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Drug Utilization Evaluation of Antibiotics and Classifying Them Based on WHO AWaRe Classification

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ABSTRACT
Antibiotics are the most prescribed medicaments in medical practices worldwide. Indiscriminate use of antibiotics adds to the emergence of Antibiotic resistance (ABR) leading to inefficiency of antibiotics. WHO fostered three unique classification systems - Access, Watch, and Reserve (AWaRe classification)- a tool to identify the safe use of antibiotics. The study aimed to evaluate antibiotic use in the Department of Surgery using the WHO ATC/DDD method and further classified the antibiotics based on WHO AWaRe Classification. An observational study was carried out among 305 samples in the In-Patient Department of Surgery at a teaching hospital, in Bangalore. Data was collected from the patient's case files using a self-designed data collection form. The collected data were entered in Microsoft Excel and appropriate statistical analysis were performed. It was found that most (28.53%) of the patients belonged to the age group of 38-47 years and most of them received antibiotic therapy as prophylaxis (69%). It was found that Ceftriaxone (28.51%), Metronidazole (21.15%), and Cefixime (18.52%) were the most frequently prescribed antibiotics. The most frequently prescribed antibiotic class was Beta-lactams (65.3%), and most prescribed antibiotics belonged to the Watch Group (53%). The most utilized antibiotics were Ceftriaxone (3.32 DDD/100 bed days) followed by Cefixime (2.15 DDD/100 bed days) and Metronidazole (1.59 DDD/100 bed days). This study shows a need to prepare and implement proper policies or guidelines for prescribing antibiotics in the hospital.

Keywords: ABR, WHO, AWaRe, ATC/DDD.

INTRODUCTION

Antibiotics are employed for treating ailments caused by microorganisms and are at present the most prescribed medicaments in medical practices worldwide. Even so, the indiscriminate use of antibiotics adds to the prevailing emergence of bacterial resistance, which speeds up the rise and spread of resistant

microorganisms and affects the therapeutic outcome [i]. Antibiotics are classified as follows based on their mechanism of action:
Inhibition of Cell Wall Synthesis
Protein Synthesis Inhibitors
DNA Synthesis Inhibitors
RNA Synthesis Inhibitors
Mycolic Acid Synthesis Inhibitors
Folic Acid Synthesis Inhibitors

Antibiotic Resistance

Antimicrobial resistance (AMR) is the evolution of a harmful bacteria in a manner that reduces the effect of antibiotics on it.
The irrational use and prescribing of antibiotics are increasing the frequency of AMR, which has been identified as an emerging issue all around the world [1]. **Suraj. B *et al.*, (2021)** conducted a prospective, observational study and concluded that periodic prescription audit and necessary modification of antibiotic prescribing policy must be carried out to ensure rational prescribing and use of antibiotics and this would also contribute towards reducing the economic burden experienced by both the patients and the hospital pharmacy [2].
Antibiotics can become inefficient due to the resistance developed against them after being used irregularly for a longer period than required [3].
The need for antibiotics has been multiplying over time whereas the development of newer antibiotics has decreased over the recent past, this leaves us with the currently available class of antibiotics to treat infectious diseases. Considering that several resistant microorganisms are evolving, it is necessary to find a potent way to preserve the currently available antibiotics and try to prolong their effectiveness [4]. AMR is divided into two types:

Relative Resistance: It is the type of resistance where certain microorganisms at certain parts of the body fail to respond to the normal dose of antibiotic. This can be treated by increasing the dose of antibiotic administered. This is the most frequently observed type of resistance in patients.

Absolute Resistance: It is the type of resistance that cannot be treated even by administering higher doses of antibiotics due to the presence of highly resistant strains of microorganisms [5].

As per the reports from the WHO priority pathogen list, there is an urgent need to develop new antibiotics to treat certain bacterial infections, for instance, Carbapenem-resistant gram-negative bacterial infections [3]. However, the development of newer antibiotics to treat the infection would not be effective in the long run, in case antibiotics are used irrationally as in the present.
AMR has also been shown to have a great impact related to increased duration and intensity of treatment in turn leading to a longer, unexpected extension of the patient's stay at the hospital.

Suhena R patel *et al.*, (2015) concluded "The need for antimicrobials should be reviewed daily on every patient, always stopping at the earliest possible opportunity where the benefits of continuing are

outweighed by the drawbacks—both to that patient and to the unit as a whole in terms of its microbial ecology" [6].

Antibiotics typically have no effect on species besides bacteria, such as viruses or fungi. It is important to aggressively discourage this practice.

A metric for measuring a bacterial isolate's susceptibility to specific antibiotics is its Minimum Inhibitory Concentration (MIC). A high MIC that is higher than the threshold for antibiotic susceptibility will be reported as a resistant illness. Bacteria may be resistant to an antibiotic due to innate or acquired characteristics. Antibiotics are not all equally efficient against all kinds of bacteria. A bacterium is said to have intrinsic resistance if it lacks the target for a certain antibiotic [7]

For example, Gram-negative bacteria cannot pass the cell wall of vancomycin, an antibiotic that is known to function against Gram-positive bacteria. Additionally, because beta-lactam antibiotics need a cell wall to work, they are ineffective against bacteria such as Mycoplasma species that do not have one [7]

Additionally, bacteria can develop resistance by acquiring resistance genes from other bacteria or by producing a mutation that causes antibiotic efficacy to be diminished or eliminated. This type of resistance is termed Acquired resistance. A bacterial organism may have more than one sort of bacterial resistance [7].

Bacterial Culture and Sensitivity Test

Microorganisms called bacteria are widely distributed in the environment. Bacterial infections have the potential to spread throughout the body if untreated, which can result in sepsis, a condition that can be fatal.

The bacterial culture and sensitivity test determines whether there is a bacterial infection present in certain bodily fluids or regions. Based on the bacteria identified and the antibiotics it is sensitive to, the course of treatment for a particular infectious disease can be determined.

Thus, it is very important to treat a patient appropriately based on the identified microorganism or resistant strains, to prevent the development of any further AMR and to reduce the rate of progress in infections [8]

AWaRe Classification

To try and resolve the issues of antibiotic resistance, the WHO aimed to come up with a tool to utilize antibiotics safely and effectively. Hence, WHO fostered three unique classification systems - Access, Watch, and Reserve - which together structure the AWaRe classification of antibiotics.

Access Group: The antibiotics under this group offer the best possible therapeutic outcome with the minimal potential of developing resistance. Antibiotics under the Access Group have a broader spectrum of activity against a wide range of susceptible microorganisms. Antibiotics categorized under this group can be considered for use as the first or second choice of empiric therapy for infectious diseases. A few antibiotics categorized under the Access Group are:

- Amikacin
- Metronidazole
- Amoxicillin-Clavulanic Acid [9].

Watch Group: The antibiotics under this group are critically important and have a higher chance of developing resistance against various microorganisms. These antibiotics need to be provided with the

prime priority while conducting Antimicrobial Stewardship Programmes. These antibiotics are specifically indicated only for certain infective diseases as first or second-line empiric treatments. A study conducted by **Vinodkumar Mugada *et al.*, (2021)** concluded that the use of antibiotics belonging to the Watch category was maximum. A few antibiotics categorized under the Watch Group are:

- Azithromycin
- Cefaclor
- Ciprofloxacin [9].

Reserve Group: The antibiotics categorized under this group are also referred to as the 'Last Resort'. These antibiotics are indicative only for highly selective patients having confirmed life-threatening infections or are infected with multi-drug-resistant bacteria. A few antibiotics categorized under the Reserve Group are:

- Aztreonam
- Colistin
- Linezolid [9].

Defined Daily Dose (DDD)

WHO defines the "Defined daily dose (DDD)" metric system as the assumed average maintenance dose per day for a drug used for its main indication in adults, which is a method of measuring drug utilization that is implemented across the world in any type of setting [10].

DDDs do not take into consideration individual characteristics such as patient height, weight, age, gender, disease condition, and so on [11].

Formulae to calculate DDD/100 bed days

- $\text{DDD} = \dfrac{\text{Number of items used} \times \text{Amount of drug per item (mg)}}{\text{WHO recommended DDD of drug}}$
- $\text{DDD/100 bed days} = \dfrac{\text{Number of units administered in the study period} \times 100}{\text{DDD (mg)} \times \text{no. of days in the study period}}$
- $\text{Occupancy index} = \dfrac{\text{Total inpatient service days for a period} \times 100}{\text{no. of beds} \times \text{Occupancy index}}$
- $\dfrac{\text{Total inpatient service days for a period} \times 100}{\text{Total inpatient bed count} \times \text{no. of days in the study period}}$

DDDs are only given to medications with an Anatomical Therapeutic Chemical (ATC) number. The fundamental rule is to only allocate one DDD per administration route under an ATC code [12]. Topical products, sera, vaccinations, antineoplastic medicines, allergen extracts, general and local anesthetics, and contrast media do not have documented DDDs [13]. The study was conducted to identify the judicious use of antibiotics that would help in enabling their use safely and effectively, it would further help in identifying antibiotics that have the potential to cause antimicrobial resistance in the future.

MATERIALS AND METHODS

This was a prospective observational study carried out over 6 months in the Department of General Surgery ESIC MC & PGIMSR, Rajajinagar, Bengaluru. Subjects for the study were identified by the investigator during ward rounds based on the inclusion and exclusion criteria. A total of 305 samples were collected and included in the study. Relevant data collected were recorded on the Self-designed data collection form. The data thus obtained was entered into a Microsoft Excel sheet and analyzed

appropriately. The study was approved per the guidelines issued by ICMR the Institutional Ethics Committee has issued ethical clearance to carry on the work.

Statistical Analysis

All recorded data were entered and analyzed using MS Excel. Descriptive statistics were computed for quantitative variables along with DDD estimation to identify the rate of consumption of antibiotics in the hospital during the study period. Frequencies and percentages were calculated for categorical values. Column charts, pie-charts, bar graphs were applied to find the nature of data distribution.

RESULTS AND DISCUSSION

The study was conducted on the subjects drawn from the population of the General Surgery Department of a Teaching Hospital based on the inclusion criteria. A total of 305 subjects who were admitted to the Department of General Surgery and their prescriptions during the study period were included for analysis in the study.

AGE DISTRIBUTION OF SUBJECTS BY GENDER:

Out of 305 subjects, the majority 87 (28.53%) were from the age group of 38-47 years followed by 84 (27.54%) from the age group of 48-57 years, 41 (13.45%) from the age group of 28-37years, 36 (11.80%) from the age group of 58-67 years, 27 (8.85%) from the age group 68-77 years, 25 (8.20%) from the age group of 18-27 years and the least 5 (1.63%) were from the age group of 78-87 years.

Table 1: Age distribution of subjects by gender

Age group (years)	Male		Female		Total no. Of Subjects	
	n	(%)	n	(%)	n	(%)
18-27	19	9%	6	6%	25	8.20
28-37	25	13%	16	16%	41	13.45
38-47	52	26%	35	33%	87	28.53
48-57	48	24%	36	34%	84	27.54
58-67	30	15%	6	6%	36	11.80
68-77	22	11%	5	5%	27	8.85
78-87	4	11%	1	1%	5	1.63
Grand Total	**200**	**66%**	**105**	**34%**	**305**	**100**

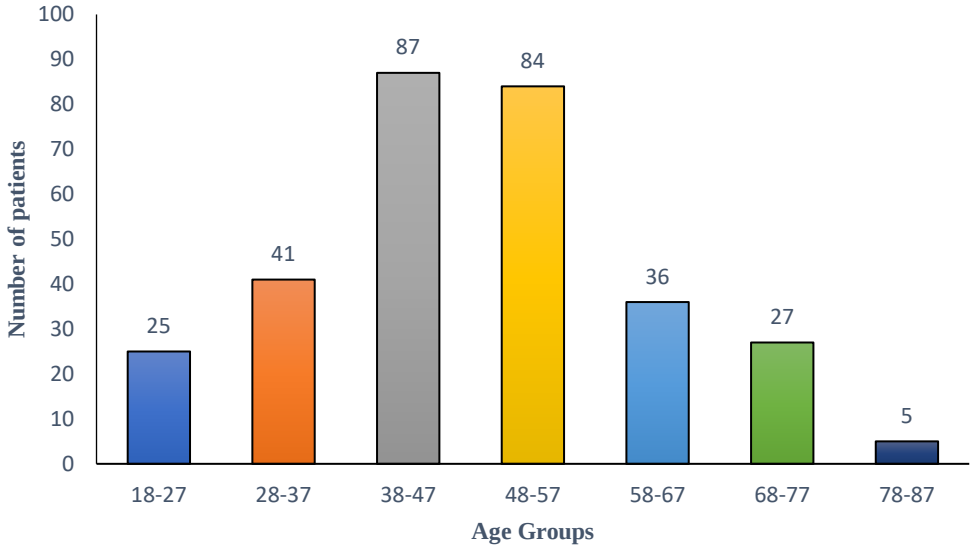

Figure 1: Age Distribution of Subjects

DISTRIBUTION OF SUBJECTS BY GENDER:

Out of 305 subjects included in the study, most of the subjects 200 (66%) were males. The percentage of females 105 (34%) included in the study was lesser than males.

Table 2: Distribution of subjects by gender		
Gender	**Number Of Subjects**	**Percentage (%)**
Male	200	66%
Female	105	34%
Total	305	100%

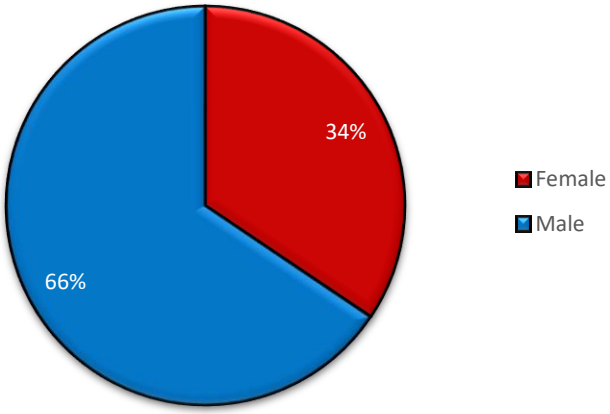

Figure 2: Distribution of subjects by gender

DISTRIBUTION OF SUBJECTS BASED ON THE TYPE OF ANTIBIOTIC THERAPY RECEIVED:

Out of 305 subjects included in the study, majority of them 211 (69%) received antibiotics as a part of Prophylaxis and 94 (31%) received antibiotics as a part of Empirical Therapy.

Table 3: Distribution of subjects based on the type of antibiotic therapy provided		
Type Of Therapy	**Number Of Subjects**	**Percentage (%)**
Empiric	94	31%
Prophylactic	211	69%
Total	305	100%

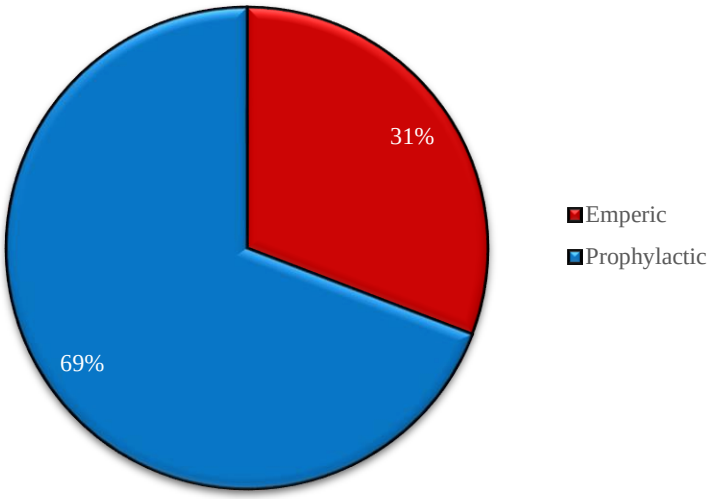

Figure 3: Distribution of subjects based on the type of antibiotic therapy provided

DISTRIBUTION OF SUBJECTS BASED ON THE STATUS OF SURGERY:

Majority of the subjects 225 (74%) underwent surgery and the remaining 80 (26%) did not undergo surgery out of the 305 patients included in the study.

Table 4: Distribution of subjects based on the status of surgery		
Surgery Status	**Number Of Subjects**	**Percentage (%)**
No Surgery	80	26%
Surgery	225	74%
Total	305	100%

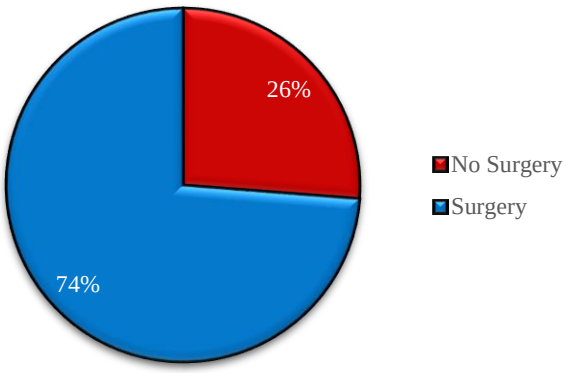

Figure 4: Distribution of patients based on the status of surgery

DISTRIBUTION OF MEDICINES USED IN THE SURGERY DEPARTMENT:

Out of 4463 medications administered during the study period, it was identified that 761 (17.05%) were antibiotics and the remaining 3702 (82.95%) were concomitant medications administered for therapy during the period of study.

Table 5: Distribution of medicines used

Drugs	Number Of Medicines	Percentage (%)
Concomitant Medicines	3702	82.95%
Antibiotics	761	17.05%
Total	4463	100%

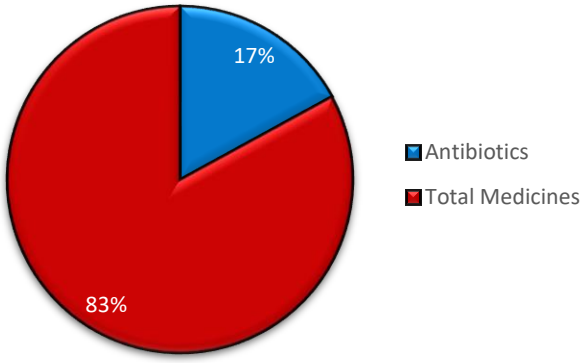

Figure 5: Distribution of medicines used

DISTRIBUTION OF ANTIBIOTICS BASED ON THE ROUTE OF ADMINISTRATION:

Out of the 761 Antibiotics administered, the majority of them 553 (73%) were administered via the parenteral route and the remaining 208 (27%) were administered via the oral route.

Table 6: Distribution of antibiotics based on the route of administration

Route Of Administration	Number Of Antibiotics	Percentage (%)
Oral	208	27%
Parenteral	553	73%
Total	761	100%

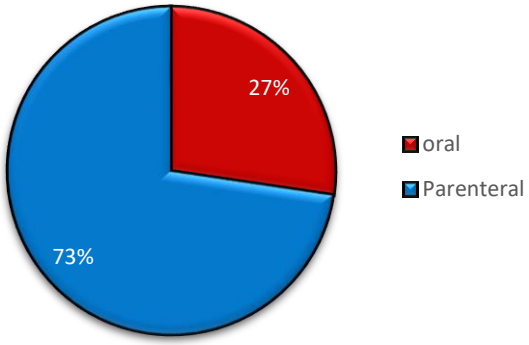

Figure 6: Distribution of antibiotics based on the route of administration

DISTRIBUTION OF ANTIBIOTICS USED IN THE SURGERY DEPARTMENT:

Out of 761 antibiotics administered, Ceftriaxone (n=217, 28.51%) was found to be administered highest followed by Metronidazole (n= 161, 21.15%), Cefixime (n= 141, 18.52%), combination of Piperacillin and Tazobactam (n= 50, 6.57%), combination of Amoxicillin and Clavulanic Acid (n= 48, 6.3%), Ciprofloxacin (n=42, 5.51%), Meropenem (n= 36, 4.73%), Amikacin (n=22, 2.89%), Colistin (n=9, 1.2%), Norfloxacin (n=8, 1.05%), Linezolid (n=7, 0.91%), Levofloxacin (n=6, 0.8%), Cefotaxime (n=4, 0.52%), Azithromycin (n=3, 0.39%), Doxycycline (n=2, 0.3%), Nitrofurantoin (n=2, 0.26%), Vancomycin (n=1, 0.13%), Tetracycline (n=1, 0.13%) and Amoxicillin (n=1, 0.13%). Vancomycin, Tetracycline, and Amoxicillin were found to be the least administered antibiotics.

Table 7: Distribution of antibiotics based on the number of antibiotics administered

Antibiotic	No. Of Antibiotics Administered	Percentage (%)
Ceftriaxone	217	28.51
Amoxicillin + Clavulanic Acid	48	6.3
Metronidazole	161	21.15
Ciprofloxacin	42	5.51
Amikacin	22	2.89
Meropenem	36	4.73
Piperacillin + Tazobactam	50	6.57
Linezolid	7	0.91
Colistin	9	1.2
Levofloxacin	6	0.8
Cefotaxime	4	0.52
Doxycycline	2	0.3
Vancomycin	1	0.13
Tetracycline	1	0.13
Cefixime	141	18.52
Azithromycin	3	0.39
Norfloxacin	8	1.05
Amoxicillin	1	0.13
Nitrofurantoin	2	0.26
Total	**761**	**100 (%)**

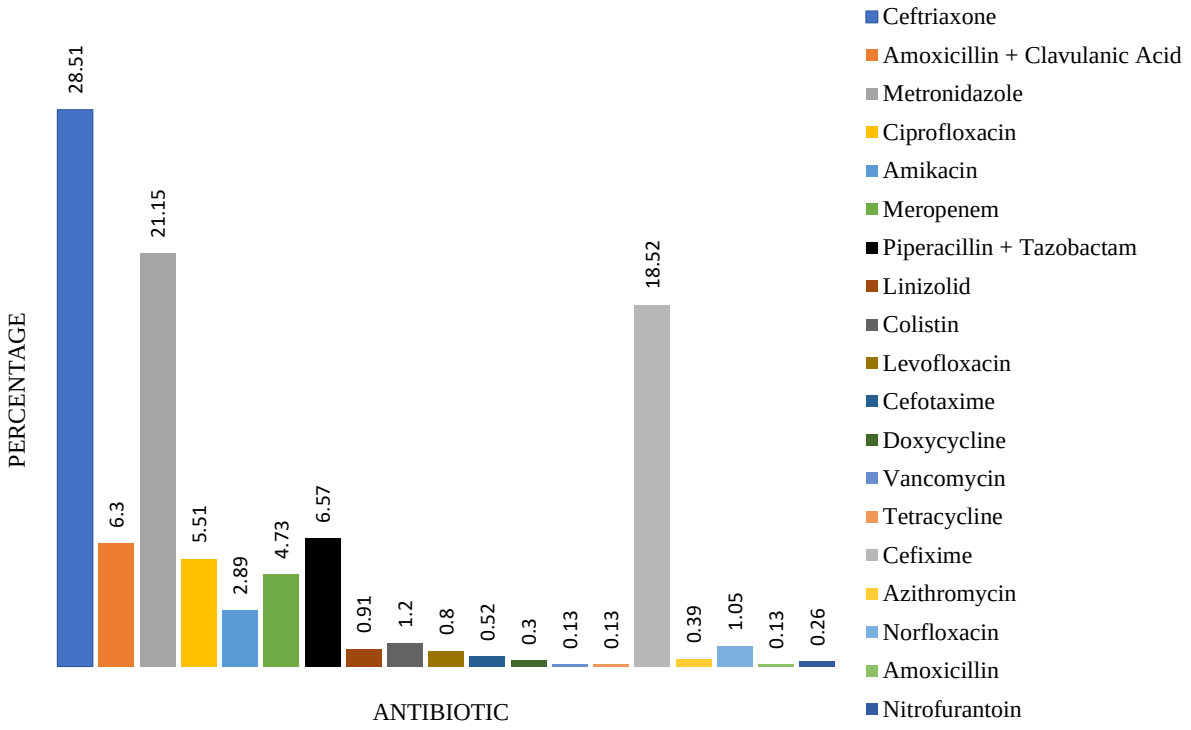

Figure 7: Distribution of antibiotics based on the number of antibiotics administered

DISTRIBUTION OF ANTIBIOTICS BASED ON AWaRe CLASSIFICATION:

During the study period, it was observed that in the department of General Surgery, a total of 19 antibiotics were used. According to WHO AWaRe Classification, among 19 antibiotics used, 7 (37%) belong to Access Category, 10 (53%) belong to the Watch Category, and 2 (10%) belong to the Reserve Category of antibiotics. It was observed that the usage of antibiotics belonging to the Watch Category was the highest compared to the Access Category and Reserve Category of antibiotics.

Table 8: Distribution of antibiotics based on AWaRe classification

Access category	Watch category	Reserve category
Amoxicillin + Clavulanic acid	Ceftriaxone	Linezolid
Metronidazole	Ciprofloxacin	Colistin
Amikacin	Meropenem	
Doxycycline	Piperacillin + Tazobactam	
Tetracycline	Levofloxacin	
Amoxicillin	Cefotaxime	
Nitrofurantoin	Vancomycin	
	Cefixime	
	Azithromycin	
	Norfloxacin	
7 (37%)	**10 (53%)**	**2 (10%)**

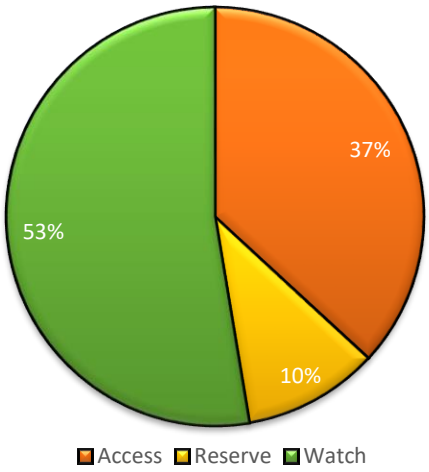

Figure 8: Distribution of antibiotics based on AWaRe classification

DEFINED DAILY DOSE (DDD)/100 BED DAYS FOR MONOTHERAPY OF PARENTERAL ANTIBIOTICS:

Out of the antibiotics administered, 11 (57.89%) antibiotics were administered parenterally as monotherapy. It was identified that Ceftriaxone (3.32 DDD/100 bed days) was the highest used during the study period, followed by Metronidazole (1.59 DDD/100 bed days), Meropenem (0.55 DDD/100 bed days), Ciprofloxacin (0.51 DDD/100 bed days), Amikacin (0.5 DDD/100 bed days), Linezolid (0.09 DDD/100 bed days), Levofloxacin (0.09 DDD/100 bed days), Doxycycline (0.06 DDD/100 bed days), Cefotaxime (0.03 DDD/100 bed days), Vancomycin (0.01 DDD/100 bed days) and Colistin (0.0015 DDD/100 bed days). Among all the antibiotics administered via the parenteral route (P), it was identified that Colistin was the least-used antibiotic during the study period.

Table 9: DDD/100 bed days for monotherapy of parenteral antibiotics

Antibiotic	ATC Code	DDD (g)	Prescribed (n)	Total Units (g)	DDD/100 Bed Days
Ceftriaxone	J01DD04	2	217	434	3.32
Metronidazole	P01AB01	2	139	208.5	1.59
Ciprofloxacin	J01MA02	0.8	27	27	0.51
Amikacin	J01GB06	1	22	33	0.5
Meropenem	J01DH02	3	36	108	0.55
Linezolid	J01XX08	1.2	6	7.2	0.09
Colistin	J01XB01	9	9	0.9	0.0015 (<0.001)
Levofloxacin	J01MA12	0.5	6	3	0.09
Cefotaxime	J01DD01	4	4	8	0.03
Vancomycin	J01XA1	2	1	1.5	0.01
Doxycycline	J01AA02	0.1	2	0.4	0.06

DEFINED DAILY DOSE (DDD)/100 BED DAYS FOR MONOTHERAPY OF ORAL ANTIBIOTICS:

Out of all the antibiotics administered, 9 (47.36%) antibiotics were administered orally as monotherapy. Among the 9 antibiotics, it was identified that Cefixime was found to be used highest with DDD/100 bed

days of 2.15 during the study period followed by Ciprofloxacin (0.22 DDD/100 bed days), Metronidazole (0.2 DDD/100 bed days), Norfloxacin (0.15 DDD/100 bed days), Azithromycin (0.07 DDD/100 bed days), Nitrofurantoin (0.06 DDD/100 bed days), Tetracycline (0.01 DDD/100 bed days), Amoxicillin (0.01 DDD/100 bed days), Linezolid (0.01 DDD/100 bed days). It was noted that Tetracycline, Amoxicillin and Linezolid were the least used antibiotics during the study period.

Table 10: DDD/100 bed days for monotherapy of oral antibiotics

Antibiotic	ATC Code	DDD (g)	Prescribed (n)	Total Units (g)	DDD/100 Bed Days
Tetracycline	J01AA07	1	1	1	0.01
Cefixime	J01DD08	0.4	141	56.4	2.15
Azithromycin	J01FA10	0.3	3	1.5	0.07
Ciprofloxacin	J01MA02	1	15	15	0.22
Metronidazole	P01AB01	2	22	26.4	0.2
Norfloxacin	J01MA06	0.8	8	8	0.15
Amoxicillin	J01CR01	1.5	1	1.5	0.01
Linezolid	J01XX08	1.2	1	1.2	0.01
Nitrofurantoin	J01XE01	0.2	2	0.8	0.06

DEFINED DAILY DOSE (DDD)/100 BED DAYS FOR DUAL THERAPY OF PARENTERAL ANTIBIOTICS:

2 (10.52%) antibiotics out of all the antibiotics that were administered via the parenteral route as combination therapy. Piperacillin + Tazobactam combination (0.73 DDD/100 bed days) was found to be used higher in comparison to Amoxicillin + Clavulanic Acid combination (0.41 DDD/100 bed days).

Table 11: DDD/100 bed days for dual therapy of parenteral antibiotics

Antibiotic	ATC Code	DDD (g)	Prescribed (n)	Total Units (g)	DDD/100 Bed Days
Amoxicillin + Clavulanic acid	J01CR02	3	34	81.6	0.41
Piperacillin + Tazobactam	J01CR05	14	50	675	0.73

DEFINED DAILY DOSE (DDD)/100 BED DAYS FOR DUAL THERAPY OF ORAL ANTIBIOTICS:

Of all the antibiotics administered, the Amoxicillin + Clavulanic Acid combination (0.18 DDD/100 bed days) was found to be the only antibiotic utilized via the oral route of administration.

Table 12: DDD/100 bed days for dual therapy of oral antibiotics

Antibiotic	ATC Code	DDD (g)	Prescribed (n)	Total Units (g)	DDD/100 Bed Days
Amoxicillin + Clavulanic acid	J01CR02	1.5	14	18.2	0.18

ANTIBIOTIC DISTRIBUTION BASED ON CLASS OF ANTIBIOTIC:

A total of 8 classes of antibiotics were observed to be used during the period of study. Among these, the beta-lactam class of antibiotics 497 (65.30%) was found to be used the highest and the Nitrofuran class of antibiotic 2 (0.30%) was found to be the least used.

Table 13: Distribution of antibiotics based on the class of antibiotic

Class Of Antibiotic	Antibiotic	Prescribed Antibiotic	No. Of Antibiotics Prescribed	Total (n)	%
Beta lactams	Penicillins	Amoxicillin	1	497	65.30
	Carbapenems	Meropenem	36		
	Cephalosporins	Ceftriaxone Cefixime Cefotaxime	217 141 4		
	Beta-lactamases inhibitors	Piperacillin+ Tazobactam Amoxicillin +Clavulanic Acid	50 48		
Polypeptides	Glycopeptides	Vancomycin	1	10	1.31
	Polymyxins	Colistin	9		
Fluoroquinolones		Ciprofloxacin	42	56	7.35
		Levofloxacin	6		
		Norfloxacin	8		
Tetracycline		Tetracycline Doxycycline	1 2	3	0.39
Nitrofurans		Nitrofurantoin	2	2	0.30
Nitroimidazoles		Metronidazole	161	161	21.15
Aminoglycosides		Amikacin	22	22	2.89
Macrolides		Azithromycin Linezolid	3 7	10	1.31

DISCUSSION

The present study was carried out to evaluate and improve the use of antibiotics in the Department of General Surgery in a teaching hospital in Bangalore. During the study period of 3 months, we monitored 305 patients prescribed at least 1 antibiotic based on the inclusion and exclusion criteria.

The patients were categorized based on age, gender, type of antibiotic therapy received, and surgery status. Out of the 305 patients included as part of the study, the majority of the patients were male (n=200, 66%) compared to female (n=105, 34%). Most of the patients belonged to the age group of 38-47 years (n=87, 28.53%), out of which 52 (59.77%) were male and 35 (40.23%) were female. The mean age of patients was calculated to be 47.82 ± 13.91 years and the average length of stay of patients was 8.78 ± 6.19 days.

The patients were further categorized based on the type of antibiotic therapy received, where it was found that 211 (69%) of them had received prophylactic therapy and the remaining 94 (31%) had received empiric therapy. Patients were also classified based on the status of surgery, in which 225 (74%) of them

had undergone surgery and the rest 80 (26%) had not undergone any surgery during their period of hospitalization.

Out of the total 305 prescriptions that were monitored, it was observed that a total of 4463 medicines were prescribed, out of which antibiotics were 761 (17.05%) and other concomitant medications used for therapy were 3702 (82.95%)**.**

Out of 761 antibiotics, the male population had received the majority of antibiotics 481 (63.20%) and 280 (36.8%) were administered to the females, which is contradictory to the study published by **Mugada *et al.,*** [14] in which 46.3% of antibiotics were administered to male while 53.37% of antibiotics were administered to female.

Out of the 761 antibiotics, it was found that the majority of the antibiotics were administered via the parenteral route (n=553, 73%), which is higher when compared to a study conducted by **Ravi *et al.,*** [15] in which the antibiotics administered via parenteral route was 71%. While this is lesser when compared to a study conducted by **Atif *et al.,*** [16] in which the antibiotics administered via the parenteral route was (98%).

On average 2.49 ±1.20 antibiotics were prescribed per person, 7(1%) being the highest number of antibiotics prescribed was higher than the study conducted by **Demoz *et al.,*** [1] in which 2.01 ±1.9 is the average number of antibiotics prescribed per person.

Totally, 19 different antibiotics were observed to be used during the period of study. Out of which, it was found that the most frequently prescribed antibiotics were Ceftriaxone (217, 28.51%), Metronidazole (161, 21.15%), and Cefixime (141, 18.52%), which is similar to a study conducted by **Atif *et al.,*** [16] in which Ceftriaxone, Metronidazole, and Cefotaxime were the most frequently prescribed antibiotics.

Like other studies conducted by **Jaganathan *et al.,*** [17] **Malpani *et al.,*** [18] **Rajalingam *et al.,*** [19] **Chandy *et al.,*** [20] **Mule *et al.,*** [21] and **Ansari *et al.,***[22] our study reports cephalosporins (47.57 %) to be the highest prescribed antibiotic.

In other studies, conducted by **Demoz *et al.,*** [1] and **Shimemeri *et al.,*** [23] it was found that Ceftriaxone was the most commonly prescribed antibiotic at 24.5% and 41.93% respectively, which is similar to the results observed in this study.

In our study, Beta-lactams (497, 65.3%) were the most frequently prescribed class of antibiotics followed by Nitroimidazoles (161, 21.15%), Fluoroquinolones (56, 7.35%), Aminoglycosides (22, 2.89%), Polypeptides (10, 1.31%), Macrolides (10, 1.31%), Tetracyclines (3, 0.39%) and Nitrofurans (2, 0.3%).

Penicillin beta-lactamase combination of antibiotics (12.88%), was the only dual therapy received by patients during the period of the study.

In the present study, it was found that 7 (37%) antibiotics belong to the Access Group, 10 (53%) antibiotics belong to the Watch Group, and 2 (10%) antibiotics belong to the Reserve Group. According to the WHO's AWaRe Classification, antibiotics consumed from the Access Group should be at least 60%.

In this study, 37% of the antibiotics were prescribed from the Access Group, which is lesser than the recommended rate. Watch Group of antibiotics accounted for 53% of the total prescribed antibiotics, which was found to be the highest-used group of antibiotics. The findings of this study are very similar to the findings of a study conducted by **Mugada *et al.,*** [14] in which 46.80% of antibiotics belonged to the Access Group and 53.19% of antibiotics belonged to the Watch Group.

In this study, it was observed that a total of 19 antibiotics were used in the Department of General Surgery during the study period, out of which 17 (89.5%) antibiotics were administered as monotherapies whereas 2 (10.5%) antibiotics were used as combination therapies.

In the present study, out of the 19 antibiotics, 2 (10.52%) antibiotics (Piperacillin + Tazobactam and Amoxicillin + Clavulanic Acid) were prescribed as dual therapy. The amoxicillin + Clavulanic Acid combination was administered via oral and parenteral administration routes.

Contradicting the results obtained from other studies conducted by **Deshmukh *et al.*,** [24] and **Mule *et al.*,** [21] it was observed that the Piperacillin + Tazobactam combination of antibiotics (51%) was the most frequently prescribed antibiotic among the two combinations of antibiotics in our study.

In this study, it was observed that Ceftriaxone (3.32 DDD/100 bed days) was the most commonly utilized antibiotic followed by Cefixime (2.15 DDD/100 bed days), Metronidazole (1.59 DDD/100 bed days) which is contradicting to the results observed in studies conducted by **Mugada *et al.*,** [14] and **Mule *et al.*,** [21] where the most commonly utilized antibiotic was identified to be Azithromycin with 14.97 DDD/1000/day and 107.83 DDD/1000/day.

CONCLUSION

The study thus concludes the need for setting up an Antimicrobial Stewardship Centre in the hospital and forming strict policies for prescribing antibiotics. This would help in preventing any probable incidence of future antimicrobial resistance that may develop due to irrational use of antibiotics, mainly antibiotics that are more prone to develop resistance.

This study can be conducted in multi-specialty hospitals to identify the rationale use of antibiotics among the various departments in a larger population (a comparative study between different states can be carried out) for a longer duration of time. A broader study could be conducted including the data on culture sensitivity tests.

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