaden the spectrum of coverage for empiric therapy, achieve synergistic activity against the infecting organism, and prevent the emergence of resistance [3].

Antibacterial medications are considered as the greatest discovery of the 20th century. The word "antibiotics" comes from the Greek word anti ("against") and bios ("life"). The first antimicrobial was discovered in the mid-20, and many new molecules were discovered between 1960 and 1980. This "golden era of antibiotics" saw a dramatic fall in the mortality from infections. Since the 80's, not many new class of molecules have been discovered and the funding into antimicrobial research is on the decline and now deaths due to resistant infections is slowly increasing; mortality due to nosocomial infections is now 4 times that due to road traffic accidents [4]. Antibiotics can be classified in many ways. The most common method of classification is based on the range of organisms killed by the antibiotic [5]. This method of classification results in two classes broad spectrum antibiotics, narrow spectrum antibiotics. The other classification divides them into bacteriostatic and bactericidal. Although it is necessary to begin the treatment in critically ill patients before culture and sensitivity tests are completed, culture specimen should always be taken before the therapy begins. Culture identifies the causative organisms, and susceptibility determines which drugs are likely to be effective against the organism. Culture and susceptibility studies are always important with suspected Gram-negative infections because of the high incidence of drug-resistant organisms. The nature of the illness, the toxicity of the drug, the patient's history of hypersensitivity or other serious reactions and cost of the antibiotics must also be considered before prescribing an antibiotic.

Causes of failure of antimicrobial agent are clinical condition not susceptible to antimicrobial treatment, failure to use the laboratory properly, limitations of laboratory methods and laboratory errors, wrong choice of antibiotics, inadequate duration, misuse of antibiotics, and development of antimicrobial resistance [6].

Microbial resistance to antibiotics is a matter of great importance if sensitive strains are supplanted by resistant ones, then a valuable drug may become useless. Based on the mechanism, resistance can be classified as: Naturally acquired resistance, acquired drug resistance, tolerance (adaptation), "single step" chromosomal mutation and transmissible drug resistance.

Surveillance of bacterial resistance is a key element in understanding the size of the problem. The large number of existing networks of resistance surveillance needs to be coordinated, and the results made available. To help doctors choose appropriate antibiotics and to detect local epidemics of resistant bacteria surveillance at local level is necessary by resistance can be minimized.

There are two-ways of fighting the development and spread of resistance. The first is to reduce the use of antimicrobial agents. About 85-90% of antibacterial drugs are used in the community, and up to 80% of these are used to treat respiratory tract infections. Sales of antibiotics over the counter should be stopped.

The second major way to tackle resistance is by improving hygiene measures to prevent the spread of transmissible diseases. In hospitals, effective prevention of cross infection and the development of strict antibiotic policies should be in the hands of experts. Each hospital thus needs an infection control team with infectious disease specialties, clinical microbiologists, and infection control nurses, and sufficient resources are a mandate to run the program.

Antibiotics are prescribed unnecessarily and empirically for complaints where no antibiotic is required or where culture and sensitivity results could be safely awaited [3]. Thus, continuous monitoring of the pattern of bacterial resistance serves as empiric guide for therapy [7].

Empirical antibiotic therapy should be given when bacterial infection is suspected and poses a sufficient health risk to demand immediate treatment. E.g., pyrexia of unknown origin, meningitis, tuberculosis.

Problems with empirical therapy are: Prescribing antibiotics to patients who do not have a bacterial infection, inappropriate antimicrobials may be selected.

Hence, an urgent need exists for less frequent use and more appropriate selection of antimicrobial drugs. Before starting an antibiotic for a patient, the clinician must consider whether the antibiotic is suitable. The importance of determining the type and sensitivity of the causative organism is obvious. The key action by the clinician should be the provision of a specimen for accurate identification of the offending pathogen by means of culture and sensitivity method [8].

In economic evaluations of health care, consequences can be expressed in monetary terms (cost-benefit), in natural units of effectiveness (cost-effectiveness) or in terms of patient preference or utility (cost-utility).

Cost-effectiveness analysis (CEA) helps to determine whether health benefits (also designated as effectiveness) of the new strategy (commonly measured in terms of life expectancy or survival rates, such as the number of life years saved) are worth the additional costs generated. CEA, therefore, deals with marginal or "incremental" costs and benefits. CEA is considered to be the most appropriate method for the evaluation of health economics when at least two alternatives are being compared and when outcomes can be expressed in common unit, such as cost per life years saved [9].

Pharmacists play vital role in combating resistance by preventing and limiting bacterial resistance to antibiotic agents require the efforts and co-operation of many health care professionals, including pharmacists, physicians, and infection control specialists, nursing staff, and public health officials. The pharmacist can play an important role in this to limit the emergence of resistance and reduce the subsequent clinical consequences of antibiotic resistance. Specific actions the pharmacist can take include: Identifying antibiotic misuse, promoting prescribing changes, and promoting patient care.

METHODS

Study site: Department of General Medicine and Pulmonology of a 500 bedded multi-specialty private corporate hospital of South India.

Study design: Retrospective study.

Study period: A retrospective study was conducted over a period of 6 months January 2014-June 2014.

Study sample: 241 patients and 796 documented records.

Study criteria

Inclusion criteria: All the inpatients who were prescribed at least one antibiotic in the pulmonology and general medicine ward were included in the study.

Exclusion criteria: The outpatients, intensive care patients, and those unwilling to participate in the study were excluded in the study.

Sources of data

All necessary data were collected from the following sources:
1. Patient data collection form
2. Patient case history
3. Patient prescriptions
4. Laboratory data
5. Treatment profiles
6. Microbiological data.

Consent from the hospital authority

The study was approved by the hospital authority, by submitting a profoma of the study which includes the objectives, methodology, and the study was conducted with the expert guidance of seniors and junior physicians of the department selected.

Literature survey

The literature supporting the study were gathered from various sources such as British Medical Journal, American Medical Journal, Journal of Clinical Pharmacy and Therapeutics, Journal of Pharmacy Practice, The Annals of Pharmacotherapy, Journal of National Medical Association, Indian Journal on Medical Microbiology.

Study procedure

The study was carried out in three phases:

Phase I

During the first phase of the study, a prospective analysis was conducted to check the sensitivity pattern of microorganisms to various antibiotics for a 6-month period (January 2014-June 2014). The necessity of this study was explained to the microbiologist in charge of the study hospital. The documented data were reviewed, and necessary information like specimen collected, organism isolated and their sensitivity pattern were noted down. The collected information was analyzed to know the scenario on the commonly prevailing organisms along with their sensitivity.

Phase II

During this phase, information regarding the pattern of antibiotics prescribed in the Pulmonology and general medicine department and also the cost of the antibiotics were obtained.

Phase III

In this final phase, the sensitivity pattern of microorganism and the antibiotic usage pattern were analyzed in detail.

A CEA was conducted by calculating the cost per failure avoided to find out the most cost-effective antibiotics in the pulmonology and general medicine department. A decision tree was created on the basis of the data collected, and this tree was used to determine the expected value (anticipated therapeutic cost per patient) for each antibiotic prescribed. Using the therapeutic effect of the antibiotic against infection and the anticipated therapeutic cost per patient, the cost-effectiveness ratio (CER) was calculated. The antibiotic with the lower CER was found to be the most cost-effective antibiotic.

The details regarding the results obtained from the study, which were evaluated, were made as a report and were submitted to the concerned department, for their perusal.

RESULTS AND DISCUSSION

The study was carried out in a 500 bedded multi-specialty private corporate hospital in South India, in three different phases in a sample size of 241 patients. The study was undertaken to know the sensitivity pattern of microorganisms prevailing to various antibiotics and also the utilization pattern of antibiotics in the Pulmonology and General Medicine Department of the study hospital.

The present study involved 241 as a sample, from which 796 documents were recorded. Demographic details of the participants involved in the study were categorized based on gender and age distribution, the results of which were thoroughly analyzed and reported in Tables 1 and 2.

The details of the length of stay were thoroughly assessed and reported in Table 3.

The data of number of drugs prescribed per prescription were thoroughly assessed and reported in Table 4.

The total number of antibiotics prescribed in the study sample of 241 patients are reported in Table 5.

The category of antibiotics prescribed is reported in Table 6.

Antibiotics in combination used are reported in Table 7.

Route of administration of antibiotics is reported in Table 8.

In a similar study, Zhang et al. [10] showed that systemic antibiotics were the most widely used.

Table 1: Demographic details-gender distribution

S. no.	Sex	Number of patients	Percentage
1	Male	165	68.5
2	Female	76	31.5

Table 2: Demographic details-age distribution

S. no.	Age	Number of patients	Percentage
1	1-20	12	5
2	21-40	30	12.4
3	41-60	105	43.6
4	61-80	85	35.3
4	81-100	9	3.7

Table 3: Length of stay

S. no.	Number of days	Number of patients	Percentage
1	3 days	14	5.8
2	4 days	11	4.6
3	5 days	30	12.4
4	6-10 days	152	63.1
5	>10 days	34	14.1

Table 4: Length of stay

S. no.	Number of drugs	Number of prescription	Percentage
1	≤5	11	4.6
2	6-10	130	53.9
3	>10	100	41.5

The major disease for which antibiotics were prescribed includes lower respiratory tract infection (LRTI) (21.2%), bronchial asthma (14.5%), and chronic obstructive pulmonary disease (13.4%) results of which are shown in Table 9.

A retrospective analysis of the prevalence and the sensitivity pattern of microorganisms for a period of 6 months were documented, regarding the specimen tested, organisms isolated, and their sensitivity to various antibiotics. A total of 796 documented records were analyzed, Table 10 shows the results of micro-organism been isolated.

The sensitivity to various antibiotics was noted down in a specially designed data entry format and was analyzed, reports of which are shown in Table 11.

The prospective data revealed that almost all the organisms isolated were highly sensitive to amikacin. It was found that amikacin showed the best sensitivity in Staphylococcus aureus (100%), Pseudomonas (96.3%). Proteus showed high sensitivity toward tigecycline (95.8%) and acinetobacter showed high sensitivity toward meropenem (91.9%).

Similar study was conducted by Gayathri et al. [11] on antibiotic susceptibility pattern of rapidly growing mycobacteria. Of the 148 rapidly growing mycobacteria isolates, 146 (98%) were susceptible to amikacin, 138 (91%) to gatifloxacin, 132 (87%) to moxifloxacin, 122 (76%) to ciprofloxacin, and 116 (74%) to norfloxacin.

The percentage of sensitivity pattern of study is shown in Fig. 1.

Table 5: Number of antibiotics prescribed

S. no.	Number of antibiotics	Number of prescription	Percentage
1	One	109	45.2
2	Two	97	40.2
3	Three	26	10.8
4	Four	9	3.7

Table 6: Category of antibiotics prescribed

S. no.	Category of antibiotics	Number of prescription	Percentage
1	Cephalosporins	176	73.0
2	Fluoroquinolones	130	53.9
3	Aminoglycosides	76	31.5
4	Penicillin	25	10.4
5	Macrolide	6	2.5
6	Lincosamide	4	1.7

Table 7: Combination of antibiotics prescribed

S. no.	Antibiotic combinations	Number of prescription	Percentage
1	Cepalosporins+Aminoglycoside	16	6.6
2	Cepalosporins+Fluoroquinolones	17	7.1
3	Cepalosporins+Penicillin	03	1.2
4	Penicillin+Aminoglycosides	10	4.2
5	Penicillin+Fluoroquinolones	10	4.2
6	Fluoroquinolones+Aminoglycosides	13	5.4

Table 8: Route of administration of antibiotics

S. no.	Route of administration	Number of prescription	Percentage
1	IV	312	74.8
2	Oral	105	25.2

IV: Intravenous

The specimen from where organisms were isolated is clearly represented in Fig. 2.

Studies conducted by Goel et al. [12] (2009) showed that a very high rate of resistance (80-100%) was observed among predominant Gram-negative bacilli to ciprofloxacin, ceftazidime, co-trimoxazole, and amoxicillin/clavulanic acid combination. Similarly, in our study, the emergence of resistance is shown in Fig. 3.

The percentage of prevalence of organisms in our study is mentioned in Table 12.

For CEA, only patients for whom either ceftriaxone or levofloxacin was included since they were the most commonly prescribed antibiotics, constituting 63.5% and 40.7%, respectively.

Decision tree was created on the basis of the data collected. A decision tree was used to determine the expected value. Usually, a decision tree starts with a decision node. This is because most health care starts with a decision about whether one alternative or another is the most appropriate course of action. Subsequent probability nodes show the chance of each possible consequence occurring. At each probability node, the sum of probabilities is 1, i.e., a 100% chance that something will happen.

A total of 153 patients received ceftriaxone, of which 112 (73.2%) was successful. Using the drug cost only, the average cost per patient in this path was Rs. 49.45. A total of 41 patients in the ceftriaxone arm failed therapy and were switched over to either levofloxacin or amikacin.

A total of 98 patients received levofloxacin. It was the drug associated with a 100% success rate and the average cost per patient in this path was Rs. 95.13. Decision analysis demonstrated that ceftriaxone was the drug associated with least cost.

Table 9: Diseases for which antibiotics were prescribed

S. no.	Disease	Number of prescription	Percentage
1	Bronchitis	26	10.7
2	Bronchial asthma	35	14.5
3	Emphysema	10	4.1
4	Urinary tract infections	26	10.8
5	Lower respiratory tract infection	51	21.2
6	Tuberculosis	22	9.1
7	APD	8	3.3
8	Pyrexia unknown origin	12	5
9	Chronic obstructive pulmonary disease	32	13.4
10	Viral pyrexia	19	7.9

APD: Acid peptic diseases

Table 10: Organisms isolated

S. no.	Organism	Number of patients
1	E. coli	291
2	Klebsiella	151
3	S. pneumonia	126
4	Pseudomonas	74
5	S. aureus	99

E. coli: Escherichia coli, S. pneumonia: Streptococcus pneumonia, S. aureus: Streptococcus aureus

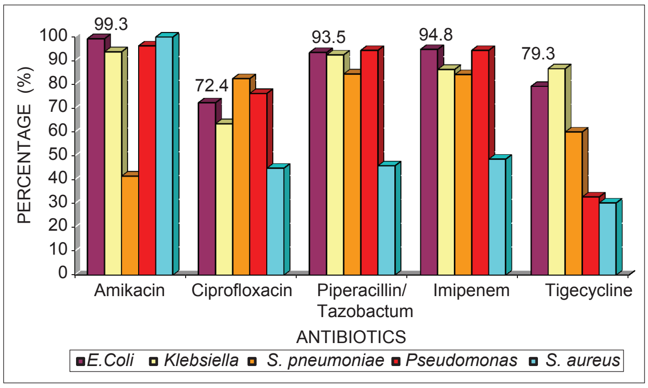

Fig. 1: Percentage of sensitivity pattern

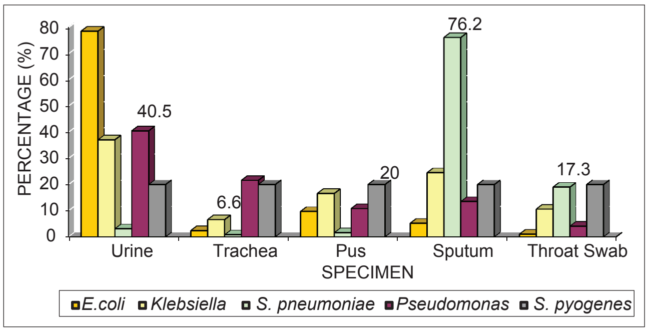

Fig. 2: Specimen versus organisms

Table 11: Sensitivity pattern toward various antibiotics

	Sensitivity pattern																			
Organism	Percentage	Amikacin	Cotrimoxazole	Ceftriaxone	Ciprofloxacin	Ofloxacin	Netilmicin	Carbenicillin	Sparfloxacin	Piperacillin/ taobactum	Cefoperazone/ sulbactam	Imipenem	Meropenem	Linezolid	Tigecycline	Cefotaxime	Teicoplanin	Ceftazidine/ sulbactam	Clindamycin	Cefuroxime
E. coli	291	289	37	181	210	213	11	24	168	271	210	276	282	-	231	1	9	54	172	10
Klebseilla	151	142	119	51	96	85	5	12	60	140	109	130	141	3	131	5	1	33	101	19
S. pneumonia	126	52	8	106	104	118	1	3	109	106	70	106	104	2	76	74	48	11	34	16
Pseudomonas	74	71	6	40	56	29	-	21	16	70	48	70	72	69	24	1	-	21	25	39
S. aureus	99	99	2	40	44	20	-	4	5	45	39	48	48	-	30	44	26	4	18	13
S. pyogenes	4	3	-	3	4	-	-	-	3	4	3	3	4	4	3	2	3	-	4	3
Citrobacter	4	3	-	2	2	-	-	-	3	4	1	3	4	2	4	-	-	-	3	-
Actinobacter	9	8	1	3	2	4	-	-	2	6	4	9	8	-	7	7	-	3	4	5
Streptococcusepidermidis	2	2	-	2	2	-	-	-	-	2	-	2	2	2	2	-	2	-	1	-
Proteus	34	28	5	12	31	16	-	-	9	2	25	32	31	-	33	-	-	8	17	2
Enterobacter	2	2	-	-	-	2	-	-	-	2	-	2	2	-	1	-	-	-	-	-

E. coli: Escherichia coli, S. pneumonia: Streptococcus pneumonia, S. aureus: Streptococcus aureus, S. pyogenes : Streptococcus pyogenes, S. epidermidis: Streptococcus epidermidis

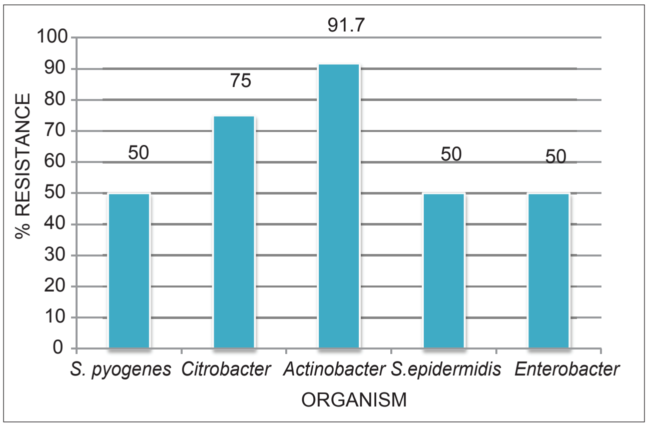

Fig. 3: Emergence of resistance

Table 12: Percentage of prevalence of organisms

Organism	Percentage prevalence
E. coli	36.4
Klebsiella	18.9
S.pneumoniae	15.8
Pseudomonas	9.3
S. pyogenes	0.6

E. coli: Escherichia coli, S. pneumonia: Streptococcus pneumonia, S. pyogenes: Streptococcus pyogenes

The total anticipated therapeutic cost per patient is calculated on the basis of the decision-tree model, which was found out to be Rs. 57.14 for the ceftriaxone group and Rs. 95.13 for the levofloxacin group.

The CER was calculated. The CER was 78.27 for ceftriaxone group and 95.13 for the levofloxacin group.

Decision tree calculation

Ceftriaxone arm

Success	Failure
Mean cost per patient=Rs. 49.45 Number of patients=112 Probability of occurrence=0.73	Mean cost per patient=Rs. 77.95 Number of patients=41 Probability of occurrence=0.27

Anticipated therapeutic cost per patient = Cost of antibiotics × probability of occurrence = (49.45×0.73)+ (77.95×0.27)= 36.09+21.04 = Rs. 57.14

Levofloxacin arm

Success	
Mean cost per patient=Rs. 95.13 No. of patients=98 Probability of occurrence=1	Anticipated therapeutic cost per patient 95.13×=Rs. 95.13

Similar study conducted by Lavoie et al. [13] on the cost effectiveness of antibiotics used for community-acquired pneumonia and acute exacerbation of chronic bronchitis. The study was conducted on 3610 patients, and it revealed that azithromycin, which is widely prescribed antibiotic appears to be most cost-effective treatment strategy for LRTI.

CONCLUSION

Antibiotics are a cause of constant concern in this era of increasing bacterial resistance. It is instrumental that physician's selection of antibiotics fulfills the condition of optimizing treatment success. Cost is also one of the factors, to be taken into consideration while prescribing antibiotics.

The pharmacist's role in advising prescribers on antibiotic prescribing is important in order to adhere to rational drug therapy and provide complete patient care. Clinical pharmacists play an important role in promoting optimal antibiotic prescribing practice among physicians, during their routine visit to wards.

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REFERENCES

1. Little P, Watson L, Morgan S, Williamson I. Antibiotic prescribing and admissions with major suppurative complications of respiratory tract infections: A data linkage study. Br J Gen Pract 2002;52: 187-90, 193.
2. Braden RL. Surgical antibiotic prophylaxis. In: Herfindale ET, Gourley DR, editors. Textbook of Therapeutics: Drug and Disease Management. 6th ed. Maryland, USA: Williams and Wilkins; 1996.
3. Abate BJ, Barriere SL. Antimicrobial regimen selection. In: Dipiro JT, Talbert RL, Yee GC, Matzke GR, Wells BG, Posey LM, editors. Pharmacotherapy: A Pathophysiologic Approach. 5th ed. New York: McGraw-Hill; 1993.
4. Srishyla MV, Nagarani MA, Venkataram BV. Drug utilization of antibacterials in the patient setting of the tertiary hospital. Indian J Pharmacol 1994;26(4):282-7.
5. Tripathi KD. Essentials of Medical Pharmacology. 5th ed. New Delhi, India: Jaypee Brothers; 2004.
6. Shanson DC. Microbiology in Clinical Practice. 3rd ed. London, UK: Butterworth Heinemann; 1999.
7. Houvinen P. Control of antimicrobial resistance: Time for action. BMJ 1999;14:953.
8. Speight TM, Holford NH. Avery's Drug Treatment: Principles and Practice of Clinical Pharmacology and Therapeutics. 4th ed. U.S.A: Wiley-Blackwell; 1997.
9. Chisin R. Cost-effectiveness analysis. J Nucl Med 2009;50(3):338-9.
10. Zhang W, Liu X, Wang Y, Chen Y, Huang M, Fan M, et al. Antibiotic use in pulmonology wards of Chinese children's hospitals: 2002-2006. J Clin Pharm Ther 2009;34(1):61-5.
11. Gayathri R, Therese KL, Deepa P, Mangai S, Madhavan HN. Antibiotic susceptibility pattern of rapidly growing mycobacteria. J Postgrad Med 2010;56(2):76-8.
12. Goel N, Chaudhary U, Aggarwal R, Bala K. Antibiotic sensitivity pattern of gram negative bacilli isolated from the lower respiratory tract of ventilated patients in the Intensive care unit. Indian J Crit Care Med 2009;13(3):148-51.
13. Lavoie F, Blais L, Castilloux AM, Scalera A, LeLorier J. Effectiveness and cost-effectiveness of antibiotic treatments for community acquired pneumonia (CAP) and acute exacerbations of chronic bronchitis (AECB). Can J Clin Pharmacol 2005;12(2):e212-7.