



# Hospital Antibiotic Prescribing Pattern in General Surgery Specialty: Analysis Based on the WHO Access, Watch and Reserve (AWaRe) Classification

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors MP, JM, SSVP conceptualized the study, methodology was performed by authors MP, JM, AU, SSVP, data analysis was done by authors MP and SSVP, the results were validated by authors MP, JM, AU, SSVP, the original draft of the manuscript was written by MP, JM, review writing and final editing was done by authors MP and SSVP. All authors take responsibility for appropriate content, critically revised the manuscript, and approved the version of the manuscript to be published.*

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## **ABSTRACT**

**Background:** Surgical site infections are a prevalent cause of nosocomial infections that require antibiotic prophylaxis. Emergence and spread of antimicrobial resistance is a major global public health issue that must be addressed. Eventually, antibiotic prescribing pattern should be examined in order to ensure that antibiotics are used appropriately and that their effectiveness is preserved.

**Objective:** To evaluate hospital antibiotic prescribing pattern emphasizing on cephalosporins in general surgery specialty using the WHO Access, Watch, and Reserve (AWaRe) classification.

**Methodology:** A cross-sectional study was carried out in 658 hospitalized patients who received prophylactic antibiotics in general surgery specialty for six months. The data were analysed using

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the 'WHO prescribing indicators' and examined for the WHO 'AWaRe' categories. The acquired data was subjected to descriptive statistics.

**Results:** Per encounter, the average number of drugs and antibiotics prescribed were 3.8 and 1.3, respectively. 83.4% encounters were with at least one antibiotic and 94.5% encounters had parenteral antibiotics. 31.3% and 77.8% antibiotics were prescribed by generic name and from the Essential Medicines List, respectively. The most frequently prescribed antibiotics were the third generation cephalosporins (36.8%) wherein ceftriaxone (22.0%) and cefoperazone (7.2%) were the two most commonly prescribed. A total of 14 specific antibiotics, 'Access' 5 and 'Watch' 9 were prescribed. Based on the WHO AWaRe classification, 42.3% 'Access' and 57.7% 'Watch' group antibiotics prescribed. All the prescribed cephalosporins (100%) were from the 'Watch' category. Amikacin (13.5%) and ceftriaxone (22.0%) were the most commonly prescribed 'Access' and 'Watch' group antibiotics, respectively. Amoxicillin index was 7.5 and 'Access-to-Watch' index was 0.7, which were much below the priority values.

**Conclusion:** The antibiotic prescription pattern seen in this study did not entirely meet the WHO recommendations. Antibiotics from the 'Watch' category, notably cephalosporins, were commonly prescribed. To retain antibiotic effectiveness and encourage rational antibiotic use, as well as to overcome antibiotic resistance, changes in and surveillance of antibiotics prescribing are required.

*Keywords: Antibiotics; antimicrobial resistance; AWaRe classification; cephalosporins; general surgery; prescribing pattern; prescribing practice.*

## 1. INTRODUCTION

Antimicrobial resistance (AMR) is a natural phenomenon that occurs when microorganisms start to evolve and develop resistance due to selective pressure when exposed to antibiotics [1]. Indeed, antibiotics are one of the most commonly prescribed drug classes in hospitals, which accounted to more than half of all patients admitted to acute care facilities [2,3]. Importantly, AMR is predicted to cause 10 million fatalities per year, with two million of those deaths occurring in India by 2050 [4].

Health care-associated infections (HAI), also known as nosocomial infections, are acquired by patients while receiving care in hospitals and represent one of the most frequent adverse events affecting patient safety worldwide [2]. Recent emergence of high incidence of secondary bacterial and fungal infections in patients hospitalized with COVID-19 is a classical example of HAI [5]. Antibiotics are used to treat both hospital- and community-acquired infections and as a preventive measure before and after invasive procedures, including surgery in various medical specialties. Particularly, surgical site infections (SSI), the common cause of HAIs necessitate antibiotic prophylaxis which is an important measure used to reduce contaminated inoculations peri-operatively [6,7]. Recent studies showed that SSI affects up to one third of patients who underwent a surgical procedure and reportedly, it is the most frequent

type of HAI in low- and middle-income countries (LMIC) [8,9]. Apart from wound itself, post-operative infections, such as deeper tissue infections within body cavities and/or more distant infections such as pneumonia or catheter associated infections, another common causes of HAI, are associated with significant morbidity and mortality [10,11]. Moreover, resistant infections were also detected in patients undergoing gastrointestinal surgeries in high income countries (HIC) and LMIC [7]. Thus, appropriate antibiotic selection and preserving antibiogram are important to ensure favourable therapeutic outcomes.

In practice, cephalosporins are favoured over other antibiotic classes because of their broad spectrum of action and lower risk of hypersensitivity events; nonetheless, AMR is progressively developing as a result of extended spectrum beta-lactamases (ESBLs) [12]. It has been reported that appropriate use of prophylactic antibiotics can reduce the incidence fourfold without increasing the incidence of *C. Diff* colitis [13]. However, accumulating data indicates that antibiotics are unnecessary or inappropriately selected for treatment in up to 50% of cases [6]. This could result in the spread of antibiotic-resistant bacteria, higher health care costs, longer hospital stays, and unnecessary adverse events. Of note, inappropriate peri-operative antibiotic prophylaxis has also been linked to an increased incidence of SSI [2].

The WHO has taken several initiatives to narrowing the gap between evidence and practice and prepared a global guidelines which provide interventions to be applied during the pre-, intra- and post-operative periods for the prevention of SSI [6,14]. However, the implementation of these measures is not standardized worldwide. Notwithstanding to the evidence-based recommendations, there is low adherence to global and hospital antibiotic protocols and prescribing guidelines [15,16].

Globally, the WHO prescription indicators have been used to evaluate drug utilisation in order to preserve antibiotic efficacy and rationalise antibiotic use [17]. The recent introduction of the WHO Access, Watch and Reserve (AWaRe) categories have offered a framework for systematic assessment of antibiotic use and consumption, with a focus on decreasing unnecessary and irrational use of 'Watch' and 'Reserve' antibiotics. In brief, the 'Access' antibiotics are the first and second choices for the empirical treatment. The 'Watch' antibiotics are associated with toxicity concerns and/or resistance potential and are recommended only for specific indications. The 'Reserve' category includes antibiotics of last resort for multidrug resistant infections [18].

The WHO AWaRe categories can help surgeons in decreasing the spread of AMR by selecting the appropriate antibiotic and justifying prescribing without compromising therapeutic outcomes. To the best of our knowledge, no such study employing the 'AWaRe' antibiotic categories has been undertaken in the field of general surgery, as a result the present status of antibiotics, particularly cephalosporins prescribing is not known. Thus, the current study used the WHO core prescription indicators and the 'AWaRe' classification to assess antibiotic prescribing pattern with special emphasis on cephalosporins in general surgery specialty.

## 2. METHODOLOGY

### 2.1 Study Design

A prospective, observational, cross-sectional study was conducted in among in-patients of the general surgery department at Sri Lalitha Multispecialty Hospital, a tertiary care teaching hospital in Warangal for a period of six months from 1 August, 2019 to 31 January, 2020.

### 2.2 Data Collection, Inclusion and Exclusion Criteria

The legible and complete prescriptions collected from patients, who were admitted in the general surgery specialty, received prophylactic drugs, underwent surgery during the study period, and willing to participate were included. Patients who visited the general surgery department for second opinion, shifted to higher healthcare specialties, absconded, those who were on chronic antibiotic use, when hospital stay less was than 24 h, and pregnant women were excluded in the beginning. The prescriptions that were incomplete and not written during the study period were also excluded. Medical case sheets and drug charts were the sources of prescription data information. After individual data extraction, information was compared, the responsible healthcare practitioner was asked for clarifications if any crucial data were unclear, and reached a consensus of inclusion or exclusion for each patient.

### 2.3 Statistical Analyses

Descriptive statistics were applied to the collected data using Microsoft Excel and the results are expressed as frequencies, averages, and percentages. Only one prescription with prophylactic drug therapy from each patient was collected and considered as one encounter. A total of 658 eligible prescriptions were analysed for socio-demographic, type of surgery performed in hospitalized patients and were systematically evaluated for general prescription pattern and distribution of antibiotics. The WHO prescribing indicators along with their standard values were used to assess rational drug and antibiotic use, with a particular focus on cephalosporin prescribing pattern [17]. Antibiotics were classified by chemical class (third and fourth levels) and medication name (fifth level) as in the WHO ATC classification system, and their inclusion in the 21st WHO Essential Medicines List (EML) was determined [19,20]. The prescribing pattern of antibiotics emphasizing on cephalosporins were described according to the 2019 WHO AWaRe antibiotic classification [18]. Further, the data were analysed for three AWaRe index metrics, namely the percentage of amoxicillin prescribed (Amoxicillin index), the percentage of 'Access' antibiotics prescribed, and the ratio of 'Access to Watch' category antibiotics prescribed (Access-to-Watch index) to

assess prescription pattern and prioritizing rationalise use of antibiotics [21].

### 3. RESULTS

#### 3.1 Patient Characteristics

Only one prescription from each eligible patient was obtained, and 658 prescriptions that matched the inclusion requirements were eventually chosen for analysis of the general prescription pattern. Out of 658 patients, 549 (83.4%) received at least one antibiotic of which 396 were male (72.1%) and 153 were female (27.9%) with the highest rate of prescription seen in the 31 - 45 years (30.6%) followed by 46 – 60 years (26.8%) age group (Table 1). The most commonly performed surgeries in hospitalized patients were hernioplasty (133, 20.2%), hemorrhoidectomy (93, 14.1%), cellulitis (86, 13.1%), among others (Table 2).

#### 3.2 General Prescription Pattern of Antibiotics and Cephalosporins

Out of 658 in-patients, 549 (83.4%) received at least one antibiotic, wherein 427 patients were prescribed with only one (64.9%) antibiotic and the remaining 122 encounters had two (89,

13.5%) and three (33, 5.0%) antibiotics. None of the patient was prescribed four antibiotics. Further, 312 encounters had at least one (47.4%) cephalosporin which constitutes 56.8% of 549 prescriptions with at least one antibiotic indicating the most frequently prescribed antibiotics belong to cephalosporins. However, none of the patient was prescribed two cephalosporins (Table 3). These 658 prescriptions accounted for a total of 2503 drug regimens, with 28.1 % (704) antibiotics (J01) and the remaining 71.9% (1799) non-antibiotics (other than antibiotics). Overall, 12.5% of the total drugs prescribed were cephalosporins (J01D; 312) and 15.7% drugs were antibiotics (392) other than cephalosporins (Table 4). Of 704 prescribed antibiotic (J01) regimens, 44.3% (312) were cephalosporins (J01D) and 55.7% were antibiotics (392) other than cephalosporins. Cefuroxime (1.6%) and cefepime (6.0%) were the only prescribed the second (J01DC; 11) and the fourth (J01DE; 42) generation cephalosporins, respectively. Among antibiotics, the third generation cephalosporins (J01DD; 259, 36.8%) were commonly prescribed wherein ceftriaxone (155, 22.0%) followed by cefoperazone (51, 7.2%) were the most frequently prescribed (Table 5).

**Table 1. Socio-demographic of the study population**

Patient characteristics	Any drug (658)	Any antibiotic (549)
	n (%)	n (%)
<b>a) Gender</b>		
Male	445 (67.6)	396 (72.1)
Female	213 (32.4)	153 (27.9)
<b>b) Age (years)</b>		
0 - 15	51 (7.8)	43 (7.8)
16 - 30	123 (18.7)	101 (18.4)
31 - 45	196 (29.8)	168 (30.6)
46 - 60	187 (28.4)	147 (26.8)
> 60	101 (15.3)	90 (16.4)

**Table 2. Classification of surgery performed based on diagnoses (658)**

Type of surgery	n (%)
Hernioplasty	133 (20.2)
Hemorrhoidectomy	93 (14.1)
Cellulitis	86 (13.1)
Hydrocoel surgery	57 (8.7)
Lipoma excision	51 (7.8)
PCNL	47 (7.1)
Diabetic foot	47 (7.1)
Cholecystectomy	34 (5.2)
Appendectomy	31 (4.7)
Hysterectomy	11 (1.7)
Others	68 (10.3)

PCNL: Percutaneous nephrolithotomy

**Table 3. Prescription pattern of antibiotics (N = 658)**

Pattern descriptor	Number of encounters, n (%)
Without antibiotic	109 (16.6)
With antibiotic	549 (83.4)
One antibiotic	427 (64.9)
Two antibiotics	89 (13.5)
Three antibiotics	33 (5.0)
At least one cephalosporin	312 (47.4)
At least one cephalosporin <sup>1</sup>	312 (N = 549, 56.8)

<sup>1</sup>at least one cephalosporin among 549 antibiotic encounters

**Table 4. Distribution of prescribed drugs (N = 2503)**

Class of drugs	ATC code	Frequency, n (%)
(1) Non-antibiotics		1799 (71.9)
(2) Antibiotics (J01)		704 (28.1)
(i) Cephalosporins	J01D	312 (12.5)
(ii) Other than cephalosporins		392 (15.7)
a. Aminoglycosides	J01G	151 (6.0)
b. Penicillins	J01C	85 (3.4)
c. Imidazoles	J01XD	68 (2.7)
d. Macrolides	J01FA	38 (1.5)
e. Tetracyclines	J01A	26 (1.0)
f. Quinolones	J01M	24 (1.0)

**Table 5. Distribution of cephalosporins among total antibiotics prescribed (N = 704)**

Class of antibiotics	Frequency, n (%)
(1) Other than cephalosporins	392 (55.7)
(2) Cephalosporins (J01D)	312 (44.3)
(i) Second generation (J01DC)	11 (1.6)
Cefuroxime	11 (1.6)
(ii) Third generation (J01DD)	259 (36.8)
Ceftriaxone	155 (22.0)
Cefoperazone	51 (7.2)
Cefpodoxime	39 (5.5)
Cefixime	14 (2.0)
(iii) Fourth generation (J01DE)	42 (6.0)
Cefepime	42 (6.0)

### 3.3 Prescribing Pattern of Drugs and Antibiotics Based on WHO Prescribing Indicators

A total of 2503 drug regimens were prescribed in the 658 prescriptions with an average number of drugs per encounter found to be 3.8. The total number of encounters prescribed with antibiotics and parenteral drugs were 549 (83.4%) and 603 (91.6%), respectively. About 28.5% of the drugs (714) were prescribed by their generic name and 74.4% prescribed drugs (1862) were from the EML (Table 6). Among 549 antibiotic

prescriptions containing 704 different antibiotics, the average number of antibiotics and cephalosporins per encounter were 1.3 and 0.6 (312), respectively. Percentage of encounter with an antibiotic and cephalosporins was 100 (549) and 56.8 (312), respectively. Percentage of antibiotics prescribed by generic name, percentage of encounters with parenteral antibiotics, and percentage of antibiotics prescribed from EML were 31.3 (220), 94.5 (519), and 77.8 (548), respectively where as that of cephalosporins were 13.5 (42), 93.3 (291), and 57.7 (180), respectively (Table 7).

**Table 6. Prescribing pattern of drugs based on WHO prescribing indicators (N = 658)**

WHO prescribing indicator	Number	WHO standard
Average number of drugs per encounter	3.8	1.6 – 1.8
Percentage of encounters with an antibiotic prescribed	83.4	20 – 26.8
Percentage of drugs prescribed by generic name	28.5	100
Percentage of encounters with parenteral drug prescribed	91.6	13.4 – 24.1
Percentage of drugs prescribed from EML	74.4	100

**Table 7. Prescribing pattern of antibiotics based on WHO prescribing indicators (N = 549)**

WHO prescribing indicator	Number
Average number of antibiotics per encounter	1.3
Average number of cephalosporins per encounter	0.6
Percentage of encounters with a antibiotic prescribed	100
Percentage of encounters with a cephalosporin prescribed	56.8
Percentage of antibiotic prescribed by generic name	31.3
Percentage of cephalosporins prescribed by generic name	13.5
Percentage of encounters with parenteral antibiotic prescribed	94.5
Percentage of encounters with parenteral cephalosporin prescribed	93.3
Percentage of antibiotics prescribed from EML	77.8
Percentage of cephalosporins prescribed from EML	57.7

### 3.4 Prescription Pattern of Antibiotics Based on WHO AWaRe Classification

A total of 704 antibiotic regimens from 549 prescriptions were systematically classified into Access, Watch, and Reserve (AWaRe) antibiotic categories. Of 704, 42.3% antibiotic regimens (298) were from the 'Access' category. None of the prescribed cephalosporins belongs to the 'Access' group. Most importantly, 57.7% of the antibiotic regimens (406 out of 704) and 100% cephalosporin regimens (312 out of 312) were from the 'Watch' category indicating a higher prescription rate. Conversely, no prescribed antibiotic including cephalosporins was from the 'Reserve' and the 'Not Recommended' categories (Table 8). The percentage of amoxicillin prescribed was less (7.5%), the percentage of 'Access' antibiotics was also less (42.3%; Recommended value more than 60%), and the ratio of 'Access to Watch' antibiotics (Access-to-Watch index) was 0.7, which was less (Priority value 1.5) indicating there is a scope for improving the prescription pattern of antibiotics to meet the WHO recommendations (Table 9).

### 3.5 Distribution of Prescribed Antibiotics by WHO AWaRe Classification

A total of 14 specific antibiotics were frequently prescribed in 549 encounters accounted to 704 antibiotic regimens that were carefully examined for their listing in the 2019 WHO-EML. Of 14 specific antibiotics, 10 antibiotics were listed and the remaining 4 antibiotics were not listed in the EML. Out of 14, 5 specific antibiotics were from the 'Access' category and all are listed. The most frequently prescribed 'Access' antibiotic was amikacin (95, 13.5%) followed by metronidazole (68, 9.7%). Amoxicillin/clavulanic acid was prescribed 7.5% (53). In particular, the most commonly prescribed (406 out of 704) antibiotics were belongs to the 'Watch' category. Among 14 frequently prescribed specific antibiotics, 9 were from the 'Watch' category, of which only 5 antibiotics are listed in the EML. The most frequently prescribed 'Watch' antibiotics was ceftriaxone (155, 22.0%) followed by cefoperazone (51, 7.2%). 'Reserve' antibiotics were not at all prescribed (Table 10).

**Table 8. Prescription pattern of antibiotics based on WHO AWaRe classification**

WHO AWaRe category	All antibiotics (704)	Cephalosporins (312)
	n (%)	n (%)
Access	298 (42.3)	0 (0.0)
Watch	406 (57.7)	312 (100)
Reserve	0 (0.0)	0 (0.0)

**Table 9. Prescription pattern of antibiotics based on AWaRe Index metrics**

AWaRe index metrics	Observed value (%)	Priority value
Amoxicillin index	7.5	> any antibiotic (%)
Access antibiotics index	42.3	> 60%
Access-to-Watch index	0.7	1.5

**Table 10. Distribution of prescribed antibiotics by WHO AWaRe classification (N = 704)**

WHO AWaRe Category	ATC code	n (%)	Listed in EML
<b>Access (298)</b>			
Amikacin	J01GB06	95 (13.5)	Yes
Metronidazole	J01XD01	68 (9.7)	Yes
Gentamicin	J01GB03	56 (8.0)	Yes
Amoxicillin/clavulanic acid	J01CR02	53 (7.5)	Yes
Doxycycline	J01AA02	26 (3.7)	Yes
<b>Watch (406)</b>			
Ceftriaxone	J01DD04	155 (22.0)	Yes
Cefoperazone	J01DD12	51 (7.2)	No
Cefepime	J01DE01	42 (6.0)	No
Cefpodoxime	J01DD13	39 (5.5)	No
Clarithromycin	J01FA09	38 (5.4)	Yes
Piperacillin/tazobactam	J01CR05	32 (4.5)	Yes
Levofloxacin	J01MA12	24 (3.4)	No
Cefixime	J01DD08	14 (2.0)	Yes
Cefuroxime	J01DC02	11 (1.6)	Yes

#### 4. DISCUSSION

In this study, 83.4% patients received at least one antibiotic prophylactically to prevent SSI. The high percent of antibiotic prescription for preventive therapy is a common practice in any surgery specialization including general surgery specialty in a hospital [2,9]. It is noticed that a large number males underwent surgery and received prophylactic antibiotics. The result is consistent to previous studies and contrary to other studies wherein more number of females than males underwent surgery and received antibiotics [17,22-24]. Furthermore, the age group 31-45 years had the most antibiotic exposure, followed by 46-60 years, indicating that these age groups had the most surgical procedures. Whilst paediatric patients had the lowest antibiotic exposure, this indicated a lower likelihood of dysbiosis and its related health issues, such as asthma, food allergies, obesity, and psychiatric disorders [25,26]. It is also noticed that hernioplasty was by far the most common procedure, followed by hemorrhoidectomy and cellulitis, among other surgeries for which patients were given antibiotics as a prophylactic measure. The

medical case charts revealed that the prescribed antibiotics, including cephalosporins, had no negative side effects and were well tolerated in patients undergoing a variety of surgical operations, implying that antibiotic prescribing practice had better patient compliance.

In the current study, antibiotics prescribed are belonging to seven different pharmacological classes and cephalosporins were prescribed in more percentage. Aminoglycosides and penicillins were the second and third most frequently prescribed prophylactic antibiotics owing to their broad-spectrum of activity, in particular selectivity for Gram-ve bacteria. Our results are parallel to previous studies which reported a higher prescription and use of third generation of cephalosporins [17,27,28]. On the contrary, few studies reported high prescription of penicillins, amikacin, metronidazole over cephalosporins [22,27]. The disparities in antibiotic selection depends on the type and nature of surgery and local antibiotic policy while some surgeons are accustomed to follow their own protocol, which has always 'worked' for them [6,16]. The most remarkable finding of the study is that monotherapy (64.9%) was chosen

over combination therapy since most preventive antibiotics were administered empirically, with cephalosporins accounting for 56.8 percent of all antibiotic encounters. Ceftriaxone was the most usually administered third generation cephalosporin in most surgeries; however, cefotaxime or cefoperazone was apparently the most regularly prescribed third generation cephalosporin in a few studies [17,27-30]. It has been reported that the most common therapeutic errors in general surgery were administration of second- or third-line antibiotics without indication and use of antibiotics when they were not required [31,32]. Therefore, it is plausible that geographical differences in bacterial susceptibility and resistance, and infectious disease prevalence in different regions and nations could affect the prescribing behaviors [6,7,28].

According to the WHO prescribing indicators, the average number of drugs per encounter was 3.8 and percentage of antibiotics per prescription was 83.4%, which is much higher than the recommended value (20-26.8). The results were similar to previous studies wherein polypharmacy, high percent of antibiotics, and more than two antibiotics per encounter were reported [17,22,33,34]. Besides, antibiotic decision-making including prescription patterns and dose escalation patterns differ significantly between general surgical and medical specialties [3,9,35]. A large number of patients reporting SSI as well as drug resistant infections was also identified that account for high prescription rate of antibiotics in patients undergoing surgery [7,10]. Of note, the number of antibiotics used per encounter with at least one antibiotic was within the recommended range, but the number of cephalosporins used per encounter was less than one, which is highly preferred. Many studies reported varying number of drugs with more than one antibiotic per encounter [17,34]. In addition to this, the use of a combination of ceftriaxone and metronidazole in the prophylaxis for elective colon surgery is associated with a decreased SSI rate [36]. Indeed, many factors in the patient's surgical journey contribute to the risk of SSI. As a result, preventing these infections is difficult and entails the use of a variety of preventive measures before, during and after surgery. A favourable indicator of appropriate clinical decisions is the low number of antibiotics prescribed per encounter, which is just above the one. This is acceptable as use of a single antibiotic per prescription minimizes polypharmacy, lessens diseases complications

caused by drug-drug interactions, and has lower risk of adverse drug reactions which includes AMR as well [9,17].

The percentage of antibiotics prescribed under generic names, including cephalosporins, was low when compared to the WHO recommended value of 100. Several factors influence the choice of brand or generic products that could be due to hospital policy on drugs and antibiotic procurement, non-existence and non-availability of generics, and affordability of drugs by in-patients. It is observed that percentage of parenteral antibiotics prescribed was found to be high exceeding the WHO standard limit. It is generally a common pre-operative practice and acceptable to administer drugs by parenteral route in order to attain faster onset of action and recovery, which could reduce the duration of hospital stay and consequently, economic burden [17,28,37]. The percentage of antibiotics provided based on the most recent EML was found to be low in this study. The WHO recommends that national EMLs be updated, as they are critical for drug availability and access on a local and regional level. Indeed, poor compliance with antibiotic prescribing protocols and national EML exists in gastrointestinal surgery in part due to general lack of awareness and partly due to variability between hospital antibiotics prescription policies [13,22,37]. However, in a typical tertiary hospital involving in-patients, where the antibiotic options may not be limited to the national EML and physicians and surgeons may manage treatment of diseases based on expertise and empirical knowledge. Though, the present study results showed high level of adherence, but better results still can be achieved.

Further, the data was carefully examined using the WHO AWaRe classification to determine the antibiotic prescribing with due focus on selection of antibiotics based on their narrow- and broad-spectrum activity. The current findings demonstrated significant disparities in the relative prescription of 'AWaRe' antibiotics, with the 'Watch' category accounting for the majority (57.7%) of antibiotics prescribed. In addition, 'Access' antibiotics (42.3%) were prescribed whereas 'Reserve' antibiotics were not all prescribed. Recent studies demonstrated similar differences in relative antibiotic use according to the WHO AWaRe categorization. The prescription of 'Watch' antibiotics was high, similar to earlier studies based on national and global antibiotic consumption and sales data,



with second and third generation cephalosporins, fluoroquinolones, and macrolides contributing the most [3,35,38-40].

Though amoxicillin is one of the most commonly prescribed "Access" antibiotics for upper respiratory tract infections and cellulitis, its use is limited to certain surgeries in which cephalosporins and amikacin are recommended owing to relative broad spectrum nature that are indicated to treat SSI [7,14]. It is observed that amoxicillin in combination with clavulanic acid was prescribed less frequently as well. Accumulating data indicated that the percentage of use accounted for amoxicillin is highly variable even in countries with high access percentages owing to highly variable health-care systems and income classification [39,40]. In this study, the most commonly prescribed antibiotics, including cephalosporins, were from the 'Watch' category indicating that their use was high as prophylactics in surgeries. Conversely, the use of 'Access' antibiotics including the first-generation cephalosporins were low when compared to the WHO-recommended target of 60%. The 'Access-to-Watch' index of the prescribed antibiotics was 0.7, which was considerably below the priority level of 1.5, indicating that relatively safer and narrow spectrum antibiotics were administered at a much lower rate. The other remarkable finding in this study was that prescriptions of 'Reserve' group antibiotics were essentially non-existent. Of note, discouraged combination of antibiotics belongs to the 'Non-Recommended' antibiotics were also not prescribed. The results clearly demonstrated that there is a high grade of rationalising in avoiding 'Reserve' and the discouraged antibiotics for prophylactic use in general surgery specialty. Nonetheless, enough focus must be given in selecting and prescribing antibiotics emphasizing on use of antibiotics belongs to 'Access' over 'Watch' category.

Accumulating data indicates that there is a considerable global and national variation in the proportion of 'AWaRe' antibiotics used in hospitalised paediatric and adult patients. A recent study reported differences in antibiotic prescribing for the most common surgeries between surgery departments of a teaching and a non-teaching tertiary care hospital [28,41]. In developed countries also, there are variability in between department wherein antibiotics were more frequently prescribed for longer duration in surgery department, associated with dose escalation, and often non-adherence to local

policies [9,12]. Indeed, HAI, particularly SSI including resistant infections were reported more in HIC and LMIC that cannot preclude the use of antibiotics [7,11]. The prevalent undesirable state of frequent prescription and availability of 'Watch' over 'Access' antibiotics should be improved by focusing on promoting awareness, changes in prescribing practice, and stringent implementation of national and/or hospital antibiotic policies to restrict their overuse.

A recent study reported that awareness and education on AMR and antibiotic prescribing among healthcare professionals has an impact on prescribing patterns [42]. Moreover, pharmacist intervention also resulted in significant reductions in the duration and average number of antibiotic prophylactic use [43]. Attempts have been made with educational intervention, such as a 'Traffic Light Poster' improved adherence to prescribing protocol and practice of rationalizing antibiotic use. Moreover, following peri-operative clean procedures has reduced inappropriate prescribing [13]. Apart from this, the barriers-enablers-ownership model with social intervention improved surgical antibiotic prescribing in hospitals [44]. Numerous strategies have also been adopted by national and international collaborations to effectively study and tackle AMR for longer periods [45]. Essentially, it is also equally important to address patient's education on antibiotic use and participation in surgical procedures reduces the gap between patient and infection-related care during and after surgeries [46]. Emerging evidence indicates that adhering to antibiotic policies and guidelines is associated with favourable therapeutic and in-patient outcomes in terms of mortality and duration of hospital stay [47]. It is highly recommended that as part of the WHO National Action Plan, regional and national guidelines can apply this AWaRe categorization in their antibiotic surveillance framework. Furthermore, increasing the use of 'Access' antibiotics while limiting the use of 'Watch' and 'Reserve' antibiotics at the same time is the highest priority for preserving effectiveness of important antibiotics and minimising the danger of AMR.

## 5. CONCLUSION

Based on the WHO core indicators and 'AWaRe' antibiotics categorization, the study provides insight into antibiotic prescription pattern, notably cephalosporins. The most commonly prescribed antibiotics are third-generation cephalosporins,

particularly ceftriaxone and cefoperazone. Only a few of the antibiotics listed in the EML were used. The majority of prophylactic antibiotics, including cephalosporins, were belongs to the 'Watch' category, implying that they were prescribed more frequently. It is imperative that prescribing prophylactic antibiotics for surgeries must be monitored and antibiotic policies and the WHO National Action Plan must be promoted to combat AMR futuristically.

## 6. LIMITATIONS

This study has certain limitations. First, incidence of SSI and infection free days if included would have been a better indicator of antibiotic selectivity. Second, since the study was conducted at one hospital, the results cannot be generalised. Third, a long-term study would give clear picture of antibiotic rational use.

## 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.

## CONSENT

The permission was obtained and individual patient consent was taken to collect the data.

## ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee of the Care College of Pharmacy, India (PDPW/CCP/201920-07-012).

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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