

An Evaluation of the intravenous to oral route conversion of antibiotics in a tertiary care hospital

Authors:

Indranil Ghosal¹, Dr. Jeeva George², Dr. Balakeshwa Ramaiah³

¹Rajiv Gandhi University of Health Sciences, Bengaluru, Karnataka.

²Assistant Professor, Department of Pharmacy Practice, Rajiv Gandhi University of Health Sciences, Bengaluru, Karnataka.

³HOD, Department of Pharmacy Practice, Rajiv Gandhi University of Health Sciences, Bengaluru, Karnataka.

Corresponding Author:

Indranil Ghosal

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ABSTRACT:

Background: Prolonged IV antibiotic use raises healthcare costs, hospital stays, and risks like infections, contributing to antimicrobial resistance. Timely IV-to-PO conversion is a safer, cost-effective alternative, yet remains underutilized in tertiary hospitals. This study assesses the frequency, outcomes, and cost savings of IV-to-PO antibiotic conversion. **Materials and method:** This six-month observational study in a tertiary care hospital involved 116 patients undergoing IV-to-PO antibiotic conversion. It assessed conversion strategies sequential, switch, and step-down therapy along with associated cost differences. Data on demographics, comorbidities, and antibiotic use were collected from case sheets, with cost analysis from hospital pharmacy and online sources. **Results:** The study population was 63% female, with 66% aged 18–59. Lower respiratory tract infections (27%) were the leading antibiotic indication, and diabetes (31%) was the most common comorbidity. Inj Ceftriaxone (34%) was the most used IV antibiotic, with IV-to-PO conversions mainly involving switch therapy (51.53%). Notable cost savings were found, particularly for Inj Meropenem (₹16,226) and Inj Linezolid (₹12,785). **Conclusion:** This study emphasizes the underutilization of IV-to-PO antibiotic conversion in tertiary hospitals, despite its cost-saving benefits. Switch therapy was most common, with significant savings from oral antibiotics. Structured conversion protocols can optimize antibiotic use, reduce hospital stays, minimize IV-related complications, and improve patient care in tertiary care setting.

Keywords: Intravenous-to-Oral Conversion, Antibiotics, Antimicrobial Stewardship, Cost Analysis, Tertiary Care Hospital, Switch Therapy.

INTRODUCTION:

Antibiotic overuse and misuse have become major global health crises, driving the rapid rise of antimicrobial resistance (AMR). According to the World Health Organization (WHO), approximately 700,000 deaths each year are attributed to drug-resistant infections, with projections estimating up to 10 million deaths annually by 2050 if no action is taken^[1]. In hospitals, intravenous (IV) antibiotics are routinely prescribed for severe infections, but studies reveal that up to 50% of antibiotic use in healthcare settings is inappropriate, often due to unnecessary prolongation of IV therapy^[2]. Oral antibiotics, when clinically appropriate, provide a safer and more cost-effective alternative. However, the transition from IV to oral therapy is frequently delayed, leading to increased healthcare costs, prolonged hospital

stays, and higher risks of catheter-related bloodstream infections (CRBSIs). Recent studies show that the timely transition from IV to oral antibiotics can address these issues without compromising patient outcomes^[3].

The practice of switching from IV to oral antibiotics known as IV-to-oral conversion—has become an essential component of antimicrobial stewardship. In light of the growing public health crisis, it is crucial to optimize antibiotic use through evidence-based strategies like IV-to-oral conversion. IV antibiotics are necessary in the initial phase of treating severe infections due to their rapid onset of action and predictable drug levels. However, as patients stabilize and show signs of improvement, many can safely be transitioned to oral antibiotics, which are equally effective for a wide range of infections. This transition reduces complications related to IV

administration, lowers healthcare costs, and enhances patient comfort and mobility. Despite the proven benefits, many hospitals delay or avoid this switch due to a lack of standardized protocols, leading to suboptimal outcomes [4].

Several studies have shown that implementing structured IV-to-oral conversion programs can significantly improve clinical outcomes, reduce the length of hospital stays, and lower the risk of IV-related complications [5]. However, the practice remains underutilized, particularly in tertiary care hospitals, where the complexity of cases and varied infection types present additional challenges.

There are three key strategies for transitioning patients from IV to oral antibiotics, each suited to specific clinical situations. Sequential therapy involves starting the patient on an IV antibiotic and switching to the same antibiotic in oral form once the patient stabilizes, ensuring continuity in treatment; this is effective for antibiotics with both IV and oral formulations [6]. Switch therapy replaces the IV antibiotic with an oral one of similar therapeutic effect but a different drug, allowing flexibility in selecting appropriate oral medications [7]. Lastly, step-down therapy begins with broad-spectrum IV antibiotics when the causative organism is unknown, later transitioning to a narrower-spectrum oral antibiotic once the pathogen is identified, reducing the risk of resistance while maintaining treatment efficacy [8]. Each of these strategies aims to optimize antibiotic use, minimize side effects, and improve patient outcomes. However, the decision-making process in tertiary care hospitals can be complicated, influenced by factors such as the patient's ability to absorb oral medications, the severity of the infection, and clinician preferences. Understanding these factors is crucial for enhancing adherence to best practices in IV-to-oral conversion.

Tertiary care hospitals manage a diverse and often critically ill patient population, which complicates antibiotic management. Patients in these settings frequently present with multiple comorbidities, immunosuppression, or unusual infections, requiring a more cautious approach to IV-to-oral conversion. Moreover, institutional barriers, such as a lack of clear guidelines or standardized protocols, contribute to inconsistent practices in IV-to-oral conversion [3,9].

Recent studies have highlighted the need for structured protocols that guide clinicians in making timely decisions about when to switch from IV to oral therapy. For instance, a study by Nathwani et al. found that hospitals with well-established protocols for IV-to-oral conversion saw significant reductions in the duration of IV antibiotic use and overall length of hospital stay [10]. Similarly, research by Hand et al. demonstrated that implementing a hospital-wide IV-to-oral conversion program led to a 50% reduction in unnecessary IV antibiotic use, with no negative impact on patient outcomes [11]. Economic

considerations are a critical factor driving the need for such studies. Sallach-Ruma et al. (2015) reported that IV antibiotics are generally associated with higher costs due to not only the medication itself but also the extended hospital resources required, such as nursing time, equipment for IV administration, and longer hospital stays. In contrast, oral antibiotics are more cost-effective and offer logistical advantages, such as ease of administration, making them a preferable option when clinically appropriate [12]. Thompson et al. (2015) also demonstrated that using a clinical intervention form in hospitals significantly improved antibiotic administration, further reinforcing the importance of proper conversion practices [13].

For instance, Kan et al. (2019) demonstrated that the use of a clinical decision support tool effectively increased IV-to-oral conversion rates in a community academic hospital, while Thompson et al. (2015) emphasized the value of using clinical intervention forms to enhance antibiotic administration [14, 15]. Jones et al. (2012) also pointed to fluoroquinolones as a prime candidate for early conversion due to their high bioavailability, suggesting that such interventions can serve as "low-hanging fruit" for antimicrobial stewardship efforts [16]. Despite these successes, many hospitals still encounter challenges, such as clinician hesitancy, lack of standardized protocols, and concerns over patient outcomes.

Given the significant clinical and economic benefits of IV-to-oral antibiotic conversion, evaluating current practices in tertiary care hospitals is essential, especially in settings where patients present with complex and severe infections. This observational study aims to assess the frequency and timing of IV-to-oral conversion and the associated clinical outcomes in a tertiary care hospital. By examining these practices, the study seeks to identify trends and areas for improvement, providing valuable insights to support evidence-based recommendations for enhancing adherence to best practices.

However, in tertiary care hospitals, this practice is often underutilized due to clinical and logistical challenges. IV antibiotics are generally more expensive, not only due to the cost of the drugs but also because of additional hospital resources such as extended stays, equipment for administration, and nursing time. Oral antibiotics, on the other hand, are significantly more cost-effective and easier to administer. This observational study aims to evaluate the current practices of IV-to-oral conversion in a tertiary care hospital and examine the associated cost variations between IV and oral therapies. By understanding these patterns, the study will contribute to optimizing antibiotic use and reducing unnecessary healthcare expenditures.

OBJECTIVES:

PRIMARY OBJECTIVES:

To evaluate the conversion of antibiotics from intravenous to oral route in a tertiary care hospital.

SECONDARY OBJECTIVES:

- To assess the cost reduction after conversion of IV to PO.
- To assess the prescription pattern of antibiotics.
- To assess the patient demographics, antibiotic indications and co-morbidities.
- To assess the type of conversion.
- To analyse the time of switch from IV to PO.

REVIEW OF LITERATURE:

Johannes Wild et al (2022) conducted a study on 'Short and Concise Peer-to-Peer Teaching-Example of a Successful Antibiotic Stewardship Intervention to Increase Iv to Po Conversion'. The aim of the study was to investigate if a single, short, peer- to peer teaching intervention (junior doctor to junior doctor) during clinical routine can successfully improve antibiotic prescriptions. They performed a quasi- experimental before-after study on a regular care cardiology ward at a large academic medical center in Germany. They evaluated antibiotic use metrics retrospectively and calculated defined daily doses (DDD) with the anatomical therapeutic chemical/DDD classification system of the World Health Organization. They hypothesize that the over-representative use of intravenous administration is a potentially modifiable target, which can be proven by antibiotic use metrics analysis. After a single peer-to-peer teaching session with a focus on indications for iv to po conversion, the normalized percentage of intravenous compared to oral administration significantly decreased (from $86.5 \pm 50.3\%$ to $41.4 \pm 70.3\%$). Moreover, after the intervention, antibiotics with high oral bio availability were no longer administered intravenously at all during the following quarter. The results indicate that even a single peer-to-peer training session is highly effective in improving the IV to PO conversion rate in the short term^[2].

Rory Sallach-Ruma et al on 2015 conducted a study on 'Correlates and Economic and Clinical Outcomes of an Adult IV to PO Antimicrobial Conversion Program at an Academic Medical Center in Midwest United States' The study objectives were to evaluate the correlates and outcomes of a parenteral (IV) to oral (PO) antimicrobial conversion program at a Midwest US Academic Medical Center with the hypothesis that it will be associated with reduced drug costs. Patient-level data (n = 237; sex, race, admission source, admission status, admission severity, risk of mortality [relative expected, admission], and early death) were extracted from the Clinical Data Base/Resource Manager. Medication-level, drug-encounter data (n = 317;

antibiotic/dose/route/frequency/duration, conversion status, 10-day IV/PO switch- eligibility criteria) were extracted from patient's hospital medical records. Univariate analyses using chi-square or Fisher's exact test for categorical variables and Wilcoxon rank-sum test for continuous variables showed patients not converted (n = 149) versus converted (n = 88) at some point from IV to PO were more likely to be of white race and had higher risk of relative expected mortality. By applying the unit drug cost (derived from 2010 Thomson Reuters RED BOOK(TM)) and labor costs for IV/PO administration, both per dose, the overall 1-month drug cost-saving estimates in 2010 in US dollars were US\$5242 from converting and US\$8805 savings missed from not converting 518 and 1387 switch-eligible antibiotic doses, respectively. Despite sample-size limitations, this study demonstrated correlates and missed opportunities to convert antimicrobials from IV to PO, which warrants providers' attention. 3

Cameron Thompson et al on 2015 conducted a study on 'The use of an IV to PO clinical intervention form to improve antibiotic administration in a community based hospital' The purpose of the project was to determine whether antibiotic prescribing patterns improved following the implementation of an IV to PO conversion clinical intervention form. A collaborative approach was used by an interprofessional team to review medical records and design a clinical intervention form that adheres to evidence-based guidelines to promote appropriate conversion for patients on intravenous antibiotics. Education efforts were made to inform health system staff about the goal of the intervention and to gather feedback for the improvement of the clinical intervention form. A five-week pilot intervention period trial was carried out with a specific focus on the fluoroquinolone class of antibiotics, specifically ciprofloxacin, moxifloxacin, and levofloxacin. Data from the intervention phase, including overall antibiotic use, ratio of intravenous:oral antibiotic time and compliance with the clinical intervention form were assessed. The ratio of intravenous to oral fluoroquinolone use changed from 39.4% IV: 60.6% PO before the intervention, to 34.7% IV: 65.3% PO during the intervention, indicating an overall increase in the usage of oral fluoroquinolones during the intervention phase. In patients eligible to receive the clinical intervention form, physician compliance with the form was 50%. IV duration decreased by 42% in patients with physician compliance. (4)

Tiffany Kan on 2019 conducted a study on 'Implementation of a Clinical Decision Support Tool to Improve Antibiotic IV-to-Oral Conversion Rates at a Community Academic Hospital'. The objective was to determine the impact of a clinical decision support (CDS) tool on the adoption and sustainability of an antibiotic IV-

PO conversion program at a community academic hospital. It is a quasi-experimental study consisting of 3 phases was conducted. During phase 1, the pre-intervention antibiotic IV-PO conversion rate was determined. During phase 2, the IV-PO conversion policy was updated, education was provided to pharmacists and physicians, and a post intervention evaluation was conducted. During phase 3, a CDS tool was developed to generate real-time electronic alerts prompting pharmacists to assess antibiotic therapy, and post-intervention audits were performed 1 month, 3 months, and 15 months after implementation of the tool. Pantoprazole IV-PO conversion was assessed during each phase as a non-equivalent dependent variable. The primary outcome was the proportion of patients eligible for IV-PO conversion who were switched to oral therapy. Of 332 patients receiving targeted IV antibiotic therapy during the overall study period, 122 (37%) met the criteria for IV-PO conversion. The phase 2 IV-PO conversion rate of 35% (9/26) was comparable to the pre-intervention rate of 29% (10/35) ($p = 0.61$). Implementation of the CDS tool significantly increased the conversion rate to 78% (14/18), an increase that was sustained at 3 months (71% [17/24]) and 15 months (74% [14/19]) after implementation ($p < 0.05$ for all comparisons with phases 1 and 2). Pantoprazole conversion rates were similar across all phases. In conclusion, implementation of the CDS tool was effective in improving and sustaining antibiotic IV-PO conversion rates and enhancing policy compliance beyond the effects of policy revision and education. Refinement of both the policy and the tool is warranted to maximize adoption of the IV-PO conversion program. 5

Makoto Jones et al conducted a study on 'Parenteral to oral conversion of fluoroquinolones: low-hanging fruit for antimicrobial stewardship programs?' on 2012. It aims to estimate avoidable intravenous (IV) fluoroquinolone use in Veterans Affairs (VA) hospitals. It is a retrospective analysis of bar code medication administration (BCMA) Data were analyzed for all medications administered on acute care wards between January 1, 2006, and December 31, 2010. Patient-days receiving therapy were expressed as fluoroquinolone-days (FD) and divided into intravenous (IV; all doses administered intravenously) and oral (PO; at least one dose administered per os) FD. We assumed IV fluoroquinolone use to be potentially avoidable on a given IV FD when there was at least 1 other medication administered via the enteral route. Over the entire study period, 884,740 IV and 830,572 PO FD were administered. Overall, avoidable IV fluoroquinolone use accounted for 46.8% of all FD and 90.9% of IV FD. Excluding the first 2 days of all IV fluoroquinolone courses and limiting the analysis to the non-ICU setting yielded more conservative estimates of avoidable IV use:

20.9% of all FD and 45.9% of IV FD. Avoidable IV use was more common for levofloxacin and more frequent in the ICU setting. There was a moderate correlation between avoidable IV FD and total systemic antibiotic use ($r = 0.32$). Unnecessary IV fluoroquinolone use seems to be common in the VA system, but important variations exist between facilities. Antibiotic stewardship programs could focus on this patient safety issue as a "low-hanging fruit" to increase awareness of appropriate antibiotic use. 6

Lizanne Béique et al on 2015 conducted a study on 'Addressing Concerns about Changing the Route of Antimicrobial Administration from Intravenous to Oral in Adult Inpatients' The aim is to provide insights into common concerns related to IV to PO conversion, with the aim of helping antimicrobial stewardship teams to address them. This study shows that when considering a change to oral therapy, it is important to have a thorough understanding of key aspects of the antimicrobial agent, the patient, and the disease being treated. The antimicrobial stewardship team has an important role in facilitating IV to PO conversion, educating prescribers, and addressing any concerns or reservations that may interfere with timely transition from IV to PO administration. 7

Shanshan Xu et al, 2021 conducted a study on. Impact and barriers of a pharmacist- led practice with computerized reminders on intravenous to oral antibiotic conversion for community-acquired pneumonia inpatients' This was a retrospective, observational pre- and post-intervention study. Interventions were introduced in 2 sequential 12 month phases: Phase 1: pharmacists implemented the conventional practice of reviewing patient charts and medication records every 24 h and verbally informed the prescribers on eligible IV-PO conversions; Phase 2: pharmacists implemented a new intervention practice to inform the prescribers with a computerized reminder in electronic medical record system on eligible IV-PO conversions. The primary outcome was the proportion of patients who converted to oral therapy on the day patients were eligible for the conversion. The secondary outcomes were length of IV antibiotic therapy days, total length of antibiotic therapy days and length of hospital stay. A total of 524 patients were studied (256 in phase 1 and 268 in phase 2). The proportion of patients who converted to oral therapy on the day patients were eligible for the conversion was significantly increased from 34.77% (89/256) in phase 1 to 62.69% (168/268) in phase 2 ($p < 0.05$). Length of IV antibiotic therapy days in phase 2 was shortened by 1.23 days, which was 5.52 days compared to 6.75 days in phase 1 ($p < 0.05$). Total length of antibiotic therapy days was 12.05 days in Phase 1, compared to 10.75 days in phase 2 ($p > 0.05$). Length of hospital stay for patients in phase 2 was significantly shorter, with a difference of 1.38 days

(6.02 days vs. 7.40 days, $p < 0.05$). The most common barrier of not converting IV-PO was the presence of co-morbidity. It was concluded that the pharmacist-led IV-PO antibiotic conversion practice with computerized reminders was successful and feasible in Chinese hospitals. More IV PO intervention studies in patients with other infections are needed in the future. 8

Masahiro Uni et al on 20 conducted a study on 'Efficacy of early switch from intravenous to oral antimicrobials in patients with aspiration pneumonia: A prospective observational study' This prospective observational study included consecutive patients admitted with aspiration pneumonia over a 10-month period at St. Luke's International Hospital; we excluded patients that required intensive care. The criteria for an early switch were stability of vital signs (temperature $\leq 38^\circ\text{C}$; respiratory rate ≤ 24 breaths/min; pulse rate ≤ 100 beats/min for >24 h) and a successful swallow evaluation (repetitive saliva swallowing test score ≥ 2 ; modified water swallowing test score ≥ 4). The primary endpoint was successful completion of antimicrobial treatment 30 days after the switch, without reversion to intravenous antimicrobials. Anticipated success rate was set as 60-75%, based on a previous study of the 70 patients admitted with aspiration pneumonia, 32 (45.7%) were excluded, and 38 (54.3%) met the inclusion criteria. Of these 38 patients, 29 (76.3%) met the switch criteria. The median duration of hospital stay for the included patients was 16 (5-30) days and 30 (12-68) days, respectively ($P=0.03$). Among patients who met the switch criteria, 26 (89.7%) completed oral treatment successfully while 3 (10.3%) reverted to intravenous antimicrobials. Approximately 75% of patients met the switch criteria; of these, nearly 90% underwent safe conversion to oral therapy. These results demonstrate the efficacy and feasibility of the switch criteria. 9

MATERIALS AND METHODS:

Study design:

The prospective observational study was carried out at a tertiary care hospital in Bangalore for a period of 6 months.

Source of data and Materials:

The data will be collected from the patient case sheets which includes:

- Patient profile form.
- Medication chart.
- Laboratory data.
- Physician notes.
- Discharge prescription.
- Observation chart.
- Medical record department.
- Electronic Health Records

INCLUSION CRITERIA:

- All patients who require IV to PO conversion.
- Patients who are above 18 years.
- Patients of both gender

EXCLUSION CRITERIA:

- Pregnant women and lactating mothers are excluded for the study.
- Patients who are under the age of 18.
- Patient who are on Nothing Per Oral (NPO).

METHOD OF COLLECTION OF DATA:

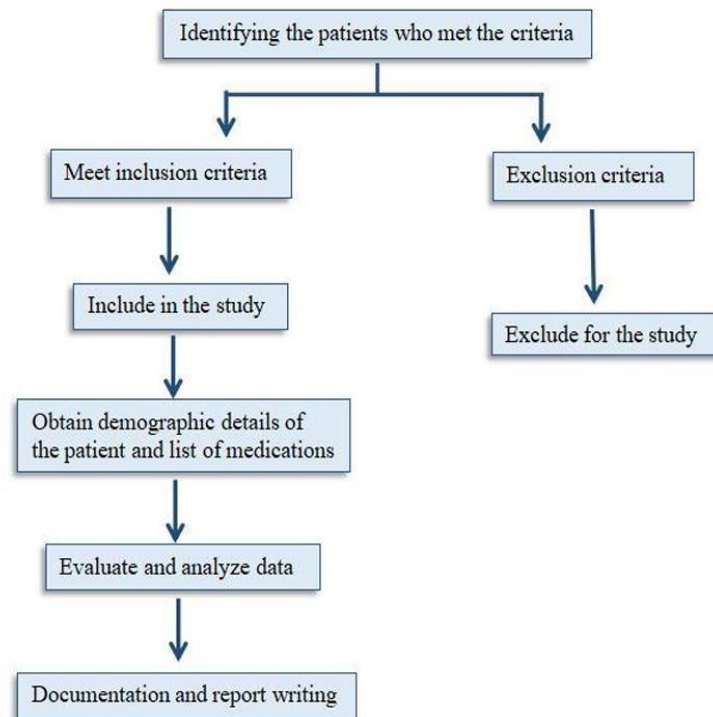
An observational study was done in different department of a tertiary care hospital. The first step was identifying patients who have met the criteria for the study. A data collection form was prepared in which the patients demographic details like age, gender, co morbidities were documented. The IV and Oral medications were also taken along with their dose, frequency and timing of the medications. The price of the drugs were collected from the IP pharmacy. medication indent as well as online sources. The discharged prescription were also taken from the Medical Record Department and Electronic Health Record.

STUDY PROCEDURE:

In this study, the initial step involved identifying patients who met the study criteria and gathering their demographic information through a data collection form. Prescription charts were examined for any instances of IV to PO conversion, focusing on the dosage, frequency, timing, duration, and antibiotic class. The costs associated with both treatment methods were also documented to compare the price differences between IV and oral therapies. Additionally, the analysis of IV to PO conversions included the timing and rationale for switching from IV medications to oral ones. All collected data were carefully recorded and analysed.

Flow chart:

The schematic diagram showing the overall process of the study.



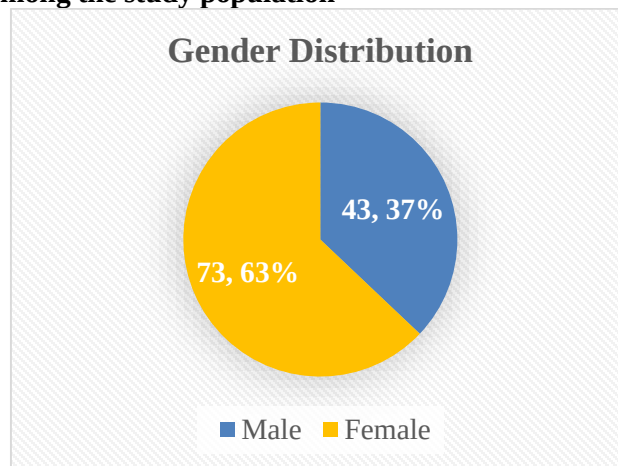
RESULTS:

Table 1: Baseline characteristics of the study population

Gender	N	%	
Male	43	37%	Mean±SD
Female	73	63%	
Age	N	%	
Adults(18-59)	76	65.5%	40.43 ± 12.56
Elders(>59)	40	34.5%	70.5 ± 6.08
Antibiotics indication	N	%	
LRTI	51	27%	
UTI	21	11%	
AGE	24	13%	
Sepsis	13	7%	
Encephalitis	17	9%	
Surgery Prophylaxis	8	4%	
Co-morbidities	N	%	
Respiratory Disease	23	19.82%	

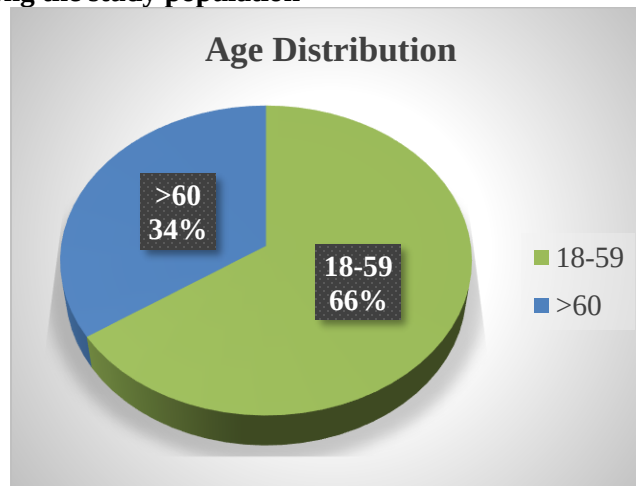
Cardiovascular Disease	11	10.34%
CKD/AKI	18	16.37%
Hypertension	20	18.1%
Head Injury	11	10.34%
GI Disease	10	8.62%
DM	41	37.93%
Cancer	11	9.48%

Figure 1: Gender Distribution among the study population



In this study, out of 116 patients 73(63%) were female and 43(37%) male, indicating a predominance of femal patients within the study population. (Table 1, figure 1)

Figure 2: Age Distribution among the study population



The age distribution within the study population with subjects were categorized into two: adult with age between 18 – 59 years old and elderly with age above 59 years old. Current study (Figure 2) shows majority of the subjects between age 18 – 59 years old. Adult patients (table 1) were 66% and had mean age of 40.43 ± 12.56 years. While elderly patients admitted with ACS were (table 1) 46.6% with mean age of 70.5 ± 6.08 .

Figure 3: Distribution of antibiotic indications within the study population.

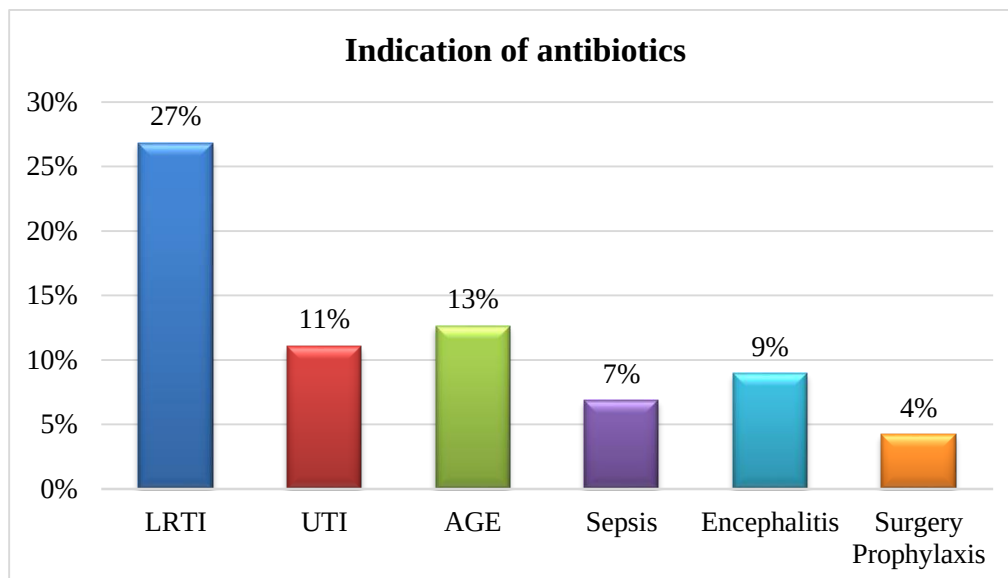


Table 1 and Figure 3 presents the percentages of various conditions for which antibiotics were indicated in the study population. Lower respiratory tract infections (LRTI) accounted for the highest percentage at 27%, followed by acute gastroenteritis (AGE) at 13%, urinary tract infections (UTI) at 11%, and encephalitis at 9%. Sepsis was indicated in 7% of cases, while surgery prophylaxis had the lowest indication at 4%

Figure 4: Comorbidities Distribution among the study population.

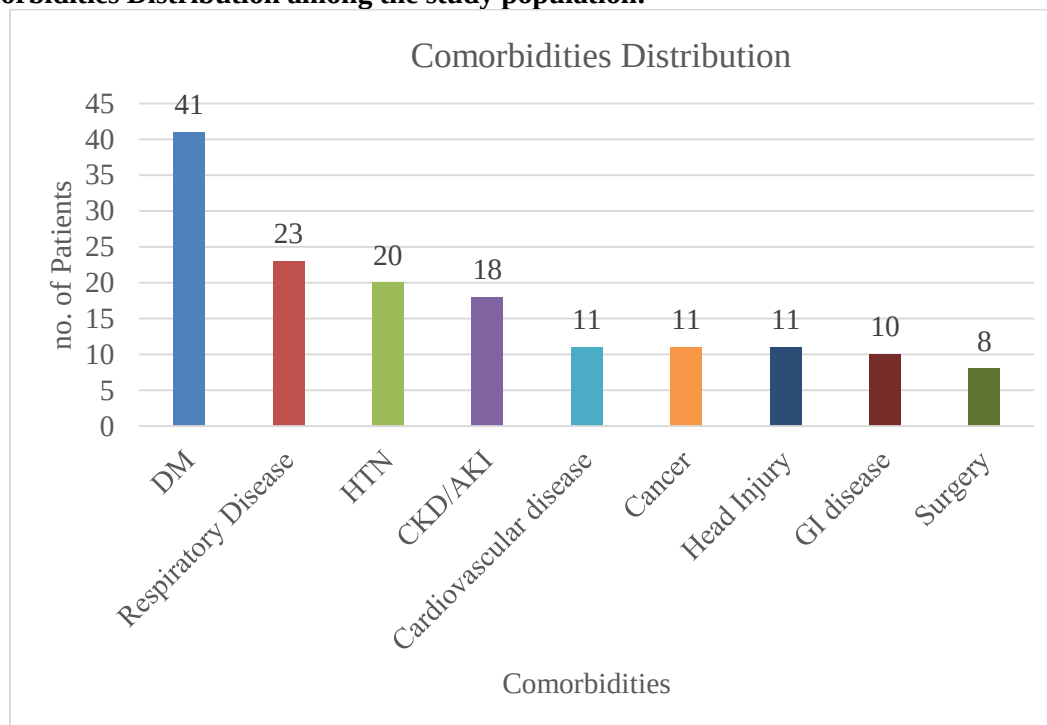


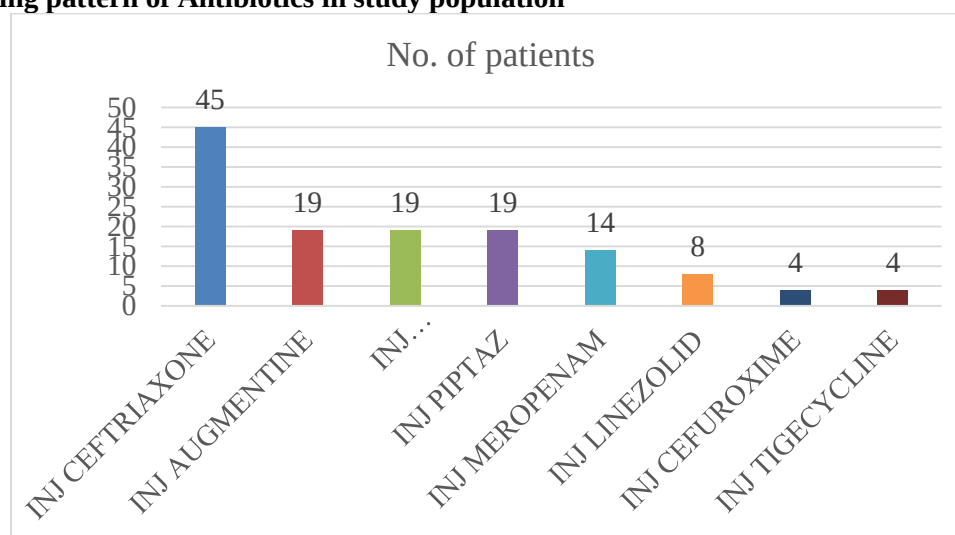
Figure 4 shows the number of patients with various comorbidities in the study. Respiratory diseases affected 23 patients, cardiovascular disease affected 11, CKD/AKI 18, diabetes mellitus (DM) 41, hypertension (HTN) 20, head injuries 11, gastrointestinal (GI) disease 10, and cancer 11 patients. Diabetes had the highest occurrence.

Prescription Pattern:

Table 2: Prescribing pattern of Antibiotics used in study population

Antibiotics	No. of patients	%
CEFUROXIME	4	3.03
TIGECYCLINE	4	3.03
LINEZOLID	8	6.06
MEROPENEM	14	10.6
PIPERACILLIN TAZOBACTAM	19	14.39
CEFTRIAZONE	45	34.09
AMOXICILLIN CLAUVULANATE	19	14.39
METRONIDAZOLE	19	14.39

Figure 5: Prescribing pattern of Antibiotics in study population



The table 2 summarizes the usage of various antibiotics in the study population. Inj Cefuroxime and Inj Tigecycline were each administered to 4 patients (3.03%), while Inj Linezolid was given to 8 patients (6.06%). Inj Meropenem was prescribed for 14 patients (10.6%), and Inj Pip-Taz was used for 19 patients (14.39%). The most frequently used antibiotic was Inj Ceftriaxone, which was given to 45 patients (34.09%), followed by Inj Augmentin and Inj Metronidazole, each prescribed to 19 patients (14.39%).

Table 3: Prescribing pattern of Antibiotic class treated in study population

Antibiotics	Class
Monotherapy	
Inj Cefuroxime	Cephalosporins
Inj Tigecycline	Tetracycline
Inj Linezolid	Oxazolidinones
Inj Meropenem	Carbapenem
Inj Metronidazole	Nitroimidazole antimicrobials
Inj Ceftriaxone	Cephalosporins
Combination therapy	
Inj Piperacillin and Tazobactam	Penicillin and Beta Lactamase inhibitor
Inj Amoxicillin and Potassium Clauvulanate	

Figure 6: Prescribing pattern of antibiotics (monotherapy) class in study population

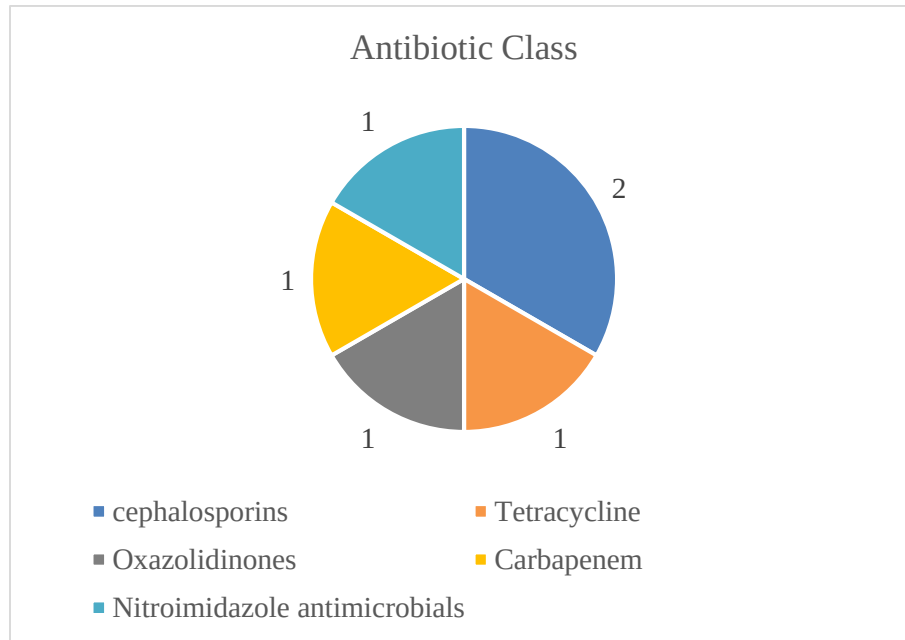
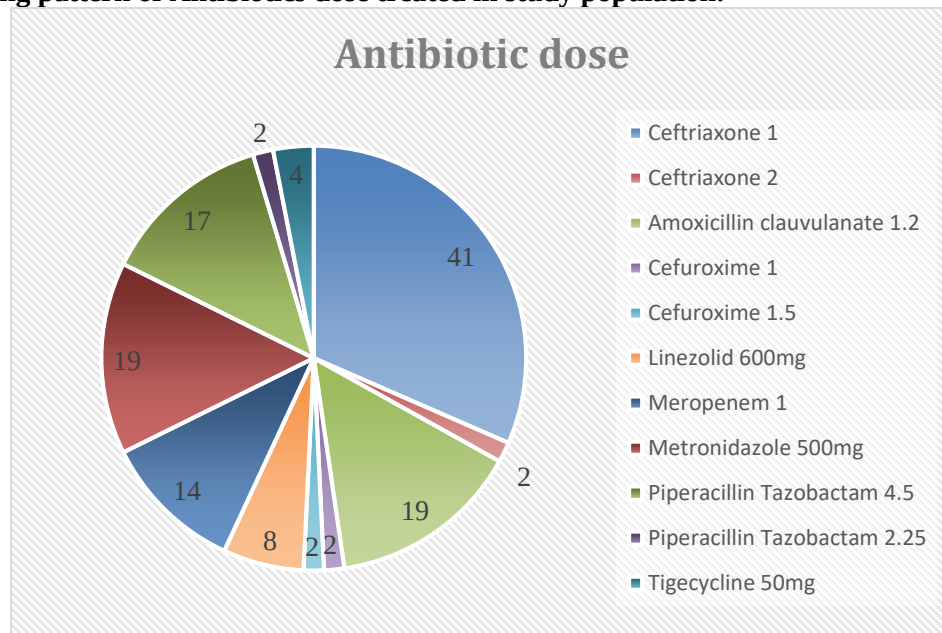


Table 3 and Figure 5 reveals a total of six instances of antibiotic monotherapy usage across various classes, with cephalosporins being the most common at two occurrences. The remaining classes include tetracycline, oxazolidinones, carbapenems, and nitroimidazole antimicrobials, each represented by one instance. The combination therapies identified are Inj Piperacillin and Tazobactam, as well as Inj Amoxicillin and Potassium Clavulanate. Both therapies feature a penicillin antibiotic combined with a beta-lactamase inhibitor.

Table 4: Prescribing pattern of Antibiotics Dose used in study population

Antibiotics	Dose	No. of patients	%
Ceftriaxone	1gm	41	32%
	2gm	2	2%
Amoxicillin clauvulanate	1.2gm	19	15%
Cefuroxime			
	1.5gm	2	4%
Linezolid	600mg	8	6%
Meropenem	1gm	14	11%
Metronidazole	500mg	19	15%
Piperacillin Tazobactam	4.5gm	17	13%
	2.25gm	2	2%
Tigecycline	50mg	4	3%

Figure 7: Prescribing pattern of Antibiotics dose treated in study population.



The data shows the antibiotic usage within the study population. Inj Ceftriaxone was administered in two doses, with 41 patients receiving 1 gm (32%) and 2 patients receiving 2 gm (2%). Inj Amoxicillin clavulanate was given to 19 patients at 1.2 gm (15%), while Inj Cefuroxime was used in two doses (2% each for 1 gm and 1.5 gm). Inj Linezolid was prescribed to 8 patients at 600 mg (6%), and Inj Meropenem was given to 14 patients at 1 gm (11%). Inj Metronidazole was administered to 19 patients at 500 mg (15%), and Inj Piperacillin Tazobactam was given to 17 patients at 4.5 gm (13%) and 2 patients at 2.25 gm (2%). Lastly, Inj Tigecycline was used for 4 patients at 50 mg (3%).

Table 5: Prescribing pattern of Antibiotic frequency used in study population

Drug	Frequency	No. of Patients	%
Ceftriaxone	BD	45	34%
Cefuroxime	BD	4	3%
Linezolid	BD	8	6%
Metronidazole	TID	19	14%
Tigecycline	TID	4	3%
Augmentin	BD	8	6%
	TID	11	8%
Meropenem	BD	3	2%
	TID	11	8%
Piptaz	TID	11	8%
	Q6H	8	6%

Figure 8: Prescribing pattern of Antibiotics frequency used in study population

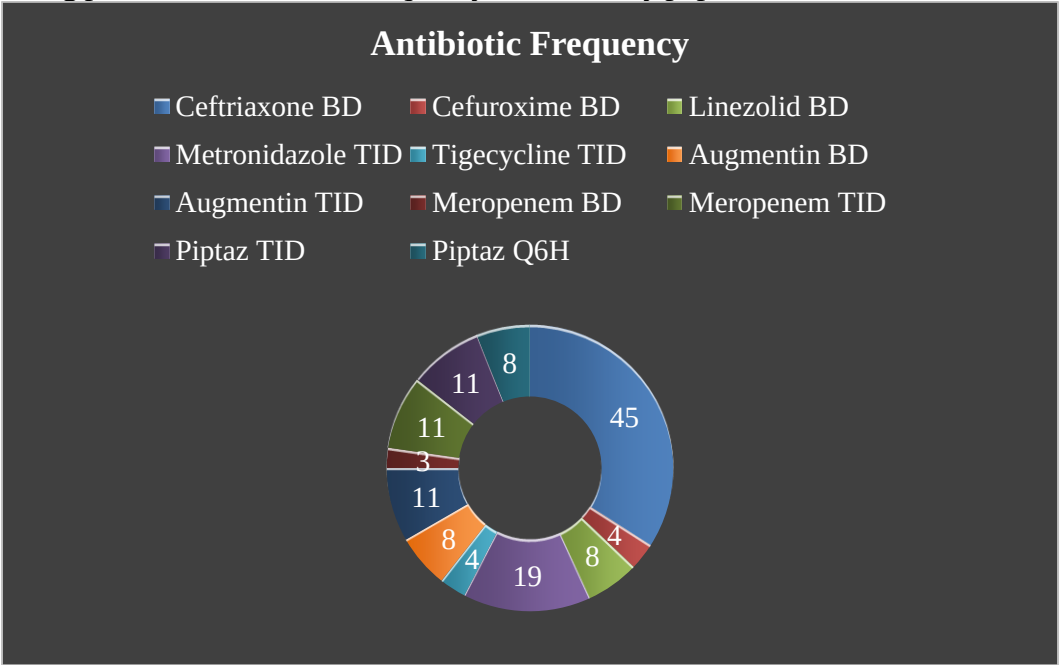
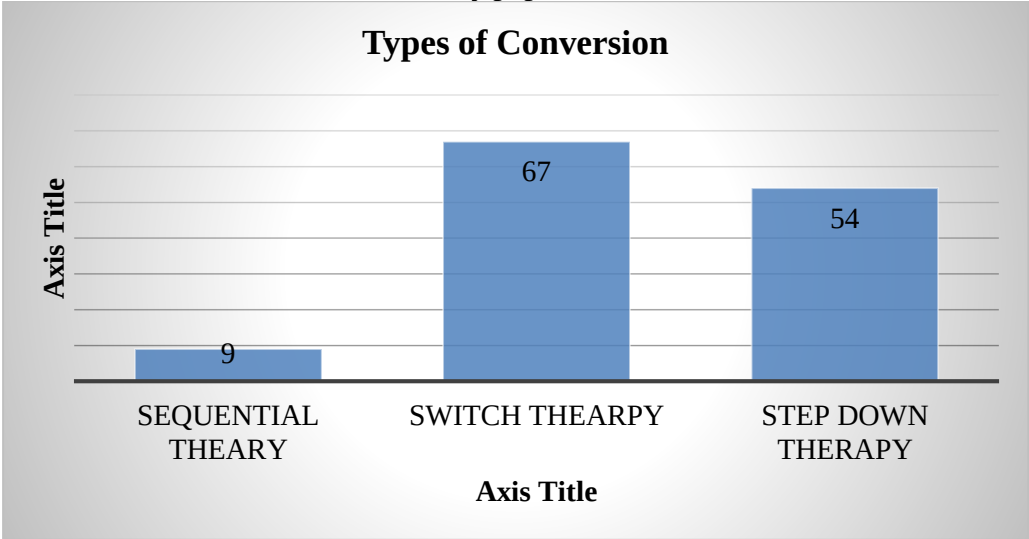


Table 5 and Figure 8 shows the frequency of antibiotic administration among patients within the study population. Ceftriaxone was given twice daily (BD) to 45 patients (34%). Cefuroxime (BD) and Linezolid (BD) were administered to 4 patients (3%) and 8 patients (6%), respectively. Metronidazole was prescribed three times daily (TID) for 19 patients (14%), while Tigecycline (TID) was given to 4 patients (3%). Augmentin was administered BD to 8 patients (6%) and TID to 11 patients (8%). Meropenem was given BD to 3 patients (2%) and TID to 11 patients (8%). Piaptaz was prescribed TID for 11 patients (8%) and every 6 hours (Q6H) for 8 patients (6%).

Table 6: Types of IV to PO Conversion observed in the study population

Types of conversion	No. of Patients	%
SEQUENTIAL THEARY	9	6.92
SWITCH THEARPY	67	51.53
STEP DOWN THERAPY	54	41.53

Figure 9: Type of conversion observed within the study population.

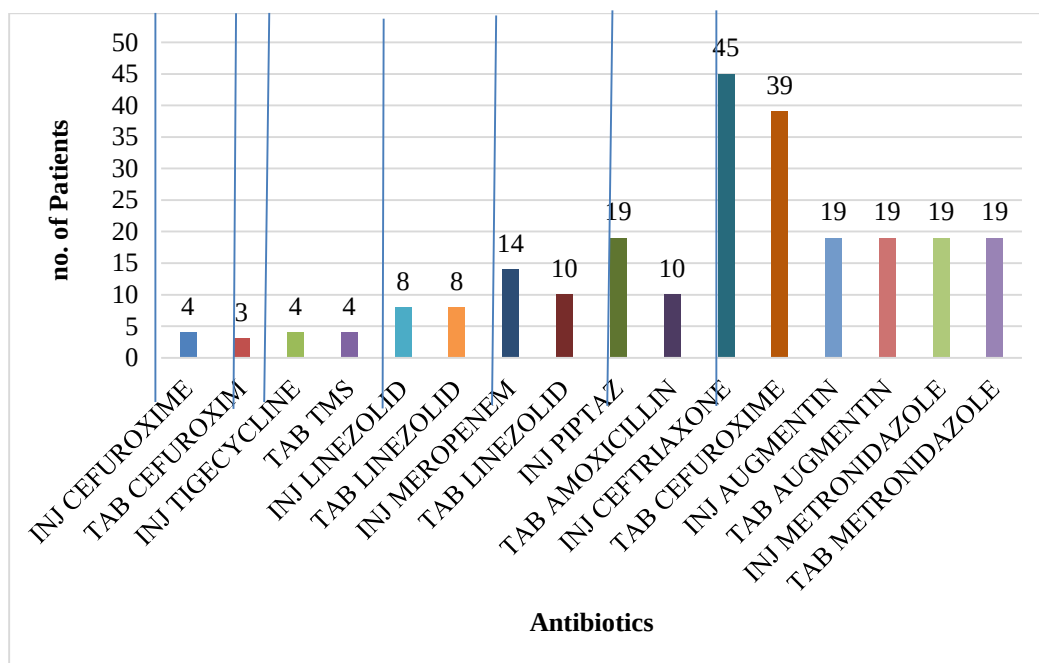


Sequential therapy involves transitioning from intravenous to oral antibiotics within the same drug with same dose, switch therapy entails a change to the same class but different drug and different dose, and step-down therapy refers to moving from broad-spectrum intravenous antibiotics to a narrower-spectrum oral option once the patient's condition improves. Table 6 and Figure 8 indicates the use of three types of antibiotic conversion therapies among patients: sequential therapy was applied to 9 patients (6.92%), switch therapy to 67 patients (51.53%), and step-down therapy to 54 patients (41.53%).

Table 7: Summary of Patient Antibiotic Conversions from IV to PO Therapy

IV Antibiotics	No. of patients	%	Ave. IV duration (days)	PO Antibiotics	%
Inj Cefuroxime	4	3.03	4.5	Tab Cefuroxime Tab Augmentin	75% 25%
Inj Tigecycline	4	3.03	5	Tab TMS	100%
Inj Linezolid	8	6.06	2.65	Tab Linezolid	100%
Inj Meropenam	14	10.6	6.07	Tab Linezolid Tab Feropenem Tab TMS Tab Metronidazole	71.4 14.3 7.1 7.1
Inj Piptaz	19	14.39	4.57	Tab Amoxicillin Tab. Cefixime Tab. Azithromycin Tab. Cefurozime Tab. Linezolid	52.6 10.5 10.5 10.5 15.7
Inj Ceftriaxone	45	34.09	4.4	Tab Cefuroxime Tab. Augmentin Tab Ciprofloxacin+Tinidazole	86.6 8.8 4.6
Inj Augmentin	19	14.39	4.78	Tab Augmentin	100
Inj Metronidazole	19	14.39	3.84	Tab Metronidazole	100

Figure 10: Antibiotic conversion from IV to PO.

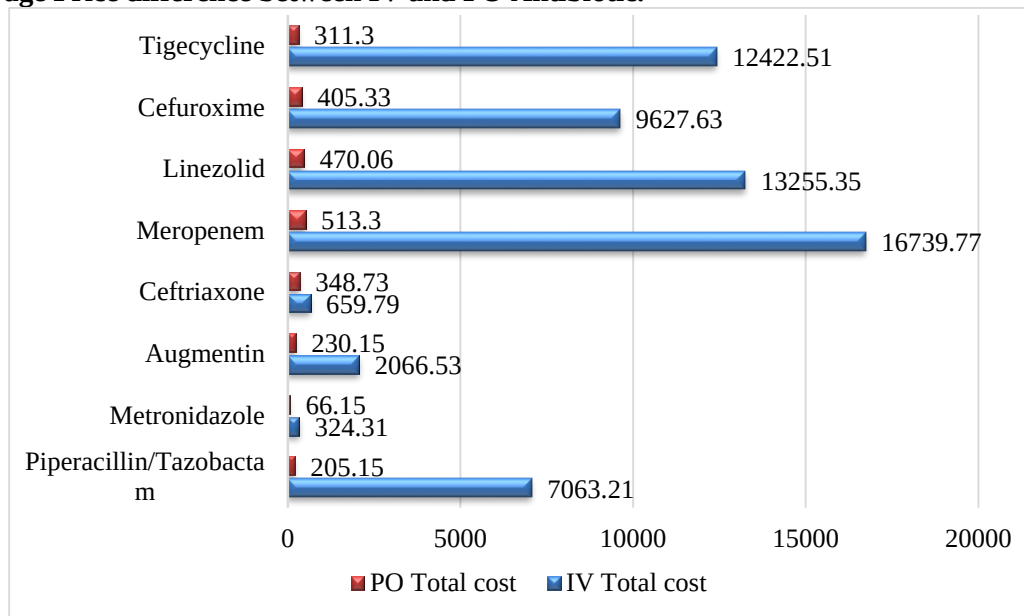


In this study, out of 116 patients, 4 patients (3.03%) who received Inj Cefuroxime for an average of 4.5 days were converted to Tab Cefuroxime (75%). Similarly, 4 patients (3.03%) on Inj Tigecycline for an average of 5 days transitioned to Tab Trimethoprim+ Sulphamethoxazole (100%). Additionally, 8 patients (6.06%) receiving Inj Linezolid for an average of 2.65 days switched to Tab Linezolid (100%), while 14 patients (10.6%) on Inj Meropenem for an average of 6.07 days were converted to Tab Linezolid (71.42%). Furthermore, 19 patients (14.39%) who took Inj Piptaz for an average of 4.57 days were converted to Tab Amoxicillin (52.63%). Among them, 45 patients (34.09%) who received Inj Ceftriaxone for an average of 4.4 days transitioned to Tab Cefuroxime (86.66%), while 19 patients (14.39%) on Inj AUGMENTIN for an average of 4.78 days were switched to Tab AUGMENTIN (100%). Lastly, 19 patients (14.39%) receiving Inj Metronidazole for an average of 3.84 days were converted to Tab Metronidazole (100%).

Table 8: Price difference between IV Antibiotic and PO Antibiotic (in rupees)

Drug	Average Total cost of IV Antibiotic	Average total cost of PO Antibiotic	Price Difference
Piperacillin/Tazobactam	7063.21	205.15	6858.06
Metronidazole	324.31	66.15	258.16
Amoxicillin Tazobactam	2066.53	230.15	1836.38
Ceftriaxone	659.79	348.73	311.06
Meropenem	16739.77	513.3	16226.47
Linezolid	13255.35	470.06	12785.29
Cefuroxime	9627.63	405.33	9222.3
Tigecycline	12422.51	311.3	12111.21

Figure 11: Average Price difference between IV and PO Antibiotic.



This study reveals that for Piperacillin/Tazobactam, the IV cost was 7063.21, while the PO cost was 205.15, resulting in a difference of 6858.06. Metronidazole showed a difference of 258.16, with costs of 324.31 for IV and 66.15 for PO. Amoxicillin Tazobactam had an IV cost of 2066.53 and a PO cost of 230.15, leading to a difference of 1836.38. Ceftriaxone's IV cost was 659.79, and PO cost was 348.73, resulting in a difference of 311.06. Meropenem and Linezolid exhibited the largest discrepancies, with IV costs of 16739.77 and 13255.35, and PO costs of 513.30 and 470.06, respectively, leading to differences of 16226.47 and 12785.29. Cefuroxime's IV cost was 9627.63 and PO cost 405.33, resulting in a difference of 9222.30, while Tigecycline had an IV cost of 12422.51 and a PO cost of 311.30, with a difference of 12111.21.

Figure 12: Average duration of IV Antibiotic taken by the patients within the study population.

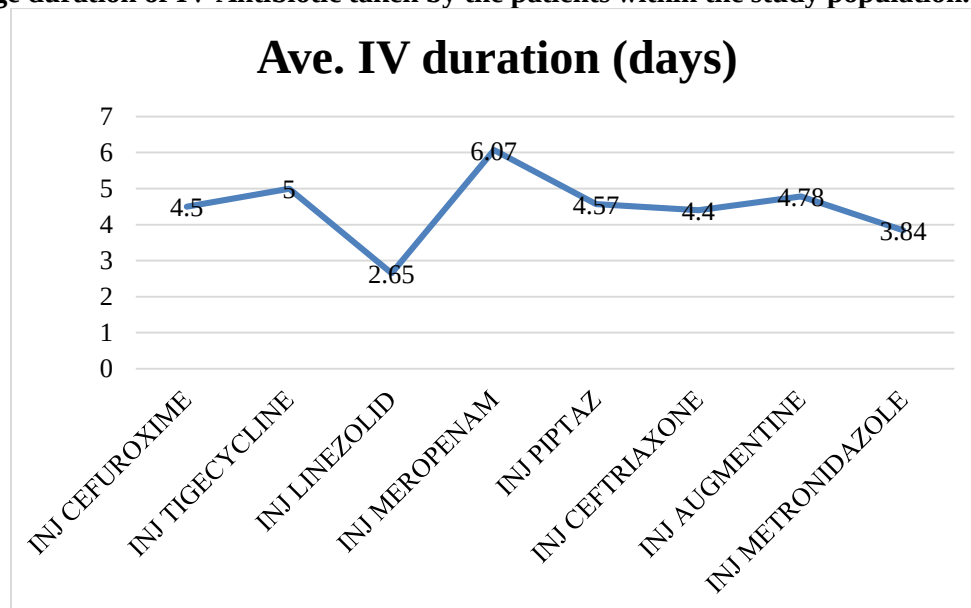


Figure 12 illustrates the average number of days for which patients in the study were administered intravenous (IV) antibiotics. For patients receiving Inj Cefuroxime, the average duration of IV therapy was 4.5 days. Inj Tigecycline was administered for an average of 5 days. For Inj Linezolid, the average IV duration was notably shorter at 2.65 days. Inj Meropenem had the longest average IV duration among the antibiotics studied, with an average of 6.07 days. For Inj Piperacillin/Tazobactam, the average IV therapy duration was 4.57 days. Inj Ceftriaxone which was the most frequently utilised in the study was given for an average of 4.4 days. Patients receiving Inj Amoxicillin and Potassium Clavulanate had an average IV duration of 4.78 days. Lastly, Inj Metronidazole had an average IV duration of 3.84 days.

DISCUSSION:

The conversion from intravenous (IV) to oral (PO) medications is crucial in clinical practice as it significantly enhances patient comfort and promotes a quicker recovery. By allowing patients to take medications orally, it reduces the need for prolonged hospital stays and minimizes healthcare costs associated with IV therapy. Additionally, the flexibility of oral dosing allows for easier adjustments in treatment, ultimately contributing to safer and more efficient patient care.

This prospective observational study aimed to evaluate the effectiveness and safety of intravenous (IV) to oral (PO) medication conversion in a diverse patient population at a tertiary care hospital in Bangalore over six months. The study employed multiple data sources, including case sheets and electronic health records, to analyze patient profiles, medication regimens, and clinical outcomes. Inclusion criteria focused on adults (≥ 18 years) requiring IV to PO conversion, while excluding pregnant women, lactating mothers, and patients under 18 to reduce confounding variables and enhance understanding of conversion practices. This approach aligns with clinical guidelines that recommend caution in these populations due to potential adverse effects.

General demographics:

The evaluation of the gender distribution in our study revealed that 63% of the patients were female, while 37% were male, indicating a notable predominance of female patients within the cohort. This finding aligns with previous research conducted in similar healthcare settings, which has often reported a higher prevalence of female patients in tertiary care hospitals^[20].

The age distribution of the study population revealed that a significant proportion of patients were adults aged 18 to 59 years, comprising 66% of the cohort with a mean age of 40.43 ± 12.56 years. In contrast, elderly patients aged 60 years and above accounted for 46.6% of the population, with a mean age of 70.5 ± 6.08 years. This distribution highlights a noteworthy trend in antibiotic therapy, where a larger segment of the population receiving intravenous to oral conversions is within the adult age group, reflecting the typical demographic profile in tertiary care settings. These findings align with existing literature that frequently reports a higher prevalence of younger adults in hospital admissions compared to the elderly^[21].

Antibiotic Indication:

The study findings highlight that lower respiratory tract infections (LRTIs) were the most common indication for antibiotic use, accounting for 27% of cases, followed by acute gastroenteritis (AGE) at 13% and urinary tract

infections (UTIs) at 11%. This pattern is consistent with existing literature, which often identifies LRTIs as a leading cause of antibiotic prescriptions in hospitalized patients^[22].

Moreover, the prevalence of AGE and UTIs in the current study aligns with data from the Centers for Disease Control and Prevention (CDC), which suggests that these infections are among the top causes for antibiotic prescriptions in outpatient settings. Sepsis, indicated in 7% of cases in the present study, is also corroborated by other research indicating a rising trend of sepsis in hospitalized patients, reflecting its status as a severe complication of various infections^[23].

Comorbidities:

In the present study, the prevalence of comorbidities among patients indicated that diabetes mellitus (DM) was the most common, affecting 41 patients, followed by chronic kidney disease (CKD) or acute kidney injury (AKI) in 18 patients, and hypertension (HTN) in 20 patients.

This study is consistent with prior research that associates Hypertension and DM^[24] with an increased rate of hospitalization and infection.

Respiratory diseases, affecting 23 patients in this study, are well-documented as common comorbidities in those requiring hospitalization, especially in relation to antibiotic use for managing infections like pneumonia^[25].

Prescription Pattern:

The prescribing pattern of antibiotics in the study population revealed a notable preference for certain antibiotics and dosing regimens. Inj Ceftriaxone was the most frequently prescribed antibiotic, administered to 45 patients (34.09%), primarily at a dose of 1 gm, given twice daily (BD) to 34% of patients. This aligns with existing literature, which emphasizes the use of cephalosporins for various infections due to their broad-spectrum efficacy^[26]. Inj Amoxicillin-clavulanate and Inj Metronidazole were also commonly used, indicating a significant reliance on beta-lactam antibiotics and nitroimidazole antimicrobials in clinical practice.

The antibiotic dosing in this study reflects a common clinical practice, with Inj Ceftriaxone prescribed predominantly at 1 gm (32%) and 2 gm (2%), aligning with guidelines for treating various infections effectively. The choice of doses for Inj Amoxicillin Clavulanate (1.2 gm for 15% of patients) and Inj Piperacillin Tazobactam (4.5 gm for 13% of patients) also mirrors standard recommendations for managing moderate to severe infections, consistent with existing literature that emphasizes these dosages for optimal therapeutic outcomes.

The frequency of antibiotic administration in the study revealed a preference for Ceftriaxone, prescribed twice

daily to 34% of patients, aligning with established treatment guidelines for various infections. Metronidazole and Augmentin were also frequently utilized, reflecting common practice in managing infections effectively. This pattern is consistent with existing literature, which emphasizes the importance of timely and appropriate antibiotic use to optimize patient outcomes and combat antimicrobial resistance^[27].

IV to PO conversion:

Type of conversion:

The results in Table 6 and Figure 8 illustrate the types of antibiotic conversion therapies used among patients. Sequential therapy was utilized by 9 patients (6.92%). Switch therapy was the most common, employed by 67 patients (51.53%). This aligns with existing literature that suggests clinicians frequently opt for switch therapy to optimize treatment and combat resistance patterns^[28].

Additionally, step-down therapy, which involves moving from broad-spectrum intravenous antibiotics to narrower oral options, was used for 54 patients (41.53%). The predominance of switch and step-down therapies in this study is consistent with the growing trend toward targeted antibiotic use, as recommended by the Infectious Diseases Society of America and similar organizations advocating for effective antibiotic management^[29].

Cost Difference:

From the study, the most common antibiotic found in the study population i.e. Ceftriaxone IV cost was 659.79, and PO cost was 348.73, resulting in a difference of 311.06. Piperacillin/Tazobactam exhibited a stark difference of Rs 6858.06, while Metronidazole showed a Rs 258.16 difference. Notably, Meropenem and Linezolid had the largest discrepancies at Rs 16226.47 and Rs 12785.29, respectively. This aligns with existing literature that emphasizes the cost-effectiveness of oral antibiotics, especially in stable patients who can tolerate them. Studies have demonstrated that early transition to oral therapy not only reduces costs but also enhances patient comfort and reduces hospital stays^[30].

Antibiotic conversion strategies:

The results of this study reveals a diverse range of antibiotic conversion strategies among patients. The most notable conversion involved Inj Cefuroxime, with 4 patients (3.03%) transitioning to Tab Cefuroxime after an average of 4.5 days of intravenous therapy.

The conversion rates of Inj Linezolid to Tab Linezolid (100%) and the switch from Inj Piptaz to Tab Amoxicillin (52.63%) highlight the feasibility of transitioning patients to oral therapy.

Additionally, the conversion of Inj Meropenem (100%) and Inj Metronidazole (100%) to oral formulations is consistent with findings from other studies that emphasize

the importance of tailoring antibiotic regimens based on patient stability and clinical guidelines.

Prior studies have demonstrated the benefits of early oral switch therapy, suggesting that such practices not only contribute to cost savings but also improve patient outcomes. For instance, a systematic review indicated that patients who switched to oral antibiotics reported shorter hospitalization times and reduced treatment costs compared to those remaining on intravenous therapy^[30].

Average duration of Antibiotic therapy:

The average duration of IV antibiotic therapy in this study varied, with Inj Meropenem lasting 6.07 .days, reflecting its use in severe infections. Inj Tigecycline (5 days) and Inj Cefuroxime (4.5 days) were also noteworthy, indicating tailored approaches to therapy based on patient stability. Shorter durations align with antimicrobial stewardship principles, supporting early transitions to oral antibiotics to enhance comfort and reduce hospital stays. Studies emphasize that timely switching not only maintains efficacy but also minimizes costs, reinforcing the importance of individualized treatment plans in optimizing patient outcomes^[31].

CONCLUSION:

In this study, a comprehensive analysis of intravenous (IV) to oral (PO) antibiotic conversion strategies was conducted, revealing significant trends and implications for patient management. The gender distribution indicated a predominance of female patients (63%), which aligns with findings in similar healthcare settings that highlight a higher female prevalence in tertiary care hospitals. The age distribution showed that 66% of patients were adults aged 18 to 59 years, underscoring a crucial demographic in antibiotic therapy.

Lower respiratory tract infections emerged as the most common reason for antibiotic prescriptions (27%), consistent with existing literature that identifies these infections as a primary cause for hospitalization. The high prevalence of comorbidities, particularly diabetes mellitus, chronic kidney disease, and hypertension, reinforces the complexity of managing infections in this patient population .

The prescribing patterns revealed a notable reliance on broad-spectrum antibiotics, with Inj Ceftriaxone being the most frequently prescribed (34.09%). This reflects current clinical practices emphasizing the need for effective treatment of severe infections. The transition from IV to PO therapy was particularly notable for Inj Cefuroxime and Inj Linezolid, highlighting the potential for cost-effective management without compromising treatment efficacy .

Overall, the findings suggest that implementing timely IV to PO transitions not only enhances patients comfort but also supports antimicrobial stewardship by minimizing

unnecessary IV usage. This study reinforces the importance of tailored antibiotic regimens based on patient stability, ultimately aiming to optimize patient outcomes and reduce healthcare costs.

LIMITATIONS:

- The lack of long-term follow-up restricts the ability to evaluate the prolonged effects of methotrexate discontinuation and resumption.
- The study was conducted in a single tertiary care hospital, which may limit the generalizability of the findings to other healthcare settings with differing patient demographics, prescribing patterns, and healthcare protocols.
- The study was observational in nature, and no direct interventions were made regarding the timing or choice of intravenous (IV) to oral (PO) conversion, which may introduce variability based on individual clinician preferences.
- The cost analysis is based on drug prices from a single source, which may not reflect price variations across different regions or hospitals.
- The study did not assess patient outcomes which would provide valuable insights into the clinical effectiveness of the conversions.

FUTURE DIRECTIONS:

- **Multi-Center Studies:** Future studies should include a multi-center approach to enhance the generalizability of the findings.
- **Interventional Studies:** Controlled interventional studies that implement standardized protocols for IV to PO conversion are necessary to evaluate the impact of specific guidelines on conversion timing, antibiotic selection, and patient outcomes.
- **Expanded Population Groups:** Future research should include populations excluded in this study, such as pediatric patients and pregnant or lactating women,
- **Longitudinal Studies with Outcome Analysis:** Future research should focus on clinical outcomes such as the rate of treatment success, infection recurrence, hospital readmissions, and adverse events after IV to PO conversion.
- **Pharmacoeconomic Studies:** Conducting pharmacoeconomic studies that compare the cost-effectiveness of various oral antibiotic formulations following IV therapy will be useful for future healthcare policy planning.

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