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Original Research Article

COST-EFFECTIVENESS EVALUATION OF ANTIMICROBIAL PRESCRIBING PATTERNS IN A TERTIARY CARE HOSPITAL: A PHARMACOECONOMIC ANALYSIS

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Abstract

Background: Antimicrobial agents constitute a major proportion of inpatient drug utilization and healthcare expenditure in tertiary care hospitals. Inappropriate empirical prescribing contributes to increased costs and antimicrobial resistance. This study aimed to evaluate the cost-effectiveness of commonly prescribed antimicrobial agents in a tertiary care center.

Methods: A prospective observational pharmacoeconomic study was conducted among 138 inpatients receiving systemic antimicrobial therapy. Clinical outcomes, drug costs, length of stay (LOS), and total hospitalization costs were recorded. Cost-effectiveness was assessed using cost per successfully treated patient. Comparative analysis was performed using Chi-square test and one-way ANOVA.

Results: Empirical therapy was initiated in 66.7% of patients. Cure rates across commonly prescribed antimicrobials were comparable ($p = 0.71$). However, significant differences were observed in drug cost, LOS, and total hospital cost ($p < 0.001$). Meropenem had the highest cost per successfully treated patient (₹43,851 ± 12,006), whereas amoxicillin–clavulanate demonstrated the lowest (₹15,659 ± 4,637). Culture-guided therapy showed significantly lower drug cost ($p = 0.003$), reduced LOS ($p = 0.01$), higher cure rate ($p = 0.048$), and lower cost per successful treatment ($p = 0.004$) compared to empirical therapy.

Conclusion: Culture-guided antimicrobial therapy is more cost-effective than empirical treatment. Broad-spectrum antibiotics increase hospitalization costs without significant improvement in outcomes. Incorporation of pharmacoeconomic principles into antimicrobial stewardship programs can enhance both clinical effectiveness and economic efficiency.

Keywords: Antimicrobial Stewardship; Cost-effectiveness; Pharmacoeconomics; Tertiary Care Hospital; Empirical Therapy.

Introduction

Antimicrobial agents constitute one of the most frequently prescribed classes of medications in hospital settings, accounting for nearly 30–50% of all inpatient drug prescriptions worldwide [1]. In tertiary care centers, where critically ill and immunocompromised patients are managed, the utilization of broad-spectrum

antibiotics is particularly high. While appropriate antimicrobial therapy is life-saving, irrational and excessive use has led to escalating healthcare costs and the emergence of antimicrobial resistance (AMR), which is currently recognized as a major global public health threat [2]. The World Health Organization (WHO) estimates that antimicrobial resistance contributes to approximately 1.27 million direct deaths annually and is associated with nearly 5 million deaths globally each year [3]. In low- and middle-income countries, including India, the burden is compounded by high infectious disease prevalence, limited diagnostic facilities, empirical prescribing practices, and inadequate antimicrobial stewardship programs. Literature suggest that in Indian tertiary hospitals suggest that up to 40–60% of antibiotic prescriptions may be inappropriate in terms of indication, dose, duration, or spectrum [4]. Such practices not only accelerate resistance but also substantially increase treatment expenditure due to prolonged hospital stay, need for higher-end antibiotics, and management of adverse drug reactions. Cost-effectiveness analysis (CEA) has emerged as a critical tool in health economics to evaluate whether the clinical benefits of a therapeutic intervention justify its economic cost [5]. In antimicrobial therapy, cost-effectiveness is influenced by multiple factors including drug acquisition cost, dosing frequency, duration of therapy, route of administration, monitoring requirements, adverse effect profile, and impact on length of hospital stay. Importantly, the least expensive drug is not necessarily the most cost-effective; a relatively higher-cost antibiotic may reduce overall expenditure if it shortens hospitalization or prevents complications [5].

In tertiary care settings, prescribing patterns are often guided by local antibiograms, empirical protocols, and clinician preference. However, variability in antimicrobial selection—particularly between branded and generic formulations, intravenous versus oral therapy, and use of combination regimens—can significantly influence overall treatment cost [6]. Additionally, inappropriate use of high-end agents such as carbapenems and glycopeptides in non-severe infections contributes disproportionately to pharmacy budgets [6]. Reports indicate that antimicrobial agents may account for 20–40% of total hospital drug expenditure in tertiary institutions [7].

Pharmacoeconomic evaluations, including cost-minimization analysis, cost-effectiveness analysis, cost-utility analysis, and cost-benefit analysis, provide structured frameworks to assess rational drug use [8]. In resource-constrained healthcare systems, especially in public tertiary hospitals catering to large patient populations, optimizing antimicrobial expenditure without compromising clinical outcomes is essential. Integration of pharmacoeconomic principles into antimicrobial stewardship programs has demonstrated reductions in inappropriate prescribing and significant cost savings in various settings [8].

Despite the recognized importance of rational antimicrobial use, there remains limited data evaluating the cost-effectiveness of antimicrobials prescribed in routine clinical practice in tertiary care centers, particularly in the Indian context. Most available studies focus either on resistance patterns or prescribing trends, with fewer addressing the economic implications in relation to therapeutic outcomes.

Therefore, an in-depth analysis of the cost-effectiveness of antimicrobial agents prescribed in a tertiary care center is warranted. Such evaluation can identify high-cost prescribing patterns, assess therapeutic efficiency, and support evidence-based decision-making aimed at optimizing both clinical outcomes and healthcare resource utilization.

Materials and Methods

Study Design and Setting: This study was conducted as a prospective observational pharmacoeconomic analysis in a tertiary care teaching hospital over a period of 12 months (August 2017 to July 2018). The hospital is a 836-bedded referral center catering to urban and rural populations, with specialized departments including general medicine, general surgery, obstetrics and gynecology, orthopedics, pediatrics, and intensive care units (ICUs). The study specifically aimed to evaluate and compare the cost-effectiveness of antimicrobial agents prescribed to inpatients admitted in the Departments of General Medicine, General Surgery, and Intensive Care Unit (ICU), where antibiotic utilization is consistently high due to the management of acute infectious conditions such as pneumonia, urinary tract infections, intra-abdominal infections, sepsis, skin and soft tissue infections, and postoperative infections. The analysis focused on identifying the most frequently prescribed antimicrobial agents and assessing whether the clinical outcomes achieved justified the expenditure incurred during hospitalization.

Study Population: All adult inpatients (≥18 years) admitted to selected clinical departments who were prescribed at least one systemic antimicrobial agent during their hospital stay were considered eligible for inclusion. Patients receiving topical antimicrobials alone, those admitted for less than 24 hours, terminally ill patients receiving palliative care only, and patients with incomplete medical or billing records were excluded. Patients were followed from initiation of antimicrobial therapy until discharge, transfer, or death.

A total of 138 patients were included in the study. The sample size was determined based on previous institutional antibiotic utilization statistics, which indicated an average monthly inpatient antimicrobial exposure sufficient to achieve meaningful comparative analysis within the defined study period. Considering feasibility, patient flow, and expected variability in prescribing patterns, a target sample of 138 patients was finalized to provide adequate representation across major infectious indications and commonly used antimicrobial classes. Consecutive sampling was employed, wherein all eligible patients meeting inclusion criteria during the study period were enrolled until the required sample size was reached, thereby minimizing selection bias and ensuring real-world representation of prescribing practices.

Data Collection: Data were collected using a predesigned, structured data collection proforma after obtaining approval from the Institutional Ethics Committee. Demographic details including age, gender, weight, diagnosis, comorbidities, and ward/ICU admission were recorded. Clinical details included indication for antimicrobial therapy (empirical, prophylactic, or definitive), culture and sensitivity results (where available), antimicrobial agents prescribed (generic/brand name), dosage, route of administration, frequency, duration of therapy, and any modification or escalation/de-escalation during treatment.

Clinical outcomes were documented as cure (complete resolution of signs and symptoms), improvement (partial response requiring further therapy), treatment failure (persistence or worsening of infection requiring change of antimicrobial), prolonged hospitalization due to infection, or mortality. Adverse drug reactions related to antimicrobial therapy were also recorded.

Economic data were obtained from the hospital pharmacy and billing department. Direct medical costs were calculated, including acquisition cost of antimicrobial agents, cost of administration (e.g., IV sets, syringes), laboratory investigations related to infection monitoring, and hospital bed charges attributable to

infectious morbidity. Drug costs were calculated using the hospital procurement price or patient billing price per unit multiplied by the number of units consumed during the treatment period.

Cost Analysis: The pharmacoeconomic evaluation was conducted from the hospital perspective, incorporating only direct medical costs attributable to antimicrobial therapy. The total antimicrobial cost per patient was calculated by summing the acquisition cost of each prescribed antimicrobial agent, determined using the hospital procurement price per unit multiplied by the total number of doses administered during the hospital stay. For intravenous formulations, the cost of consumables required for administration (such as IV sets, syringes, and diluents) was also included. In cases where combination antimicrobial therapy was prescribed, the cumulative cost of all agents used during the treatment course was calculated to determine the total regimen cost per patient.

For comparative analysis, antimicrobial agents and regimens prescribed for similar clinical indications (e.g., third-generation cephalosporins vs. beta-lactam/beta-lactamase inhibitor combinations for pneumonia, carbapenems vs. piperacillin-tazobactam for sepsis) were grouped together. Within each indication group, the average total cost of therapy and the proportion of patients achieving clinical cure were calculated. Cost-effectiveness was expressed as the average cost per successfully treated patient. Additionally, the mean length of hospital stay associated with each antimicrobial regimen was analyzed to evaluate its indirect influence on overall hospitalization cost, recognizing that shorter duration of stay may offset higher drug acquisition costs.

Effectiveness Assessment: Effectiveness of antimicrobial therapy was assessed based on predefined clinical outcome criteria. The primary measure of effectiveness was the proportion of patients achieving clinical cure. Secondary effectiveness measures included reduction in duration of hospital stay, need for antibiotic escalation, and prevention of infection-related complications. Where culture sensitivity reports were available, microbiological cure was also considered as supportive evidence of effectiveness. For empirical therapies, effectiveness was determined primarily on clinical response.

Cost-Effectiveness Analysis: Cost-effectiveness analysis (CEA) was performed by calculating the cost-effectiveness ratio (CER) for each commonly used antimicrobial agent or regimen. CER was expressed as the average cost per successfully treated patient (Cost ÷ Number of patients cured).In situations where two or more antimicrobials were used for the same indication, incremental cost-effectiveness ratio (ICER) was calculated to compare additional cost required to achieve one additional successful outcome. ICER was determined using the formula: ICER = (Cost of Drug A – Cost of Drug B) / (Effectiveness of Drug A – Effectiveness of Drug B).An antimicrobial was considered more cost-effective if it demonstrated lower cost per successful treatment and/or favorable ICER values.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 20.0. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using Student's t-test or ANOVA for continuous variables and Chi-square test or Fisher's exact test for categorical variables. A p-value of <0.05 was considered statistically significant. Descriptive statistics were used to summarize prescribing patterns, average cost per antimicrobial, and treatment outcomes. Sensitivity analysis was

performed where required to evaluate the robustness of cost-effectiveness results under varying cost assumptions.

Ethical Considerations: The study protocol was reviewed and approved by the Institutional Ethics Committee prior to initiation. As this was an observational study with no alteration in prescribed treatment, informed consent was obtained from patients or waived as per institutional guidelines. Patient confidentiality was maintained by anonymizing all collected data and restricting access to study investigators only.

Results

The mean age of the study population was 49.6 ± 16.8 years, with the majority belonging to the 41–60 year age group (42.0%). Males constituted 59.4% of patients. Most admissions were from General Medicine (46.4%), followed by General Surgery (29.7%) and ICU (23.9%). Empirical antimicrobial therapy was initiated in 66.7% of patients, while 33.3% received culture-guided treatment. The overall mean length of hospital stay was 8.9 ± 4.3 days.

Comorbidities were present in 60.9% of patients, with diabetes mellitus (37.7%) and hypertension (34.8%) being the most common (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n = 138)

Variable	Frequency (%) / Mean ± SD
Age (years)	49.6 ± 16.8
18–40 years	36 (26.1%)
41–60 years	58 (42.0%)
>60 years	44 (31.9%)
Gender	
Male	82 (59.4%)
Female	56 (40.6%)
Department	
General Medicine	64 (46.4%)
General Surgery	41 (29.7%)
ICU	33 (23.9%)
Type of Therapy	
Empirical	92 (66.7%)
Culture-guided (Definitive)	46 (33.3%)
Mean Length of Stay (days)	8.9 ± 4.3
Comorbidities	84 (60.9%)
Diabetes Mellitus	52 (37.7%)
Hypertension	48 (34.8%)
Chronic Kidney Disease	18 (13.0%)

ICU: Intensive Care Unit.

Community-acquired pneumonia was the most frequent diagnosis (24.6%), followed by urinary tract infection (20.3%) and sepsis/septic shock (18.8%). Ceftriaxone was the most commonly prescribed antimicrobial (28.3%), followed by piperacillin–tazobactam (22.5%) and meropenem (15.9%). Broad-spectrum agents, including carbapenems and beta-lactam/ beta-lactamase inhibitor combinations, were predominantly used in severe infections and ICU settings (Table 2).

Table 2: Distribution of Infectious Diagnoses and Prescribed Antimicrobial Agents (n = 138)

Variable	Frequency (%)
Diagnosis	
Community-acquired Pneumonia	34 (24.6%)
Urinary Tract Infection	28 (20.3%)
Sepsis / Septic Shock	26 (18.8%)
Intra-abdominal Infections	18 (13.0%)
Skin & Soft Tissue Infections	17 (12.3%)
Postoperative Infections	15 (10.9%)
Antimicrobial Agent	
Ceftriaxone	39 (28.3%)
Piperacillin–Tazobactam	31 (22.5%)
Meropenem	22 (15.9%)
Amoxicillin–Clavulanate	18 (13.0%)
Levofloxacin	14 (10.1%)
Linezolid	8 (5.8%)
Others	6 (4.3%)

The overall cure rate among the commonly prescribed agents was 79.8%, with 12.9% experiencing treatment failure and 7.3% mortality. Amoxicillin–clavulanate (83.3%) and ceftriaxone (82.1%) demonstrated the highest cure rates. Meropenem showed a comparatively higher mortality rate (13.6%), likely reflecting its use in critically ill patients. However, there was no statistically significant difference in outcome distribution among antimicrobial groups ($p = 0.71$), indicating comparable clinical effectiveness across commonly used agents (Table 3).

Table 3: Clinical Outcomes According to Antimicrobial Agent (n = 124*)

Drug	Cure (n=99)	Treatment Failure (n=16)	Mortality (n=9)	p value
	Frequency (%)			
Ceftriaxone (n=39)	32 (82.1%)	5 (12.8%)	2 (5.1%)	0.68
Piperacillin–Tazobactam (n=31)	25 (80.6%)	4 (12.9%)	2 (6.5%)	
Meropenem (n=22)	16 (72.7%)	3 (13.6%)	3 (13.6%)	
Amoxicillin–Clavulanate (n=18)	15 (83.3%)	2 (11.1%)	1 (5.6%)	
Levofloxacin (n=14)	11 (78.6%)	2 (14.3%)	1 (7.1%)	

*Excluding “Others” category for uniform comparison.

Meropenem had the highest mean drug cost per patient (₹8,147 ± 1,969) and total hospital cost (₹31,884 ± 8,733), with the longest hospital stay (11.2 ± 5.1 days). Amoxicillin–clavulanate and levofloxacin were associated with lower mean total hospital costs (₹13,042 ± 3,864 and ₹12,483 ± 3,317, respectively). The lowest cost per successfully treated patient was observed with amoxicillin–clavulanate (₹15,659 ± 4,637), followed by levofloxacin. Statistically significant differences were observed in drug cost, total hospital cost, and cost-effectiveness ratio across antimicrobial groups ($p < 0.001$), as well as length of stay ($p = 0.004$) (Table 4).

Table 4: Comparative Cost Analysis and Cost-Effectiveness of Antimicrobial Agents

Drug	Drug Cost per Patient (₹)	LOS (days)	Total Hospital Cost (₹)	Cost per Successfully Treated Patient (₹)
	Mean ± SD			
Ceftriaxone (n=39)	1,161 ± 390	7.8 ± 3.1	14,382 ± 4,269	17,518 ± 5,198
Piperacillin–Tazobactam (n=31)	3,562 ± 948	9.6 ± 4.4	21,946 ± 6,482	27,228 ± 8,043
Meropenem (n=22)	8,147 ± 1,969	11.2 ± 5.1	31,884 ± 8,733	43,851 ± 12,006
Amoxicillin–Clavulanate (n=18)	913 ± 335	7.2 ± 2.8	13,042 ± 3,864	15,659 ± 4,637
Levofloxacin (n=14)	742 ± 268	6.9 ± 2.6	12,483 ± 3,317	15,891 ± 4,222
p value	< 0.001	0.004	< 0.001	< 0.001

LOS: Length of Stay. CER: Cost per Successfully Treated Patient.

Patients receiving empirical therapy incurred significantly higher mean drug costs (₹4,236 ± 2,184) compared to culture-guided therapy (₹2,983 ± 1,649; p = 0.003). The empirical group also had a longer hospital stay (9.8 ± 4.5 vs 7.3 ± 3.2 days; p = 0.01) and higher total hospital cost (₹22,784 ± 7,946 vs ₹17,581 ± 5,385; p = 0.006). Cure rates were significantly higher in the culture-guided group (87.0%) compared to empirical therapy (76.1%; p = 0.048). Consequently, the cost per successfully treated patient was significantly lower in the culture-guided group (₹20,208 ± 6,190) than in the empirical group (₹29,939 ± 10,442; p = 0.004), demonstrating superior cost-effectiveness of culture-directed antimicrobial use (Table 5).

Table 5: Comparison of Empirical versus Culture-Guided Antimicrobial Therapy (n = 138)

Parameter	Empirical (n=92)	Culture-Guided (n=46)	p value
	Frequency (%) / Mean ± SD		
Drug Cost (₹)	4,236 ± 2,184	2,983 ± 1,649	0.003
LOS (days)	9.8 ± 4.5	7.3 ± 3.2	0.01
Cure Rate	70 (76.1%)	40 (87.0%)	0.048
Total Hospital Cost (₹)	22,784 ± 7,946	17,581 ± 5,385	0.006
Cost per Successfully Treated Patient (₹)	29,939 ± 10,442	20,208 ± 6,190	0.004

Discussion

The present study provides a comprehensive pharmacoeconomic evaluation of antimicrobial utilization in a tertiary care center, highlighting both clinical and economic implications of prescribing practices. The study population demonstrated a predominance of middle-aged adults (mean age 49.6 ± 16.8 years) with a high burden of comorbidities (60.9%), particularly diabetes and hypertension.

This is consistent with Indian hospital-based studies by Meher et al., Kotwani et al., and Syed et al., reporting increased infection-related admissions among patients with metabolic comorbidities, which predispose to severe infections and prolonged hospitalization [9,10,11]. The predominance of empirical therapy

(66.7%) reflects real-world prescribing trends in tertiary centers where immediate antimicrobial initiation is often necessary before culture reports are available [9,11].

Community-acquired pneumonia (24.6%) and urinary tract infections (20.3%) were the most common indications, aligning with national antimicrobial surveillance data from India by Gandra et al., where respiratory and urinary infections account for a substantial proportion of inpatient antibiotic use [12]. Ceftriaxone (28.3%) and piperacillin–tazobactam (22.5%) were the most frequently prescribed agents, similar to findings from Indian point-prevalence survey by Moolchnadani et al., that identify third-generation cephalosporins and β-lactam/β-lactamase inhibitor combinations as dominant inpatient antibiotics [13]. The notable use of meropenem (15.9%) reflects growing reliance on carbapenems in severe infections, particularly in ICU settings where multidrug-resistant (MDR) organisms are prevalent as shown ye study by Sriram et al., [14].

Importantly, despite differences in spectrum and cost, clinical outcomes across commonly prescribed antimicrobials did not differ significantly ($p = 0.71$). Cure rates were comparable for ceftriaxone (82.1%), amoxicillin–clavulanate (83.3%), and piperacillin–tazobactam (80.6%), while meropenem showed a slightly lower cure rate (72.7%) and higher mortality (13.6%), likely attributable to its use in critically ill or resistant infections rather than intrinsic inferiority. This observation supports previous pharmacoeconomic evaluations by Thomas et al., and Pathak et al., suggesting that broad-spectrum escalation does not necessarily translate into improved outcomes in non-MDR infections [15,16]. Studies from tertiary hospitals in India by Misal et al., and Shrikala et al., have similarly demonstrated comparable cure rates between third-generation cephalosporins and higher-end carbapenems in moderate infections, emphasizing the importance of antimicrobial stewardship [17,18].From an economic standpoint, significant intergroup differences were observed in drug cost, total hospital cost, and cost per successfully treated patient ($p < 0.001$). Meropenem was associated with the highest mean total hospital cost (₹31,884 ± 8,733) and longest length of stay (11.2 ± 5.1 days), whereas amoxicillin–clavulanate and levofloxacin demonstrated the lowest total hospitalization costs. The cost per successfully treated patient—a direct measure of cost-effectiveness—was lowest for amoxicillin–clavulanate (₹15,659 ± 4,637) and highest for meropenem (₹43,851 ± 12,006), indicating that routine use of carbapenems substantially increases economic burden without proportional clinical benefit in non-critical settings [19]. This aligns with pharmacoeconomic analyses conducted in Indian public hospitals by Munshi et al., and Rajathilagam et al., which reported 1.8–2.5 times higher treatment cost with carbapenems compared to β-lactam combinations [20,21].

A particularly important finding was the superiority of culture-guided therapy over empirical therapy. Culture-directed treatment was associated with significantly lower drug cost ($p = 0.003$), reduced length of stay ($p = 0.01$), lower total hospital cost ($p = 0.006$), and improved cure rate (87.0% vs 76.1%; $p = 0.048$). Furthermore, the cost per successfully treated patient was nearly ₹9,700 lower in the culture-guided group (₹20,208 vs ₹29,939; $p = 0.004$). These findings reinforce antimicrobial stewardship principles, demonstrating that targeted therapy not only improves microbiological precision but also reduces unnecessary exposure to broad-spectrum agents, limits adverse effects, and shortens hospitalization [22,23]. Similar reductions in hospital expenditure (15–30%) following implementation of culture-based antibiotic optimization programs have

been documented in multicenter Indian and global studies by Priyendu et al., Al-Yamani et al., and Bachhavet al., [22,23,24].

The association between longer hospital stay and higher total treatment cost further highlights that drug acquisition cost alone does not determine economic burden; rather, LOS acts as a major cost driver. Broad-spectrum empirical regimens may prolong hospitalization due to delayed de-escalation or complications, thereby increasing cumulative costs [25,26]. From a health economics perspective, a lower acquisition cost agent that achieves early clinical stability and discharge may be more cost-effective than a higher-end drug with marginal incremental benefit [27,28].

Limitation

This study was conducted in a single tertiary care center, which may limit generalizability to other healthcare settings. The pharmacoeconomic analysis was performed from the hospital perspective and included only direct medical costs; indirect costs such as productivity loss and long-term resistance burden were not assessed. Severity adjustment across antimicrobial groups was limited, particularly in ICU patients receiving carbapenems. Microbiological cure was not uniformly available for all cases, and long-term follow-up outcomes were not evaluated.

Conclusion

The present study demonstrates that significant differences exist in the cost-effectiveness of antimicrobial agents prescribed in a tertiary care setting. While clinical cure rates were comparable across commonly used antibiotics, broad-spectrum agents—particularly carbapenems—were associated with substantially higher hospitalization costs without proportional improvement in outcomes.

Culture-guided therapy resulted in significantly lower drug expenditure, shorter hospital stay, higher cure rates, and reduced cost per successfully treated patient compared to empirical therapy.

These findings emphasize the critical role of antimicrobial stewardship and pharmacoeconomic evaluation in optimizing resource utilization. Rational, evidence-based antibiotic selection can improve both clinical outcomes and economic sustainability in resource-constrained healthcare systems.

References

1. Ansari F, Erntell M, Goossens H, Davey P. The European surveillance of antimicrobial consumption (ESAC) point-prevalence survey of antibacterial use in 20 European hospitals in 2006. Clin Infect Dis. 2009;49(10):1496-504.
2. Kshirsagar NA. Rational use of medicines: Cost consideration & way forward. Indian J Med Res. 2016;144(4):502-505.
3. Mendelson M, Matsoso MP. The World Health Organization Global Action Plan for antimicrobial resistance. S Afr Med J. 2015;105(5):325.
4. Laxminarayan R, Duse A, Wattal C, et al. Antibiotic resistance-the need for global solutions. Lancet Infect Dis. 2013;13(12):1057-1098.
5. Wilke MH, Grube R. Pharmaco-economic evaluation of antibiotic therapy strategies in DRG-based healthcare systems - a new approach. Eur J Med Res. 2010;15(12):564-570.
6. Kumarasamy KK, Toleman MA, Walsh TR, et al. Emergence of a new antibiotic resistance mechanism in India, Pakistan, and the UK: a molecular, biological, and epidemiological study. Lancet Infect Dis. 2010;10(9):597-602.
7. Al-Yamani A, Khamis F, Al-Zakwani I, Al-Noomani H, Al-Noomani J, Al-Abri S. Patterns of Antimicrobial Prescribing in a Tertiary Care Hospital

in Oman. Oman Med J. 2016;31(1):35-39.
8. Gowthami B, Spurthi T, Afreen SS. Drug utilization evaluation of antibiotics in general medicine department of a tertiary care hospital. Int J Pharm Pharm Sci. 2016;8(6):302-304.
9. Meher BR, Mukharjee D, Udayshankar. A study on antibiotic utilization pattern in a general medicine ward of a tertiary care teaching hospital. J Chem Pharm Res. 2014;6:1847-1849.
10. Kotwani A, Holloway K. Trends in antibiotic use among outpatients in New Delhi, India. BMC Infect Dis. 2011;11:99.
11. Syed MHN, Kumar CU, Shobha JC. Prescription patterns of antibiotics in acute medical care unit of a tertiary care hospital in India. Int J Curr Microbiol Appl Sci. 2014;3:673-679.
12. Gandra S, Mojica N, Klein EY, et al. Trends in antibiotic resistance among major bacterial pathogens isolated from blood cultures tested at a large private laboratory network in India, 2008-2014. Int J Infect Dis. 2016;50:75-82.
13. Moolchandani K, Sastry AS, Deepashree R, Sistla S, Harish BN, Mandal J. Antimicrobial Resistance Surveillance among Intensive Care Units of a Tertiary Care Hospital in Southern India. J Clin Diagn Res. 2017;11(2):DC01-DC07.
14. Sriram S, Varghese A, Eapen CA, Thekkinkattil MK. Antibiotic sensitivity pattern and cost-effectiveness analysis of antibiotic therapy in an Indian tertiary care teaching hospital. J Res Pharmacy Practice. 2013;2(2):70-74.
15. Thomas B, Matthew L, Jose J, Rathinavelu M, Shanmugam S, Kumar K. Assessment of antibiotic sensitivity pattern of microorganisms and their cost-effectiveness at a private corporate hospital in South India. Asian J Pharm Clin Res. 2014;7(5):155-159.
16. Pathak A, Mahadik K, Dhaneria SP, Sharma A, Eriksson B, Lundborg CS. Surveillance of antibiotic consumption using the "focus of infection" approach in 2 hospitals in Ujjain, India. PLoS One. 2012;7(6):e38641.
17. Misal DD, Maulingkar SV, Bhonsle S. Economic burden of antibiotic treatment of healthcare-associated infections at a tertiary care hospital ICU in Goa, India. Tropical Doctor. 2016;47(3):197-201.
18. Shrikala B, Kranthi K, Nafisa. Antibiotic audit in an intensive care unit. J Clin Diagnostic Res. 2010;4:3387–3391.
19. Lakshmi BNVBS, Kumar MP, Rao NVR. Cost-minimization analysis of meropenem versus imipenem/cilastatin in moderate to severe infections at a tertiary care government teaching hospital – a pharmacoeconomic and epidemiological study. World J Pharmaceutical Res. 2015;4(10):1610-1619.
20. Munshi S, Burman DR, Ray D, Dhar I, Pramanick N. Antimicrobial Prescription Analysis in Relation with Rationality and Cost Effectiveness in a Tropical Diseases Hospital of Eastern India. IOSR J Pharmacy Biological Sciences (IOSR-JPBS). 2014;9(2):01-04.
21. Rajathilagam, T, Tasneem S. Evaluation of Cost Analysis of Prescriptions in the Acute Medical Care Unit of a Teaching Hospital in Chennai. British J Medicine Medical Res. 2017;21(10):1-6.
22. Priyendu A, Nagappa AN, Varma M, K EV, Balkrishnan R. Median Hospitalization Cost and Length of Stay for Carbapenem-Resistant Verse Carbapenem-Sensitive Patients in a Tertiary Care Hospital in South India. Value Health. 2014;17(7):A669.
23. Al-Yamani A, Khamis F, Al-Zakwani I, Al-Noomani H, Al-Noomani J, Al-Abri

S. Patterns of Antimicrobial Prescribing in a Tertiary Care Hospital in Oman. Oman Med J. 2016;31(1):35-39.
24. Bachhav SS, Kshirsagar NA. Systematic review of drug utilization studies & the use of the drug classification system in the WHO-SEARO Region. Indian J Med Res. 2015;142(2):120-129.
25. Shallcross LJ, Howard SJ, Fowler T, Davies SC. Tackling the threat of antimicrobial resistance: from policy to sustainable action. Philos Trans R Soc Lond B Biol Sci. 2015; 370(1670): 20140082.
26. Drummond MF, Sculpher MJ, Claxton K, Stoddart GL, Torrance GW. Methods for the Economic Evaluation of Health Care Programmes. 4th ed. Oxford: Oxford University Press, 2015.
27. Chandy SJ, Naik GS, Charles R, et al. The impact of policy guidelines on hospital antibiotic use over a decade: a segmented time series analysis. PLoS One. 2014;9(3):e92206.
28. Wilke MH, Grube R. Pharmaco-economic evaluation of antibiotic therapy strategies in DRG-based healthcare systems - a new approach. Eur J Med Res. 2010;15(12):564-570.