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Prescribing Pattern of Antibiotics in Bacterial Infectious Diseases in a Corporate Care Hospital

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: The antibacterial preparations are commonly used to control various bacterial infections, which may vary from one hospital to other. Hence, understanding the antibiotic practice will help the pharmacist gain knowledge and implement the safe use of drugs.
Objectives: To assess the antibacterial use in the management of the selected bacterial infections
Methodology: This study is a retrospective, observational, cross-sectional study over six months as per the inclusion & exclusion criteria in the Inpatients. A well-designed questionnaire was used for collecting the required data, and the obtained data were subjected to descriptive statistics.
Results and Discussion: Out of 334 cases observed, 54.19% were female, and 45.81% were male. The mean stays 3.81±2.21 days. Acute gastroenteritis was
59.58%, followed by UTI 25.15%. Pneumonia was 8.68%, and 6.29% had COPD. 0.30% had Acute gastroenteritis with UTI. 39.87% of patients were overweight18.35% were obese, and only 3.16% were underweight. Most of them were in the age group of 61-70, and the least was from 10-20. The mean age of the patients observed in this study was 55.21 ± 18.46. Single antibiotic therapy in 142 cases,165 cases had two antibiotics, in 24 instances three antibiotics were used, in 4patients 4 antibiotics were used for management of the infections. The commonly used antibiotics in managing bacterial infections are penicillin, cephalosporin, carbapenems, macrolides,

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Nitorimidazoles, quinolines, etc. The clinical outcome showed all the patients were improved, except 3 cases were discharged on request. 139 drug-drug interactions were present in this study and metronidazole (63.01%) was found to have highest major drug-drug interactions. The average cost of antibiotics used in treating Pneumonia (6534 Rs), AE of COPD (4459.7 Rs)., UTI 3778 Rs, acute GE 1176.2 Rs.

Conclusions: This study showed that pharmaceutical care services are essential in the bacterial infection management for the prevention of drug-drug interactions and minimization of the cost (rational drug usage promotion)

Keywords: DDI: Drug-Drug Interactions; RDU: Rational Drug Usage; UTI: Urinary Tract Infection; COPD: Chronic Obstructive Pulmonary Disease GE: Gastroenteritis.

1. INTRODUCTION

The prescribing pattern studies help to monitor, evaluate and suggest modifications in the prescribing pattern to make patient care safe and cost-effective [1]. Improper use of antibiotics has led to antibiotic resistance's significant public health problem in the community [2]. Inappropriate antibiotic use constitutes wrong dose, nasty duration, incorrect choice of antibiotics, the incompatible combination of antibiotics, and therapeutic or prophylactic use in unproven clinical situations. Frequent prescribing pattern studies in hospitals are crucial to maintaining the quality and standard of clinical practice [3].

Antibiotics are one of the most crucial medical science findings used widely against infectious diseases. Most of the antibiotics presently in use have been discovered more or less accidentally, and their mode of action has only been explained after their discovery. Antibiotics play a crucial role in treating bacterial infections, and antibiotic resistance prevents an antibiotic from working effectively against diseases [4].

Depending on the range of bacterial species susceptible to these agents, antibiotics are classified into

1. Broad-spectrum antibiotics;
2. Narrow spectrum antibiotics;

Broad-spectrum antibiotics: These work against both Gram-positive and Gram-negative organisms—examples: Tetracyclines, fluoroquinolones, Beta-lactamase inhibitors, and third-generation and fourth-generation cephalosporins.

Narrow spectrum antibiotics: These drugs have limited activity and are primarily useful against particular species of microorganisms. Example: Macrolide antibiotics like azithromycin, clarithromycin, and erythromycin are effective against Gram-positive organisms. Penicillins like amoxicillin is effective against Gram-positive bacteria. Amikacin is effective against gram-negative bacteria [5].

Pneumonia is an inflammation of one or both lungs' parenchyma, often caused by infections. Treatment of bacterial pneumonia most initially comprises the empirical, practical use of a relatively broad-spectrum antibiotic that is effective against potential pathogens after appropriate cultures and specimens for laboratory evaluation have been obtained. Therefore, therapy should be narrowed to cover specific pathogens after the results of cultures are known. Commonly drugs given are piperacillin-tazobactam, 2nd or 3rd generation cephalosporins (Ceftriaxone, Cefixime, cefuroxime), and macrolides (clarithromycin), fluoroquinolones (ciprofloxacin, moxifloxacin, levofloxacin) and linezolid.

Acute exacerbations of COPD describe the phenomenon of sudden worsening in airway function and respiratory symptoms in patients with COPD. These exacerbations can range from self-limited diseases to episodes of florid respiratory failure requiring mechanical ventilation. Recommended antibiotics are macrolides (clarithromycin, azithromycin), second or third-generation cephalosporins (cefuroxime, cefoperazone, Ceftriaxone), amoxicillin-clavulanate, fluoroquinolones (levofloxacin, Gemifloxacin, moxifloxacin) or piperacillin-tazobactam based on the organism detected. [6]

Urinary tract infections (UTIs) are a severe public health problem. Various pathogens cause them, most commonly *Escherichia coli*, *Klebsiella pneumonia*, *Proteus mirabilis*, *Enterococcus faecalis*, and *Staphylococcus saprophyticus.*

Commonly used antimicrobial agents in the treatment of UTI are Aminoglycosides (Gentamicin Tobramycin Amikacin), penicillin's (Piperacillin-tazobactam, Ticarcillin-clavulanate) 2nd and 3rs generation Cephalosporins (Ceftriaxone, cefuroxime, cefoperazone, cefotaxime), Carbapenems (Meropenem, ertapenem) and Fluoroquinolones (Ciprofloxacin, ofloxacin) for parenteral therapy. Trimethoprim-sulfamethoxazole, nitrofurantoin, Amoxicillin-clavulanate, Cephalosporins (cefoperazone, Ceftriaxone, cefotaxime), and fluoroquinolones (ciprofloxacin and levofloxacin) for oral treatment [7].

The word "gastroenteritis" originates from the Greek word gastrin, meaning "stomach," and enteron, meaning "small intestine." So, "gastroenteritis" means "inflammation of the stomach and small intestine." Medically, gastroenteritis is defined as diarrheal disease, in other words, an increase in bowel movement frequency with or without vomiting, fever, and abdominal pain. Moderate to severe cases should be treated with antibiotics. Commonly used antibiotics are Cephalosporins (cefoperazone, Ceftriaxone, cefotaxime), nitroimidazoles(metronidazole), and fluoroquinolones (ciprofloxacin and ofloxacin) [8].

A drug interaction occurs when the patient's response to a drug is modified by food, nutritional supplements, formulation excipient, environmental factors, other medicines, or disease. Interactions between drugs (drug-drug interactions) may be advantageous or harmful. Harmful drug-drug interactions are significant as they cause 10-20% of the adverse drug reactions requiring hospitalization and can be avoided. Knowing how drug-drug interactions occur and how to manage them is an integral part of clinical practice [9].

Pharmacokinetic drug-drug interactions: Pharmacokinetics is 'what the body does to the drug.' These interactions occur when one drug alters the concentration of another medicine with clinical consequences.

Pharmacodynamic drug-drug interactions: Pharmacodynamics is 'what the drug does to the body. These interactions occur between drugs with additive or opposing effects. The brain is the organ most commonly affected by pharmacodynamic interactions. Pharmacodynamic interactions between drugs with additive effects may be intentional, for example, when combining antihypertensives, or unintentional, for example, serotonin syndrome caused by adding tramadol to a selective serotonin reuptake inhibitor (SSRI). [10].

2. NEED FOR THE STUDY

Antibiotic resistance is associated with the improper, as well as frequent, use of antibiotics [11]. It occurs when bacteria change in some way that makes them resistant to antibiotics. Resistant bacteria continue to multiply in the presence of therapeutic levels of an antibiotic [12]. Antibiotic-resistant bacteria pose a massive problem as infections fail to respond to standard pharmacotherapy, resulting in extended illness, increased treatment costs, prolonged hospitalization, and possibly death. Additionally, while patients do not respond to standard therapy, they stay infectious and can potentially infect others, leading to possible outbreaks [13].

Getting treated with an antibiotic makes the patient believe antibiotics are warranted in similar conditions. Thus, patients may continue to visit physicians each time similar symptoms occur, expecting that antibiotics are again needed [14]. Appropriate use of antibiotics is essential as its irrational use can adversely affect the patient, produce resistance, and increase the cost of health care.

Underuse of antibiotics can increase the duration of disease and its complications. Inappropriate use of antibiotics, i.e., not completing the course, taking an insufficient dose, or taking antibiotics for the wrong indications, can lead to severe infections. Overuse of antibiotics leads to antibiotic resistance. Antibiotic resistance in bacterial pathogens is a challenge associated with high morbidity and mortality. Resistant strains are often too difficult to treat and may even be untreatable with conventional antibiotics. According to the World Health Organization (WHO), 20–50% of antibiotics are not used appropriately. So, the present study focuses on assessing the current prescription patterns of antibiotics in bacterial infectious diseases Inpatients, with the following objectives [15].

1. To assess the prescribing pattern/ practice & Class of antibiotics usage in bacterial infectious diseases. (Pneumonia, COPD, UTI, and gastroenteritis)
2. To assess the antibiotics cost used for the management of the disease.

3. To assess the drug interaction associated with antibiotics used.

3. METHODOLOGY

The study was a retrospective observational cross sectional study carried out in a tertiary care hospital over six months from October 2020 to March 2021 after obtaining the institutional ethical clearance (DSU/P-D/IHEC/2020-21/0010) in Medical Records(Inpatient records) Department at Sagar Hospitals, Bangalore, India.

Enrolled the patients as per inclusion and exclusion criteria.

Inclusion Criteria:

1. Patients who are diagnosed with Pneumonia, COPD, UTI, and gastroenteritis in the age group of ≥ 18 years.
2. Patients prescribed and managed these diseases, with minimum one or more antibiotic.

Exclusion Criteria:

1. Illegible prescriptions will be excluded.
2. Incomplete data will be excluded

A well-designed data collection form was prepared and used. This form contains all preliminary information about the subject, name, age, gender, IP number, past medical history, current medical problem, current diagnosis, and treatment.

Patient details, including age, sex, date of prescribing, number of medicines and antibiotics prescribed, and costs of antibiotics, were collected from patients' records and documented in the patient profile forms from prescriptions containing one or more antibiotics. The collected information includes:

- The name of the antibiotic prescribed.
- Routes of administration.
- A dose of antibiotic.
- Details like laboratory investigations from patient medical records.

The data was analyzed using Microsoft Excel & SPSS software 17 version. The drug interactions were estimated using Micromedex 2.0 software and Medscape.

4. RESULTS

In our study, 334 prescriptions were Comprise as per inclusion and exclusion criteria, out of which 181(54.19%) were female, and 153(45.81%) were male. The numbers of females were slightly higher than males. Age-wise distribution of the study population showed, Most of them were in the age group of 61-70, and the least was from 10-20. The mean age of the patients observed in this study was 55.21 ± 18.46. In our study, 39.87% of patients were overweight, 38.61% were average, 18.35% were obese, and only 3.16% were underweight.
In this study, the maximum number of patients, 175(52.40%) of them, stayed in the hospital for 1 to 3 days, and found the mean average hospitalization stay was 3.81±2.21 days.

Common past medical history found in the present study and the diagnosis were: DM, HTN, Hypothyroidism, IHD, COPD, CKD, Parkinson's, IBD, epilepsy, and Asthma. The majority of patients had DM and HTN.

Among our 334 patients, 291 followed a mixed diet, whereas only 43 of them followed a veg diet.

Most patients were diagnosed with gastroenteritis (59.58%), followed by UTI (25.15%). 8.68% were with Pneumonia, 6.29% with COPD with acute exacerbations, and only 0.30% had Acute gastroenteritis with UTI.

The culture sensitivity test is the gold standard diagnostic test to identify the causative microorganism for bacterial infections. Different culture sensitivity tests are performed based on the patients' symptoms.

Out of 199Acute GE cases, Performed stool culture tests were in 38(19.06%), Urine culture was carryout in 32(16.08%), blood/bone marrow culture was accomplished in 4(2.01%), and sputum culture carries out in only 2(1%) of them.

Out of 21 AE of COPD cases, sputum culture was performed in 4(19.04%), completed urine culture in 1(4.76%), and blood/bone marrow culture was carryout in 1(4.76%) of them.

Table 1. Distribution of final diagnosis

Final Diagnosis category	Specimen used	N(%)
Acute GE	Blood/Bone marrow	4 (2.01)
	Stool	38 (19.06)
	Urine	32(16.08)
	Sputum	2(1.00)
AE of COPD	Blood/bone marrow	1(4.76)
	Sputum	4(19.04)
	Urine	1(4.76)
	Stool	0(0)
Pneumonia	Blood/ Bone-marrow	8(27.58)
	Urine	8(27.58)
	Stool	0(0)
	Sputum	9(31.03)
UTI	Blood/Bone-marrow	10(11.90)
	Stool	2(2.38)
	Urine	51(60.71)
	Sputum	1(1.19)

Performed Sputum culture tests in 9(31.03%), Completed blood/bone marrow culture in 8(27.58%), and urine culture was carryout in 8(27.58%) cases out of 29 pneumonia cases.

Out of 84 UTI cases, Performed urine culture tests were in 51(60.71%), completed blood/bone marrow culture in 10(11.90), Completed stool culture in 2(2.38), and constructed sputum culture in 1(1.19%) of the cases.

All the 199 patients with acute GE, 29 patients with pneumonia, and one with critical GE with UTI were stable and discharged. Out of 21 patients with AE of COPD, one patient was against medical advice, and out of 84 UTI patients, two were released against medical advice.

In this part, we have analyzed the number of antibiotics prescribed in each prescription, the number of antibiotics prescribed in brand name and generic name, commonly prescribed antibiotics based on pharmacological classification and distribution of antibiotics in each class.

Number of antibiotics per prescription showed most patients have been advising two antibiotics per prescription, followed by one antibiotic per prescription.

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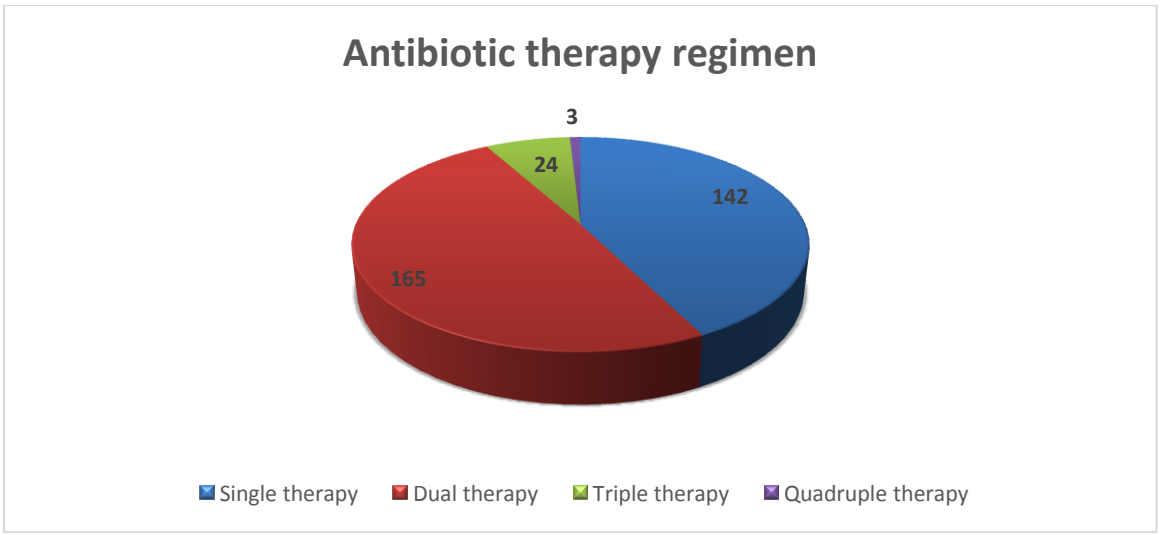

Fig. 1. Analysis of prescribing pattern of antibiotics

Table 2. Number of antibiotics prescribed in generic name per prescription

Final Diagnosis category	Antibiotics	N(%)
Acute GE	0	157(78.89)
	1	35(17.59)
	2	7(3.52)
Acute GE with UTI	1	1(100.0)
AE of COPD	0	18(85.71)
	1	2(9.52)
	2	1(4.76)
Pneumonia	0	17(58.62)
	1	11(37.93)
	2	1(3.45)
UTI	0	58(69.0)
	1	24(28.6)
	2	2(2.4)

Out of 199 acute GE, in 21 AE OF COPD, 29 pneumonia, and 84 UTI patients did not prescribe most of the antibiotics in generic name.

Out of 199 Acute GE cases, most prescriptions had two antibiotics (49.75%) prescribed in a brand name. In 21 AE of COPD patients, most prescriptions had either 1 (36.84%) or 2(36.84%) antibiotics prescribed in a brand name. In 29 pneumonia patients, most cases were prescribed 2 (50%) antibiotics in the brand name. Out of 84 UTI cases, most prescriptions had 1(61.73%) antibiotic prescribed in the brand name. So, ordered most antibiotics for Acute GE, COPD, pneumonia, and UTI were in Brand names compared to generic names.

Table 3. Number of antibiotics prescribed in brand name per prescription

Final Diagnosis category	Antibiotics	N (%)
Acute GE	0	14(7.04)
	1	76(38.19)
	2	99(49.75)
	3	9(4.52)
	4	1(0.50)
Acute GE with UTI	1	1(100.00)
AE of COPD	0	4(21.05)
	1	7(36.84)
	2	7(36.84)
	4	1(5.26)
Pneumonia	0	2(7.69)
	1	10(38.46)
	2	13(50.00)
	3	1(3.85)
UTI	0	12(14.81)
	1	50(61.73)
	2	16(19.75)
	3	1(1.23)
	4	2(2.47)

Table 4. Duration of antibiotic therapy

Antibiotics	Duration, days (mean ± SD)
Penicillins combination	3.27 ± 1.36
Cephalosporins	3.01 ± 1.11
carbapenems	4.25 ± 2.06
Macrolides	3.52 ± 1.37

Antibiotics	Duration, days (mean ± SD)
Fluroquinolones	2.78 ± 1.12
Aminoglycosides	3.24 ± 1.37
Cephalosporins combination	3.46 ± 1.50
Tetracyclines	4.28 ± 1.49
Nitroimidazoles	2.98 ± 1.04
Oxazolidines	3.5 ± 0.70
Nitrofuran antibiotics	3 ± 0
Other antibiotics	3.5 ± 2.06

The mean ± SD duration of total antibiotic therapy among the study population was 3.12 ± 1.23 days.

5. PRESCRIPTION PATTERN OF VARIOUS CLASSES OF ANTIBIOTICS

Table 5. Prescription pattern of Penicillin + Beta lactamase antibiotics

Final Diagnosis category	Antibiotics	N (%)
Acute GE	Amoxicillin + Clavulanic acid	2(1.0)
	Piperacillin + Tazobactam	12(6.0)
	Not prescribed	185(93.0)
AE of COPD	Amoxicillin + clavulanic acid	2(9.5)
	Piperacillin + tazobactam	3(14.4)
	Not prescribed	16(76.2)
Pneumonia	Piperacillin + tazobactam	17(58.6)
	Not prescribed	12(41.4)
UTI	Amoxicillin + clavulanic acid	1(1.2)
	Ticarcillin + clavulanic acid	1(1.2)
	Piperacillin + tazobactam	17(20.2)
	Not prescribed	65(77.4)

Amoxicillin + clavulanic acid was prescribed in two acute GE, 2 COPD with acute exacerbation, and 1 UTI patient. Piperacillin + tazobactam gave for 12 critical GE, 3 AE of COPD, 17 pneumonia, and 17 UTI patients. Ticarcillin + clavulanic acid was prescirbed for one UTI patient.

Table 6. Prescription pattern of 2nd generation cephalosporins

Final Diagnosis category	Antibiotics	N(%)
COPD with Acute exacerbations	Cefuroxime	1(4.8)
	Not prescribed	20(95.2)
Pneumonia	Cefuroxime	2(6.9)
	Not prescribed	27(93.1)
UTI	Cefuroxime	1(1.2)
	Not prescribed	83(98.8)

Cefuroxime was prescribed for 1 COPD with acute exacerbation, 1 UTI, and two pneumonia patients

Cefixime is prescribed in 18 acute GE, two UTIs, and one pneumonia patient. Ceftazidime was only prescribed to one acute GE patient. Cefotaxime was prescribed in 53 acute GE and 3 UTI patients. Ceftriaxone has been prescribed in 37 critical GE, 4 COPD with acute exacerbation, eight pneumonia, and 15 UTI patients.

Faropenem was prescribed to 2 UTI patients and only one COPD with acute exacerbation, and one pneumonia patient.

Clarithromycin has been prescribed in 2 acute GE, 4 COPD with acute exacerbation,11 pneumonia, and 6 UTI patients. Azithromycin was defined only in 2 pneumonia patients.

Ciprofloxacin was prescribed in 3 acute GE, one pneumonia, and 2 UTI patients. Ofloxacin was specified in 43 acute GE, one acute GE with UTI, one pneumonia, and 14 UTI patients. Levofloxacin was prescribed for 4 COPD with acute exacerbation and one pneumonia. Moxifloxacin was prescribed/ordered only for one pneumonia patient.

Table 7. Prescription pattern of 3rd generation antibiotics

Final Diagnosis category	Antibiotics	N(%)
Acute GE	Cefixime	18(9.0)
	Cefotaxime	53(26.6)
	Ceftazidime	1(0.5)
	Ceftriaxone	37(18.6)
	Not prescribed	90(45.2)
Acute exacerbations of COPD	Ceftriaxone	4(19.1)
	Not prescribed	17(81.0)
Pneumonia	Cefixime	1(3.4)
	Ceftriaxone	8(27.5)
	Not prescribed	20(69.0)
UTI	Cefixime	2(2.4)
	Cefotaxime	3(3.6)
	Ceftriaxone	15(17.9)
	Not prescribed	64(76.2)

Table 8. Prescription pattern of carbapenems

Final Diagnosis category	Antibiotics	N(%)
COPD with Acute exacerbation	Meropenem	1(4.8)
	Not prescribed	20(95.2)
Pneumonia	Meropenem	1(3.4)
	Not prescribed	28(96.6)
UTI	Faropenem	2(2.4)
	Not prescribed	82(97.6)

Table 9. Prescription pattern of Macrolides

Final Diagnosis category	Antibiotics	N(%)
Acute GE	Clarithromycin	2(1.0)
	Not prescribed	197(99.0)
COPD with Acute exacerbation	Clarithromycin	4(19.0)
	Not prescribed	17(81.0)
Pneumonia	Azithromycin	2(6.9)
	Clarithromycin	11(37.9)
	Not prescribed	16(55.2)
UTI	Clarithromycin	6(7.1)
	Not prescribed	78(92.9)

Table 10. Prescription pattern of fluroquinolones

Final Diagnosis category	Antibiotics	N(%)
Acute GE	Ciprofloxacin	3(1.5)
	Ofloxacin	46(23.11)
	Not prescribed	150(75.37)
Acute GE with UTI	Ofloxacin	1(100.0)
COPD with Acute exacerbation	Levofloxacin	4(19.0)
	Not prescribed	17(81.0)
Pneumonia	Ciprofloxacin	1(3.4)
	Levofloxacin	1(3.4)
	Moxifloxacin	1(3.4)
	Ofloxacin	1(3.4)
	Not prescribed	25(86.2)
UTI	Ciprofloxacin	2(2.4)
	Not prescribed	68(81.0)
	Ofloxacin	14(16.7)

Table 11. Prescription pattern of Aminoglycosides

Final Diagnosis category	Antibiotics	N(%)
Acute GE	Amikacin	23(11.6)
	Not prescribed	176(88.4)
Pneumonia	Amikacin	4(13.8)
	Tobramycin	1(3.4)
	Not prescribed	24(82.8)
UTI	Amikacin	18(21.4)
	Not prescribed	66(78.3)

Amikacin was prescribed in 23 acute GE, four pneumonia, and 18 UTI patients. Tobramycin was ordered only for one pneumonia patient.

Table 12. Prescription pattern of Cephalosporin's + Betalactam Inhibitors

Final Diagnosis category	Antibiotics	N(%)
Acute GE	Cefoperazone + sulbactam	16(8.0)
	Not prescribed	183(92.00)
COPD with Acute exacerbation	Cefoperazone + sulbactam	7(33.3)
	Not prescribed	14(66.7)
UTI	Cefoperazone + sulbactam	29(34.5)
	Not prescribed	55(65.5)

Cefoperazone+ sulbactam was prescribed in 16 acute GE, 7 COPD with acute exacerbation, and 29 UTI patients.

Table 13. Prescription pattern of Tetracycline's

Final Diagnosis category	Antibiotics	N(%)
Acute GE	Doxycycline	5(2.5)
	Not prescribed	194(97.5)
UTI	Doxycycline	2(2.4)
	Not prescribed	82(97.6)

Doxycycline was prescribed in 5 acute GE and 2 UTI patients

Table 14. Prescription pattern of Nitroimidazoles

Final Diagnosis category	Antibiotics	N(%)
Acute GE	Metronidazole	123(61.8)
	Not prescribed	66(33.16)
	Ornidazole	10(5.02)
Acute GE with UTI	Ornidazole	1(100.0)
COPD with Acute exacerbation	Fluconazole	2(9.5)
	Not prescribed	19(90.5)
UTI	Metronidazole	3(3.6)
	Not prescribed	81(96.4)

Ordered Metronidazole in 123 acute GE and 3 UTI patients. Fluconazole was advised in 2 COPD with acute exacerbation patients. Ornidazole was defined in 7 sensitive GE and critical GE with UTI.

Table 15. Prescription pattern of oxazolidine

Final Diagnosis category	Antibiotics	N(%)
Pneumonia	Linezolid	29(6.8)
	Not prescribed	27(93.1)

Linezolid was prescribed only in 2 pneumonia patients.

Table 16. Prescription pattern of nitrofurantoin antibiotics

Final Diagnosis category	Antibiotics	N(%)
UTI	Not prescribed	82(97.6)
	Nitrofurantoin	2(2.4)

Nitrofurantoin was prescribed only in 2 UTI patients.

Table 17. Prescription pattern of other antibiotics

Final Diagnosis category	Antibiotics	N(%)
Acute GE	Not prescribed	193(97.0)
	Rifaximin	6(3.0)
COPD with Acute exacerbation	Not prescribed	20(95.2)
	Trimethoprim+ Sulfamethoxazole	1(4.8)
UTI	Clindamycin	1(1.2)
	Not prescribed	81(96.4)
	Polymyxin B	1(1.2)
	Rifaximin	1(1.2)

Rifaximin was prescribed only in 6 acute GE and in 1 UTI patient. Trimethoprim+ sulfamethoxazole was ordered only in 1 COPD with acute exacerbation. Clindamycin was advised only in 1 UTI patient. Polymyxin B was prescribed for only 1 UTI patient.

6. PRESCRIBING PATTERN OF ANTIBIOTICS IN ACUTE GE

Table 18. Distribution of antibiotics in Acute GE

Acute GE	N(%)
Amoxicillin + Clavulanic acid	2(0.56)
Piperacillin + Tazobactam	12(3.39)
cefixime	18(5.08)
Cefotaxim	53(14.97)
Ceftazidime	1(0.28)
ceftriaxone	37(10.45)
Clarithromycin	2(0.56)
Ciprofloxacin	3(0.85)
Ofloxacin	46(12.99)
Amikacin	23(6.50)
Cefoperazone + sulbactam	16(4.52)
Doxycycline	5(1.41)
Metronidazole	123(34.75)
Ornidazole	10(2.82)
Rifaximin	6(1.69)

In our study, 354 Antibiotics were prescribed in 199 acute GE patients, among which the most commonly prescribed is Metronidazole (34.75%), and followed by Cefotaxime (14.97%). Ceftazidime (0.28%), Amoxicillin + clavulanic acid (0.56%), and clarithromycin (0.56%) were the least prescribed antibiotics in acute GE.

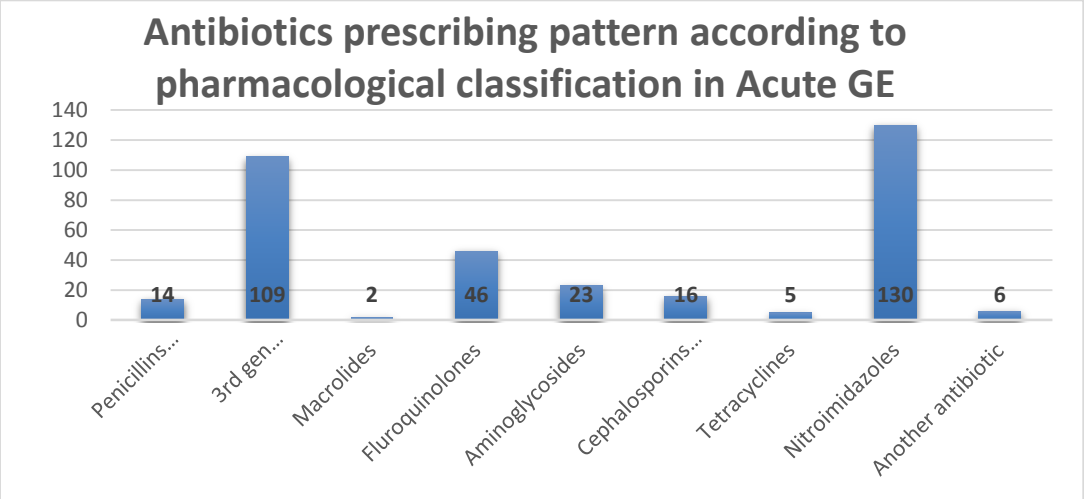

Fig. 2. Antibiotics prescribing pattern according to pharmacological classification

The nitroimidazole class was prescribed more, followed by 3rd generation cephalosporin's in treating acute GE.

7. PRESCRIBING PATTERN OF ANTIBIOTICS IN COPD

Table 19. Distribution of antibiotics in COPD

COPD	N(%)
Amoxicillin + clavulanic acid	2(6.67)
Piperacillin + Tazobactam	3(10.00)
cefuroxime	1(3.33)
Cefoperazone + sulbactam	7(23.33)
Ceftriaxone	4(13.33)
Meropenem	1(3.33)
Clarithromycin	4(13.33)
Levofloxacin	4(13.33)
Fluconazole	2(6.67)
Trimethoprim+ Sulfamethoxazole	1(3.33)

A total of 29 antibiotics were prescribed in 21 COPD patients, among which Cefoperazone + sulbactam (23.33%) was mostly prescribed.

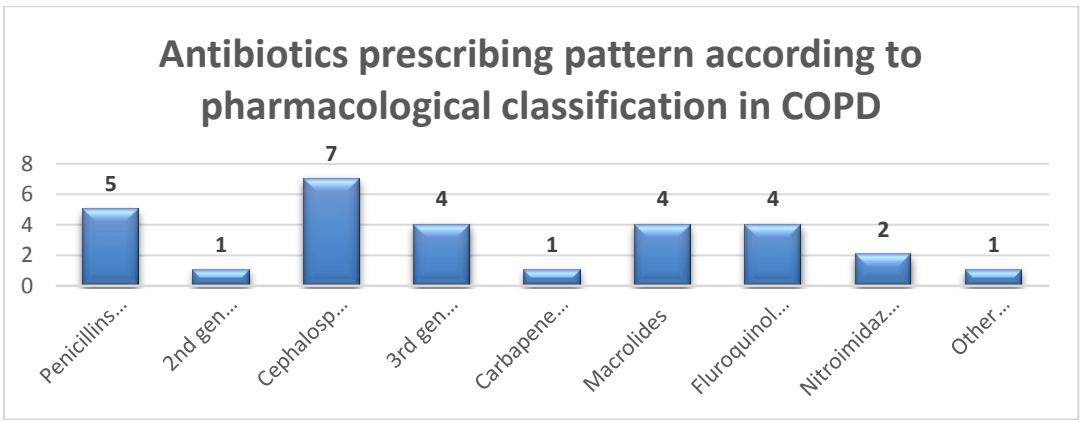

Fig. 3. Antibiotics prescribing pattern according to pharmacological classification in COPD

Found that cephalosporin's combination was the mainly prescribed class of antibiotic.

8. PRESCRIBING PATTERN OF ANTIBIOTICS IN PNEUMONIA

Table 20. Distribution of antibiotics in Pneumonia

Pneumonia	N(%)
Piperacillin + tazobactam	17(32.69)
Cefuroxime	2(3.85)
cefixime	1(1.92)
Ceftriaxone	8(15.38)
Meropenem	1(1.92)
Azithromycin	2(3.85)
Clarithromycin	11(21.15)
Ciprofloxacin	1(1.92)
Levofloxacin	1(1.92)
Moxifloxacin	1(1.92)
Amikacin	4(7.69)
Tobramycin	1(1.92)
Linezolid	2(3.85)

A total of 52 antibiotics were prescribed in 29 pneumonia patients, among which most commonly is piperacillin + tazobactam (32.69%), followed by clarithromycin (21.15%).

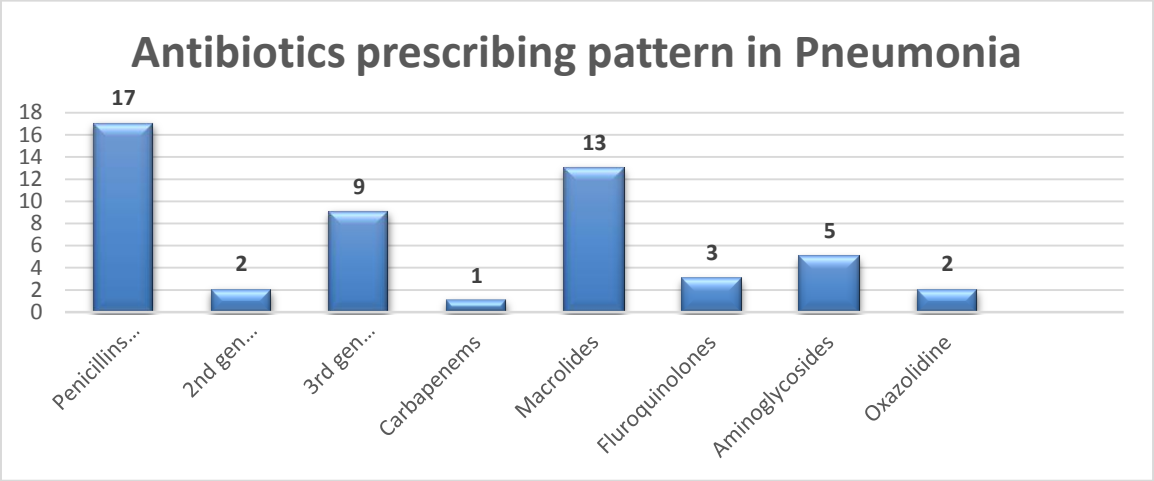

Fig. 4. Antibiotics prescribing pattern according to pharmacological classification in pneumonia

It was found that Penicillins combination was the most prescribed class of antibiotic followed by macrolides.

9. PRESCRIBING PATTERN OF ANTIBIOTICS IN UTI

Table 21. Distribution of antibiotics in UTI

UTI	N(%)
Amoxycillin + Clavulanic acid	1(0.83)
Piperacillin + tazobactam	17(14.05)
Ticarcillin + clavulanic acid	1(0.83)
Cefuroxime	1(0.83)
cefixime	2(1.65)

UTI	N(%)
Ceftriaxone	15(12.40)
Cefotaxime	3(2.48)
Faropenem	2(1.65)
Clarithromycin	6(4.96)
Ciprofloxacin	2(1.65)
Ofloxacin	14(11.57)
Amikacin	18(14.88)
Cefoperazone + sulbactam	29(23.97)
Doxycycline	2(1.65)
Metronidazole	3(2.48)
Nitrofurantoin	2(1.65)
Clindamycin	1(0.83)
Polymyxin B	1(0.83)
Rifaximin	1(0.83)

Total of 121 antibiotics were prescribed in 84 UTI patients among which Cefoperazone + sulbactam (23.97%) was mostly prescribed followed by amikacin (14.88%) and piperacillin + tazobactam (14.05%).

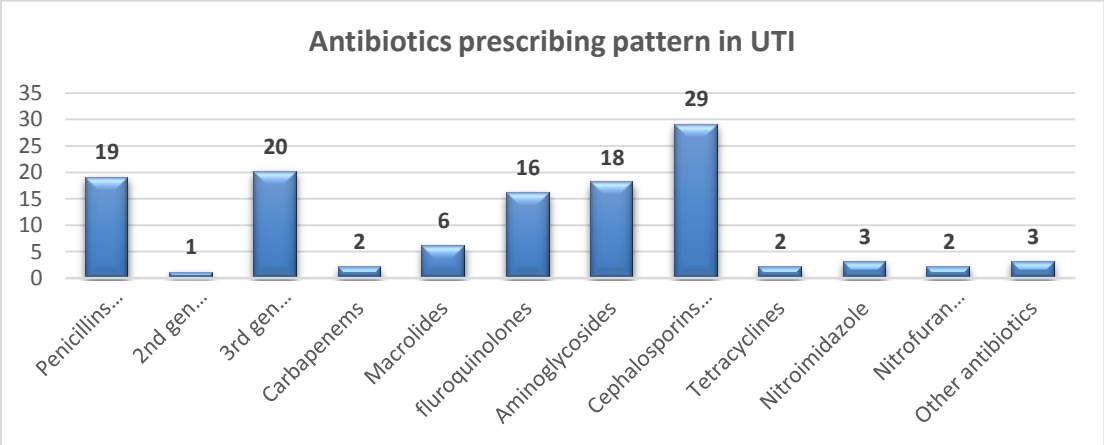

Fig. 5. Antibiotic prescribing pattern according to pharmacological classification in UTI It was found that cephalosporin combination was the most prescribed antibiotic class followed by 3rd generation cephalosporins

10. DRUG INTERACTIONS

In current study possible drug interaction between Antibiotics with Antibiotics and also Antibiotics with other drugs has been analyzed.

Table 22. Distribution of antibiotics DDI

Final Diagnosis category		N(%)
Acute GE	Absent	87(43.20)
	Present	112(56.8)
Acute GE with UTI	Absent	1(100.0)
COPD with Acute exacerbation	Absent	15(71.4)
	Present	6(28.6)
Pneumonia	Absent	23(79.3)
	Present	6(20.7)
UTI	Absent	70(83.3)
	Present	14(13.1)

Out of 334 patients 112 Acute GE, 6 COPD with acute exacerbations, 6 pneumonia and 14 UTI patients were found to have drug interactions.

11. SEVERITY OF POTENTIAL DRUG INTERACTIONS WITH ANTIBIOTICS

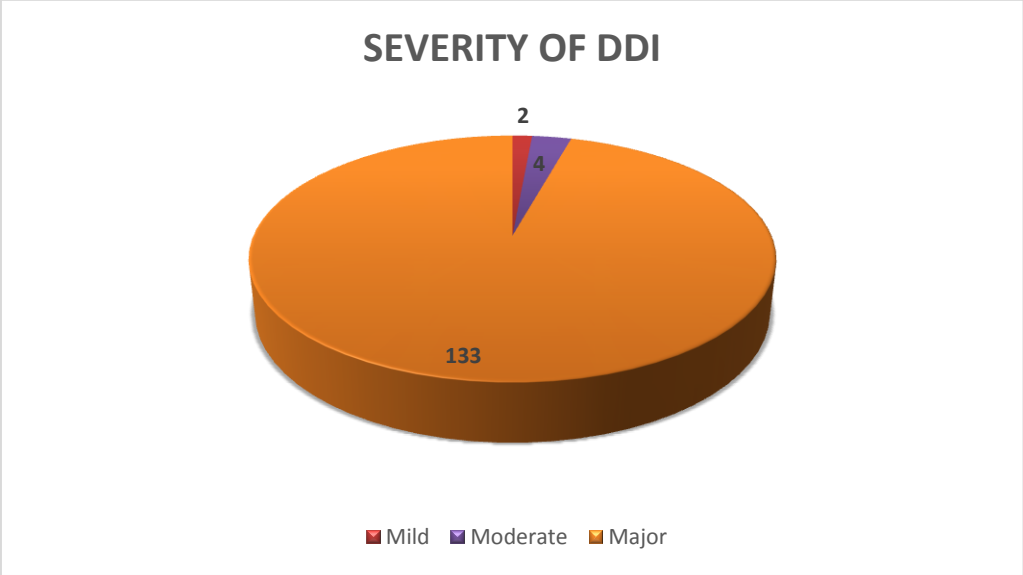

Fig. 6. Severity of potential drug interactions

Out of 139 drug-drug interactions found most of them were found to be severe drug-drug interactions

Table 23. List of possible major drug interactions with antibiotics

Final Diagnosis category	List of major DDI	N(%)
Acute GE	Ciprofloxacin + Ondansetron	1(0.5)
	Clarithromycin + Atorvastatin	1(0.5)
	Doxycycline + Piperacillin	1(0.5)
	Levofloxacin + ondansetron	1(0.5)
	Metronidazole + Fluconazole	1(0.5)
	Metronidazole + Domperidone	3(1.5)
	Metronidazole + Ofloxacin	4(2.0)
	Metronidazole + Ondansetron	80(40.2)
	Ofloxacin + Glimepiride	1(0.5)
	Ofloxacin + Ondansetron	18(9.0)
COPD with Acute exacerbation	Clarithromycin + Ondansetron:	1(4.8)
	Levofloxacin + Hydrocortisone	2(9.5)
	Metronidazole +Ondansetron	2(9.5)
Pneumonia	Clarithromycin + Ondansetron	4(13.8)
	Clarithromycin + Tramadol	1(3.4)
	Levofloxacin +Ondansetron	1(3.4)
	Ofloxacin + Ondansetron	1(3.4)
UTI	Doxycycline + Piperacillin	1(1.2)
	Cefoperazone+ Heparin	1(1.2)
	Clarithromycin + Ofloxacin	1(1.2)
	Metronidazole + Ondansetron:	2(2.4)
	Ofloxacin + Ondansetron	5(6.0)

Table 24. List of possible moderate drug interactions with antibiotics

Final Diagnosis category	List of moderate DDI	N(%)
COPD with Acute exacerbation	Clarithromycin + budesonide	1(4.8)
Pneumonia	Clarithromycin + budesonide	1(3.4)
UTI	Clarithromycin + Atorvastatin	1(1.2)
	Clarithromycin +Budesonide	1(1.2)

Table 25. List of possible minor drug interactions with antibiotics

Final Diagnosis category	List of minor DDI	N(%)
Acute GE	Ofloxacin + aspirin	1(0.5)
UTI	Clarithromycin+Theophylline	1(1.2)

Table 26. List of antibiotics with possible drug interactions

Antibiotics with major DDI	N(%)
Ciprofloxacin	1(0.68)
Cefoperazone	1(0.68)
Clarithromycin	13(8.90)
Doxycycline	3(2.05)
Levofloxacin	3(2.05)
Metronidazole	92(63.01)
Ofloxacin	31(21.23)
Piperacillin	2(1.37)

Table 27. Distribution of costs of various diagnostic tests

Final Diagnosis category		Cost of Biochemistry	Cost of Hepatology	Cost of hematology	Cost of sugar tests	Total Cost of Urine analysis	Cost of other diagnostic tests
Acute GE	Mean	654.02	403.6	278.2	104.8	283.2	1470.6
	Std. Deviation	142.70	269.0	108.1	60.9	137.9	1244.59
Acute GE with UTI	Mean	685.00	582.0	320.0	140.0	350.0	1500
COPD with Acute	Mean	587.14	166.3	259.0	113.3	250.0	1616.67

Final Diagnosis category		Cost of Biochemistry	Cost of Hepatology	Cost of hematology	Cost of sugar tests	Total Cost of Urine analysis	Cost of other diagnostic tests
exacerbation	Std. Deviation	245.62	269.4	128.8	56.3	162.0	1254.62
Pneumonia	Mean	566.90	220.8	198.6	96.6	181.0	1631.03
	Std. Deviation	263.33	287.4	158.0	65.9	178.0	1294.73
UTI	Mean	668.69	256.4	270.5	111.7	325.0	1526.19
	Std. Deviation	105.06	290.7	116.4	56.6	90.7	1424.09

Table 28. Distribution of costs of antibiotics used

Antibiotics	Acute GE		Acute GE with UTI	COPD with Acute exacerbation		Pneumonia		UTI	
	Mean	Std. Deviation	Mean	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Penicillins combination	237.7	980	0	723.00	1753.92	2490.5	2614.59	1120.8	2465.80
2nd gen cephalosporins	0	0	0	167.57	767.90	283.13	1070.26	27.92	255.96
3rd gen cephalosporins	117.47	229.61	0	51.14	183.0	194.35	407.71	71.80	222.01
Carbapenems	0	0	0	851.14	3900.42	616.34	3319.11	6.13	4.33
Macrolides	79.4	799.0	0	661.4	1766.7	2653.1	3809.6	182.1	1099.5
Fluroquinolones	155.2	350.4	26.4	10.8	27.01	55.03	236.7	116.9	328.2
Aminoglycosides	8.5	26.6	0	0	0	57.01	244.9	15.45	36.8
Cephalosporins combination	424.9	1516.1	0	1978.7	3085.5	0	0	2048.1	3197.6
Tetracyclines	0.6	4.3	0	0	0	0	0	1.07	6.9
Nitroimidazole	132.4	120.4	390.6	7.8	25.1	0	0	8.1	45.5
Oxazolidines	0	0	0	0	0	184.4	697	0	0
Nitrofuran antibiotics	0	0	0	0	0	0	0	2.8714	18.49
Other antibiotics	6.06	38.7	0	8.6	39.4	0	0	186.4	1646.2
Total cost	1176.2	1946.3	417.0	4459.7	5505.3	6534.0	7530.0	3788	3708.6

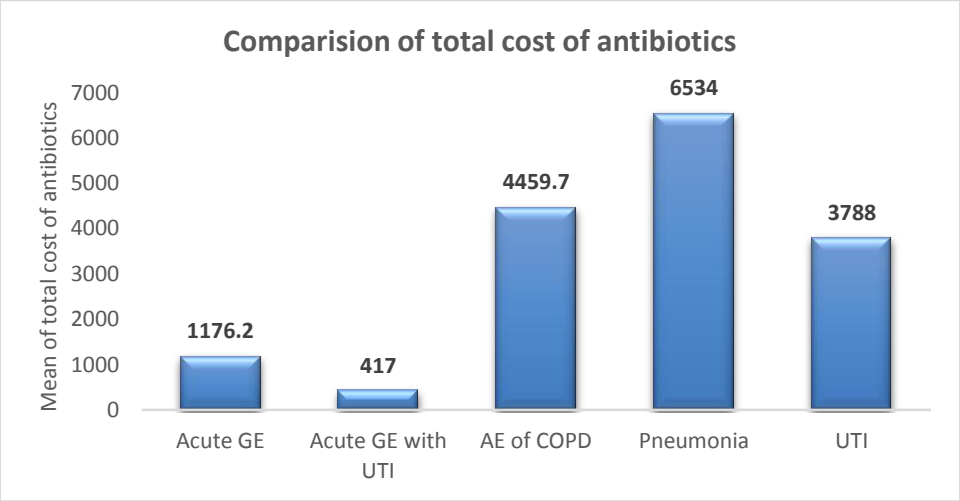

Fig. 7. Comparison of total costs of antibiotics

In this study metronidazole (63.01%) were found to have highest potential major drug interactions followed by ofloxacin (21.23%). Ciprofloxacin, cefoperazone and piperacillin were found to have least potential drug interactions.

It was found that in our study average cost of diagnostic tests was found to be the highest in Acute GE and least in Pneumonia.

In our study average cost of antibiotics used in the treatment of Pneumonia(6534 Rs) was found to be the highest followed by AE of COPD (4459.7 Rs).

12. DISCUSSION

An attempt was made to study the prescribing patterns of antibiotics in selected bacterial infectious diseases. Our study includes a total of 334 patients as per the inclusion and exclusion criteria. The prevalence of four bacterial infectious diseases i.e., pneumonia, AE of COPD, UTI and Acute GE was high among females (54.19%) than males (45.81%) which was similar to a study conducted by Dinesh K. Dhodi et al which had higher percentage of females than males [16].

Among the total prescriptions collected, age was taken into consideration by dividing into 8 age groups being kept at interval of 10 years each. The mean age of the patients observed in this study was 55.21 ± 18.46. As per the study population the greatest number of patients were in the age group of above 60 years. This was similar to the study conducted by Rosman et al., where it was found that greatest number of patients were in the age group of more than 60 years with the mean age of 56.2 ± 17.7 years [17].

Common past medical history found in the present study along with the diagnosis were DM and HTN. The similar study was conducted by Harish et al., where it was found that HTN (38.2%) and DM (36.2%) are the most common co-morbidities in the study population [18]. In our study more than half of the patients were diagnosed with Acute gastroenteritis (59.58%) followed by UTI (25.15%), pneumonia (8.68%) and AE of COPD (6.29%), as diarrheal disease is the most commonly and frequently observed cause of visiting physician.

Bacteriological analysis in bacterial infectious diseases helps in providing accurate antibiotic therapy to the patients in turn leading to better patient outcome and decreased emergence of drug resistance. In our study out of 334 patients, culture sensitivity tests were performed in only 175(47.6%). Samples collected for culture sensitivity tests includes blood, sputum, urine and stool [19].

In our study generic prescriptions were found low. A study conducted by Kothai R et al., showed similar results. Prescribing the drugs with their brand name increases the cost of therapy to the patients. There can be various factors behind this such as influence from the manufacturers to promote a specific brand. Increasing generic prescribing would rationalize the use and reduce the cost of drug and also reduces the confusion relating to drug names, cost and stock items [20].

In our study a total of 354 Antibiotics were prescribed in 199 acute GE patients among which most commonly prescribed is Metronidazole (34.75%) followed by Cefotaxime (14.97%). Similar results were observed in the study conducted by Hyo-Jin Lee et al., where it was found that metronidazole and cephalosporins were the mostly prescribed antibiotics in the treatment Acute GE. A total of 29 antibiotics were prescribed in 21 COPD patients, among which Cefoperazone + sulbactam (23.33%) were mostly prescribed [21].

A total of 52 antibiotics were prescribed in 29 pneumonia patients among which most commonly prescribed antibiotic is piperacillin + tazobactam (32.69%) followed by clarithromycin (21.15%) which was similar to the study conducted by Robert A Fowler et al., where the most commonly used antibiotics to treat pneumonia was piperacillin + tazobactam [22]. Total of 121 antibiotics were prescribed in 84 UTI patients among which Cefoperazone + sulbactam (23.97%) was mostly prescribed followed by amikacin (14.88%) and piperacillin + tazobactam (14.05%). Similar results were observed in the study conducted by Samira Kumar Naik et al., where it was observed that cephalosporins are the mostly prescribed antibiotics in the management of UTI [23].

Drug interactions are an avoidable cause of patient harm. Harm occurs due to either increased drug effect or decrease drug effect leading to therapeutic failure. Out of 334 patients 112 Acute GE, 6 AE of COPD, 6 pneumonia and 14 UTI patients were found to have drug interactions. Out of 139 drug-drug interactions, most of them were found to be severe drug-drug interactions. Metronidazole (63.01%) was found to have highest potential major drug interactions followed by ofloxacin (21.23%). Ciprofloxacin, cefoperazone and piperacillin were found to have least potential drug interactions.

13. CONCLUSIONS

This study serves to spotlight the current prescribing trends of antibiotics in acute GE, pneumonia, AE of COPD and UTI. Prescription pattern studies have become a potential tool for evaluating the health care systems. Periodic study on the usage of antibiotics and sensitivity pattern in the hospital will enable the health care professionals to select the appropriate one to promote the rational use of antibiotics.

It was observed that percentage of antibiotics prescribed by its generic name was less than optimal and culture sensitivity tests were performed in less than half of the study population. Prescribing by generic name helps the hospital pharmacy to have better inventory control. There is vital need for microbiological investigation before treatment of infections.

Most of the potential drug interactions can be detected by applying principles of clinical pharmacology and good clinical care. Increased vigilance by clinicians at the time of changing drug improves the chance of identifying unwanted drug interactions before they cause significant harm.

Implementation of clinical pharmacy services plays a vital role in optimizing drug therapy. Assessment of rational use of antibiotics involved in possible drug interactions and interacting with physicians about this can result in improved patient care.

LIMITATIONS OF THE STUDY

The data were also collected only by reviewing the inpatient medical records in the MRD, which does not include interviews with prescribers and/or patients and thus does not assess factors contributing to the current practice.

Findings of the study were restricted to only health care professionals working only in one hospital. The outcome would have been more significant, if the study was conducted in different hospitals.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

ETHICAL APPROVAL

The institutional ethical clearance (DSU/P-D/IHEC/2020- 21/0010) has been collected from

Medical Records(Inpatient records) Department at Sagar Hospitals, Bangalore, India.

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Competing interests

Authors have declared that no competing interests exist.

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