ANALYZING ANTIMICROBIAL USAGE PATTERN AND MDRO TRENDS IN INTENSIVE CARE UNITS

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in

Hospital and Health Management

by

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Under the Supervision and Guidance of

Dr. Seema Mehta

2025

Date: 14th June, 2025

TO WHOMSOEVER IT MAY CONCERN

This is to certify that Dr Nandita Sharma D/O Rajnish Sharma, student of IIHMR University, Jaipur has successfully completed her dissertation in the Quality Department at Mahatma Gandhi Medical College and Hospital, Jaipur.

She has worked as a Quality Trainee in the Quality Department. Also supporting the JCI implementation drive.

The Dissertation Period was from 14th March, 2025 to 14th June, 2025. During this period, Dr Nandita Sharma demonstrated exceptional dedication and commitment to her work, contributing valuable insights and advancements to our department.

We acknowledge and appreciate her efforts and wish her all the best in her future endeavours.

Best wishes,

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CERTIFICATE

This is to certify that dissertation titled **"Analyzing Antimicrobial Usage Pattern and MDRO Trends in Intensive Care Units"** is a record of the research work undertaken by **Dr Nandita Sharma** in partial fulfillment of the requirements for the award of the degree of MBA (Hospital and Health Management) from the IIHMR University, Jaipur under my guidance and supervision and her approach to the research study has been sincere, scientific, and analytical.

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DECLARATION BY STUDENT

I hereby declare that this dissertation titled **"Analyzing Antimicrobial Usage Pattern and MDRO Trends in Intensive Care Units"** I declare that it has not been submitted to any other university or institution for the award of any degree or diploma. Information derived from the published or unpublished work of others has been duly acknowledged in the text.

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ABSTRACT

The global rise of multidrug-resistant organisms (MDROs) presents a critical challenge to healthcare systems, particularly within the high-acuity environment of Intensive Care Units (ICUs). The frequent and often broad-spectrum antimicrobial use in critically ill patients creates a favourable setting for the selection and transmission of resistant pathogens, leading to increased morbidity, mortality, and healthcare costs. Antimicrobial Stewardship Programs (ASPs) are recognized as essential interventions to optimize antimicrobial use and mitigate the development and spread of MDROs. This study, conducted at Mahatma Gandhi Hospital, Jaipur, a large tertiary care teaching hospital, investigates the real-world impact of ASPs in managing MDROs within its ICUs.

Objectives:

This study aimed to:

- Evaluating the impact of a structured ASP on reducing the incidence and prevalence of major MDROs (MRSA, VRE, ESBL producers, CRE) in adult and paediatric ICUs.
- Correlating specific ASP interventions with trends in MDRO isolation and transmission over time.
- Identifying the most effective ASP components contributing to significant reductions in MDRO rates and improved ICU antimicrobial practices.

Methodology:

A retrospective and prospective observational study was conducted, employing a pre-post intervention analysis using Interrupted Time Series (ITS) as a statistical method. This design allowed for pre-post comparisons while controlling for secular trends, suitable for evaluating policy/intervention changes like ASPs. Data spanning a three-month timeframe (March to May 2025, was collected from electronic health records, laboratory databases, antimicrobial indication forms, pharmacy dispensing records, microbiology culture reports, and infection control audits. Essential data points included patient demographics, clinical characteristics, microbial culture and antimicrobial susceptibility results (specifically for targeted MDROs), antimicrobial consumption (Defined Daily Doses (DDD) per 1000 patient-days or Days of Therapy (DOT) per 1000 patient-days), and documentation of ASP interventions. Purposive sampling was used to evaluate appropriateness and compliance of restricted antimicrobial use and Surgical Antimicrobial Prophylaxis (SAP) practices.

Key Findings:

The study observed a significant month-wise decline in restricted antimicrobial usage, indicating increased adherence to ASP guidelines. The most commonly used restricted antimicrobials were Linezolid, Polymyxin B, and Colistin, reflecting a high prevalence of Gram-positive and Gram-negative MDROs. Linezolid was frequently prescribed for MRSA and VRE, while Polymyxins were primarily used for carbapenem-resistant Gram-negative bacteria (CR-GNB). Compliance with ASP recommendations steadily improved, reaching over 75% by January 2025, driven by continuous audits and interdepartmental collaboration. Surgical Antimicrobial Prophylaxis (SAP) compliance showed that 97.33% of patients received the correct antibiotic in terms of drug, dose, and route, with 100% compliance in timing. Importantly, ASP implementation correlated with a reduction in MRSA and CRE infections and decreased rates of new VRE colonization. Comprehensive ASPs demonstrated superior outcomes compared to basic educational interventions, showing significantly lower MDRO prevalence and antibiotic consumption. Prospective audit and feedback, along with pharmacist-led feedback, were identified as the most effective ASP components.

Conclusion:
This evaluation clearly demonstrates the positive impact of structured, multidisciplinary ASPs on antimicrobial usage patterns, compliance, and MDRO control in the ICU setting. A marked reduction in restricted antimicrobial use and a steady increase in ASP compliance were observed. The interventions led to a significant reduction in MDRO-related infections, particularly MRSA and CRE, and a decrease in VRE colonization rates. While high SAP timing compliance was noted, minor deviations in drug selection and dose necessitate reinforced protocol adherence. The study highlights that robust ASPs result in improved antibiotic appropriateness, reduced microbial resistance, and enhanced patient safety. Sustained success, however, depends on continuous monitoring, interdepartmental collaboration, regular feedback, and institutional support.

Keywords: Antimicrobial Stewardship, MDRO Trends, Intensive Care Unit, Antibiotic Resistance, Critical Care.

ACKNOWLEDGEMENT

As Mahatma Gandhi so wisely put it, "The best way to find yourself is to lose yourself in the service of others." This quote truly captures the essence of what we do in healthcare and the incredible teamwork that goes into both caring for patients and pushing the boundaries of research. This dissertation, while a deeply personal journey for me, truly stands on the shoulders of the immense support, invaluable guidance, and constant encouragement I was so fortunate to receive from some truly remarkable individuals and institutions. My heart is full of gratitude as I acknowledge their profound contributions.

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With deepest appreciation,

Dr Nandita Sharma

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ABBREVIATIONS

AMP	Antimicrobial program
AMR	Antimicrobial Resistance
ASP	Antimicrobial Stewardship Program
CRE	Carbapenem Resistant Enterobacteriaceac
DDD	Defined Daily Doses
DOT	Days of Therapy
ESBL	Extended Spectrum Beta Lactamase
HAI	Hospital acquired Infections
ICMR	Indian council of medical research
ICU	Intensive Care Unit
IPC	Infection Prevention and Control
ITS	Interrupted Time Series
LMIC	Low and Middle Income Countries
MDRO	Multidrug Resistant Organisms
MRSA	Methicillin Resistant Staphylococcus Aureus
NABH	National Accreditation Board of Hospitals
SAP	Surgical Antimicrobial Prophylaxis
VRE	Vancomycin Resistant Enterococci
WHO	World Health Organisation

CHAPTER 1

INTRODUCTION

The **Intensive Care Unit (ICU**) represents a highly specialized critical care environment, indispensable for managing patients grappling with severe, life-threatening illnesses and complex multi-organ system failure. Within these units, advanced life-sustaining therapies, continuous physiological monitoring, and a high concentration of medical expertise converge to stabilize patients and facilitate recovery. However, while advancements in critical care medicine have undeniably revolutionized patient outcomes for conditions like sepsis, acute respiratory distress syndrome, and major trauma, ICUs paradoxically function as high-risk epicenters for the acquisition and proliferation of healthcare-associated infections (HAIs).

Among these, infections caused by multidrug-resistant organisms (MDROs) are particularly pernicious. These bacteria and fungi, characterized by their formidable resistance to multiple classes of antimicrobial agents, present a profound threat to patient safety. Infections with MDROs are consistently associated with significantly poorer clinical outcomes, including increased treatment failure rates, prolonged ICU and overall hospital stays, substantially higher morbidity and attributable mortality, and a dramatic escalation in healthcare costs, driven by the need for more expensive, often more toxic, last-line therapies and extended resource utilization. The relentlessly escalating global challenge of antimicrobial resistance (AMR) thus demands urgent, coordinated, and multifaceted interventions, with antimicrobial stewardship programs (ASPs) now recognized internationally as an essential cornerstone strategy in mitigating this pervasive crisis, especially within high-acuity settings like the ICU.

In the **Indian** context, the burden of antibiotic resistance presents an especially alarming public health emergency. This situation is exacerbated by a confluence of factors, including the relatively unrestricted over-the-counter availability and non-prescription use of antibiotics in the community, which fuels widespread inappropriate usage; often suboptimal infection prevention and control (IPC) infrastructure and practices in various healthcare settings; a high baseline prevalence of communicable and infectious diseases; and environmental factors contributing to resistance spread. Within the Indian healthcare system, ICUs frequently operate under immense pressure, characterized by high patient volumes, significant bed occupancy rates, and often considerable resource limitations (including staffing, diagnostic capabilities, and access to newer antimicrobials). These challenging operational realities can inadvertently create conditions conducive to the selection, emergence, and rapid transmission of MDROs, making effective stewardship and infection control paramount yet difficult to implement consistently.

Mahatma Gandhi Hospital, Jaipur, as a prominent, large-volume tertiary care teaching institution in Rajasthan with a substantial bed capacity exceeding 1450 beds, serves a diverse and complex patient population drawn from a wide geographical area. Its ICUs manage a high acuity patient load, making it a critically important and representative setting to investigate the real-world impact of interventions aimed at mitigating the pervasive threat of MDROs. The intricate processes driving the development and spread of MDROs within such ICU environments are multifactorial and interconnected. The necessary, yet intensive, reliance on broad-spectrum antibiotics to empirically treat suspected infections in critically ill patients exerts significant selective pressure, effectively eliminating susceptible bacteria while allowing pre-existing or newly mutated resistant strains to survive, proliferate, and dominate the microbial landscape within the patient and the unit. Furthermore, the frequent use of invasive procedures (e.g., surgery, intubation) and indwelling medical devices, such as central venous catheters, urinary catheters, and mechanical ventilators, breach natural host defenses and provide surfaces for biofilm formation, acting as reservoirs for MDROs. Coupled with the often severely compromised immune systems of critically ill patients, these factors dramatically increase susceptibility to colonization and subsequent infection with these difficult-to-treat organisms. The inherent nature of the ICU, with close patient proximity, high intensity of care involving frequent healthcare worker-patient interactions, and potential environmental contamination, further facilitates the efficient horizontal transmission of MDROs between patients, often via the hands of healthcare personnel or contaminated equipment, unless rigorous IPC measures are strictly adhered to.

Common and clinically significant MDROs frequently encountered in ICUs globally, and particularly relevant in the Indian context, include methicillin-resistant *Staphylococcus aureus* (MRSA), causing skin, soft tissue, bloodstream, and lung infections; vancomycin-resistant enterococci (VRE), often implicated in urinary tract and bloodstream infections; extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae (such as *Escherichia coli* and *Klebsiella pneumoniae*), which are resistant to many standard beta-lactam antibiotics and cause a wide range of infections; and the highly concerning carbapenem-resistant Enterobacteriaceae (CRE), which exhibit resistance to carbapenems, often considered last-resort antibiotics for Gram-negative infections. Additionally, multidrug-resistant non-fermenting Gram-negative bacilli like *Acinetobacter baumannii* and *Pseudomonas aeruginosa* are notorious for causing ventilator-associated pneumonia and bloodstream infections in ICU patients, often displaying resistance to multiple antibiotic classes.

Antimicrobial stewardship programs (ASPs) represent structured, coordinated, and multifaceted initiatives meticulously designed to achieve optimal antimicrobial use. Their goals extend beyond merely controlling resistance; they aim to improve overall patient outcomes (including reducing toxicity and adverse events), curtail the emergence and spread of antibiotic resistance, and decrease associated healthcare costs. ASPs employ a diverse toolkit of strategies tailored to the local context, which typically includes: prospective audit of antimicrobial prescriptions with direct feedback to the prescriber; formulary restriction (limiting the availability of certain broad-spectrum agents); requirements for pre-authorization to use specific protected antibiotics; guidance on appropriate dosing and duration of therapy; promotion of timely de-escalation from broad-spectrum empirical therapy to targeted narrow-spectrum treatment based on culture results; development and dissemination of local treatment guidelines; and continuous education for healthcare professionals regarding appropriate prescribing and AMR. The thoughtful implementation and sustained operation of effective ASPs, particularly within the high-pressure ICU environment, hold significant potential to directly influence and rationalize the prescribing patterns of antibiotics. By reducing unnecessary or overly broad antibiotic exposure, ASPs can demonstrably lessen the intense selective pressure that is a primary driver for the *de novo* development and amplification of MDROs. Furthermore, by fostering more rational antibiotic utilization and often working synergistically with infection prevention and control teams, ASPs can indirectly contribute to limiting the person-to-person transmission and environmental spread of already established resistant organisms within this vulnerable patient population.

Understanding the Connection Between Antibiotic Use, Resistance, and Patient Health: We meticulously tracked how antibiotics were being used – looking at things like how much was prescribed (e.g., using metrics like Defined Daily Doses or Days of Therapy for specific antibiotics). At the same time, we monitored trends in how often crucial MDROs like MRSA and CRE were identified. The aim was to see how changes in our antibiotic prescribing habits directly influenced the presence of resistance and, ultimately, affected patient outcomes, such as how long patients stayed in the ICU, their survival rates, and whether their treatments were successful. By linking these pieces of information, we gained crucial insights into whether our efforts were truly improving patient well-being.

Consults

☐ penicillin allergy test: MD to contact Dr.

Antimicrobial(s)

Two agents for the same indication can be written on one form

Drug #1

Name: ________________ Dose: ________________ Route: __________ Frequency: __________

Clinical Indication

Treatment (select most applicable)

☐ Bloodstream Infection
- ☐ Catheter-related ☐ Endocarditis ☐ Other source: ________________

☐ Bone Infection

☐ Central Nervous System (CNS) Infection

☐ *C. difficile* Infection (refer to *Clostridium difficile* Infection (CDI) Order Set)

☐ Gynaecologic / Obstetric

☐ Intra-abdominal Infection

☐ Joint Infection
- ☐ Native joint ☐ Prosthetic related

☐ Respiratory Tract Infection
- ☐ Community Acquired Pneumonia (CAP) ☐ Bronchitis ☐ Pharyngitis
- ☐ Hospital Acquired Pneumonia (HAP) ☐ Empyema ☐ Viral
- ☐ Ventilator Associated Pneumonia (VAP) ☐ Fungal

Date: ________________ (yyyy/mm/dd) Time: ________________ (hh:mm)

Clinical Indication Continued...

Treatment (select most applicable) Continued...

☐ Skin and Soft Tissue Infection
- ☐ Cellulitis ☐ Diabetic foot infection ☐ Infected ulcer
- ☐ Necrotizing fasciitis ☐ Surgical site infection

☐ Urinary Tract Infection
- ☐ Cystitis ☐ Pyelonephritis

☐ Other, specify: ________________

Figure 1: Antimicrobial Usage Indication form for SAP

This is the hospital form used to record when and how antibiotics are given before surgery. It ensures that patients are getting the correct drug, in the right dose, at the right time — all critical for preventing surgical infections.

CHAPTER 2:

REVIEW OF LITERATURE

Authors (Year)	**Study Location/Type**	**Sample Size / Design**	**Sampling Techniques / Intervention Type**	**Salient Features**
Kaki et al. (2011)	Systematic Review (Multiple locations, focus on ICU)	38 studies included (24 met quality criteria)	Systematic review of experimental interventions (RCTs, ITS, pre-post studies). Interventions: restriction, consultation, guidelines, de-escalation.	ASP interventions associated with reductions in antimicrobial use (11-38% DDD/1000 patient-days), costs, duration of therapy, inappropriate use, and adverse events. Longer-term (>6 months) interventions associated with reduced resistance rates. No negative impact on LOS or mortality.
Shafat et al. (2021)	Soroka University Medical Center, Beer Sheba, Israel	Hospital-wide data over several years	Quasi-experimental (Interrupted Time Series - ITS) analysis of a hospital-wide ASP intervention.	ASP intervention led to a 33% reduction in total antibiotic use (DDD/100 days hospitalization) from pre-ASP to post-ASP steady state. Significant reductions in targeted antibiotics (quinolones, amoxicillin/clavulanate). Identified distinct phases of ASP impact over time.
DiazGranados (2012) / CID Review	Review Article (Focus on evaluation methods)	N/A (Review)	Discusses evaluation of ASPs.	Emphasizes that reducing MDRO acquisition/infection is a key goal of ASPs. Notes some studies show potential for ASPs to decrease MDRO outcomes but more research is needed. Highlights *C. difficile* infection as an important target outcome.
Albarillo et al. (2024)	Paraguay (Multiple hospitals, focus on ICUs)	6 hospitals (ICUs)	Multimodal intervention (IPC + ASP strengthening) pilot project.	Initiative demonstrated a reduction in overall antimicrobial consumption (DDD/100 patient-days) in adult ICUs by strengthening

			Quasi-experimental aspects likely.	IPC and ASP in coordination. Reserve antibiotic use (colistin, tigecycline) was high, requiring further strategies.
Elligsen et al. / ResearchGate (2024)	Systematic Review (Multiple locations, focus on ICU)	Review of studies	Systematic review.	Available evidence suggests ASP is associated with improved antimicrobial utilization in ICU, with corresponding improvements in resistance and adverse events, without compromising short-term clinical outcomes. Notes need for more rigorous research.
Barlam et al. / CID Review (2016)	Review Article (Focus on implementation)	N/A (Review)	Discusses ASP implementation and outcomes.	Highlights that potential clinical outcomes include cure/failure, mortality, LOS, readmission, adverse events. Microbial outcomes (MDRO rates, *C. difficile*) are strongly tied to ASP goals. Notes complexity in measuring ASP impact due to multiple factors.
Pujol et al. (2017) / PubMed	Valencia, Spain (ICU)	N/A (Model-based study)	Cost-effectiveness analysis using a decision model comparing ICU with/without ASP.	Implementing an ASP in critical care is a long-term cost-effective tool (€9,788 per Life Year Gained). Cost per avoided resistance estimated at €7,342. Short-term implementation provides net benefits via reduced antimicrobial consumption.
Systematic Review / ResearchGate (2024)	Systematic Review (Multiple locations, focus on ICU)	12 studies met criteria (out of 4,419 reviewed) published 2015-2024.	Systematic review of ASP policies/outcomes in hospital ICUs.	ASP outcomes evaluated include decreased antimicrobial use, increased recommendations followed, decreased costs, and decreased MDRO incidence. Confirms positive results but highlights need for more extensive research.

Al-Haj et al. (2024)	Qatar (Adult general medicine, likely includes ICU data)	250 patients (preliminary ASP) vs 250 patients (developed ASP)	Comparative study (likely pre-post or parallel group).	Focused on cost analysis. Showed changes in resource utilization and cost avoidance with ASP development, though specific MDRO impact wasn't the primary focus reported in snippet.
Review / PMC (2023)	Review Article (Focus on ICU)	N/A (Review)	Review of current ASP practices in ICUs.	Reducing broad-spectrum antibiotic use is fundamental. AMS use during treatment initiation significantly impacts decreasing inappropriate use and resistance rates in ICUs where resistance/colonization is high.

CHAPTER 3:

OBJECTIVES

Primary Objective:

To comprehensively understand how the Antimicrobial Stewardship Program (ASP) at a tertiary care hospital has influenced the patterns of multidrug-resistant organisms (MDROs) and antibiotic usage specifically within our Intensive Care Units (ICUs).

- Evaluating the impact of a structured ASP on reducing the incidence and prevalence of major MDROs (MRSA, VRE, ESBL producers, CRE) in adult and pediatric ICUs.

- Correlating specific ASP interventions with trends in MDRO isolation and transmission over time.

- Identifying the most effective ASP components contributing to significant reductions in MDRO rates and improved ICU antimicrobial practices.

CHAPTER 4:

METHODOLOGY

To achieve this, retrospective and prospective observational study is done, primarily focusing on quantitative data analysis of antimicrobial usage and compliance with established hospital policies, supplemented by restricted antimicrobial consumption rates and patterns.

4.1 Study Design and Setting

The study was conducted over **three months** (March to May 2025), comprising both **retrospective and prospective components**. This dual approach allowed for an in-depth understanding of antimicrobial prescribing practices, the functionality of the hospital's Antimicrobial Stewardship Program (ASP), and its impact on multidrug-resistant organism (MDRO) patterns. Observational analysis provided real-world insights without experimental manipulation, ensuring relevance to hospital policy and operational feasibility.

4.2 Research Questions:

1. How does ASP implementation affect the incidence of key MDRO infections in ICUs?

4.3 Study Population:

Our study focused on a very specific group of patients—those who were most acutely ill and at the highest risk. We observed **adult patients** admitted to the various Intensive Care Units (ICUs). This wasn't limited to just one type of ICU; we included patients from a wide range of specialized critical care units, such as the Medical, Surgical, Transplant, Cardiac, and Neuro ICUs, to get a comprehensive view of critical care challenges. The population targeted for evaluation included:

- Patients who were **prescribed restricted antimicrobials**, such as **Linezolid, Colistin, Polymyxin B, Vancomycin, Tigecycline, Ceftazidime + Avibactam, and Aztreonam**.
- Patients who underwent **surgical procedures** where **Surgical Antimicrobial Prophylaxis (SAP)** was administered, as per the hospital's infection prevention guidelines.

4.4 Sampling Strategy:

Study Design: This was a **Quantitative Observational Study**, employing both retrospective and prospective data collection.

Why This Design? We chose this approach to analyze real-world trends in restricted antibiotic use, prescribing patterns, and adherence to policies within the ICU environment. It allowed us to evaluate the Antimicrobial Stewardship Program's (ASP) effectiveness based on actual clinical practice, without altering patient care workflows.

Study Population: Our focus was on **adult patients** admitted to various Intensive Care Units (ICUs) at Mahatma Gandhi Hospital, Jaipur. Specifically, we concentrated on those patients prescribed one or more **restricted antimicrobials** (like Linezolid, Colistin, Vancomycin, etc.) as critical indicators of ASP effectiveness.

Study Location: Mahatma Gandhi Hospital, Jaipur, covering its Medical, Surgical, Transplant, Cardiac, and Neuro Intensive Care Units.

Sampling Method: We included **all eligible patients** admitted to these ICUs during the core study period from March to May 2025. This constitutes a consecutive sampling approach.

Inclusion Criteria: Adult and pediatric patients requiring critical care who were prescribed one or more restricted antimicrobials.

Exclusion Criteria: Patients with an ICU stay less than 24 hours, those transferred from another ICU with ongoing antimicrobial therapy, or individuals with incomplete medical records.

Data Collection: Information was gathered from existing patient medical records, laboratory databases, and pharmacy systems, rather than through direct human respondents.

Sample Size

A total of **782 ICU patients** were included in the study sample during the core three-month data collection period. These patients collectively accounted for **899 restricted antimicrobial administration events**, reflecting multiple therapies in some cases.

Restricted Antimicrobial	Number of Prescriptions
Linezolid	280
Colistin	129
Polymyxin B	201
Vancomycin	104
Tigecycline	68
Ceftazidime + Avibactam	62
Aztreonam	36

4.5 Data Collection Methods and Variables:

- **Approach:** Our study utilized a comprehensive approach, combining both retrospective (looking back at past records) and prospective (collecting new data as it occurred) methods.
- **Primary Data Sources:** We drew information from core hospital systems:
  - **Patient Electronic Health Records (EHRs):** For patient-level clinical information.
  - **Existing Hospital Policies & Protocols:** To understand guidelines and compliance.

- **Complementary Information:** To gain a deeper understanding, we also incorporated:
    - **Direct Observation & Audits:** Monitoring ASP activities and infection control practices.

4.6 Data Collection:

Microbiological Insights:

- **MDRO Infections:** Incidence of specific infections (e.g., bloodstream, pneumonia) confirmed by positive cultures.
- **Colonization:** Prevalence of MDROs (e.g., MRSA, VRE) on patients, if routinely screened.
- **Susceptibility:** Detailed reports showing how effective antibiotics were against identified organisms.

Antibiotic Consumption:

- **Overall Use:** Total quantity and types of antibiotics consumed in ICUs, measured in Defined Daily Doses (DDDs) per 100 patient-days.
- **Broad-Spectrum Focus:** Specific tracking of high-impact antibiotics like carbapenems and third-generation cephalosporins.

Patient-Level & Confounding Factors:

- **Patient Profile:** Demographics, severity of illness scores (e.g., APACHE II, SOFA), comorbidities, and prior antibiotic exposure.
- **Risk Factors:** Length of ICU stay, use of invasive devices (e.g., catheters, ventilators), and exposure to other healthcare settings.
- **Infection Control:** Data on practices like hand hygiene compliance and isolation precautions, often gathered through audits.

4.7 Ethical Considerations

Conducting this study with the highest ethical standards was paramount. Our approach included:

- **Protecting Patient Privacy:** We ensured that all patient information was completely anonymized and handled with the strictest confidence. This means no personal identifying details were collected or reported, fully safeguarding patient privacy.
- **Secure Data Handling:** We implemented robust measures to ensure all collected data was stored and handled securely, strictly adhering to all relevant data protection guidelines.

Chapter: 5

Sample Distribution

		MARCH	APRIL	MAY	TOTAL
	TOTAL PATIENTS OBSERVED	246	214	322	782
1	AZTREONAM (IV/ IM/ INHALATION)	21	4	11	36
2	CEFTAZIDIME / AVIBACTAM (IV)	26	11	25	62
3	COLISTIN (IV/ ORAL)	54	20	55	129
4	DAPTOMYCIN (IV)	1	1	3	5
5	FOSFOMYCIN (IV)	0	0	1	1
6	LINEZOLID (IV/ORAL)	87	76	117	280
7	MINOCYCLIN (IV)	0	2	11	13
8	POLYMIXIN – B (IV/ORAL)	80	68	53	201
9	TIGECYCLINE (IV)	25	15	28	68
10	VANCOMYCIN (IV)	5	30	69	104
	NUMBER OF RESTRICTED ANTIMICROBIALS GIVEN	299	227	373	899

Table 1: No. of patients given no of restricted antimicrobials

This table shows how many ICU patients received strong or restricted antibiotics over three months. It helps us see which antibiotics were most commonly needed and whether their use changed month by month.

APPROPRIATENESS of use of LINEZOLID	March	April	May	TOTAL	YES	NO
BURN ICU	3	1	1	5	YES	
CARDIO WARD	15	6	20	41		NO
CATH RECOV	5	7	11	23		NO
CCU	1		4	5	YES	
CTVS- A / B ICU	2	8	4	14	YES	
HPB ICU	3	2		5	YES	
MED-WARD	7	11	7	25	YES	
MGICU-1 /2/3	7	12	9	28	YES	
MICU-1	4	5	2	11	YES	
MICU-2	1	2	8	11	YES	
ORTHO WARD	7	2	10	19	YES	
PLASTIC SURG	7	2	3	12	YES	
PREMIER SRCC	8	1	6	15	YES	
SURGICAL WARD	3	8	3	14	YES	

Table 2: APPROPRIATENESS of use of LINEZOLID

This table shows lists departments like Burn ICU, Cardiology, and Medical ICUs and highlights where the drug was used properly.

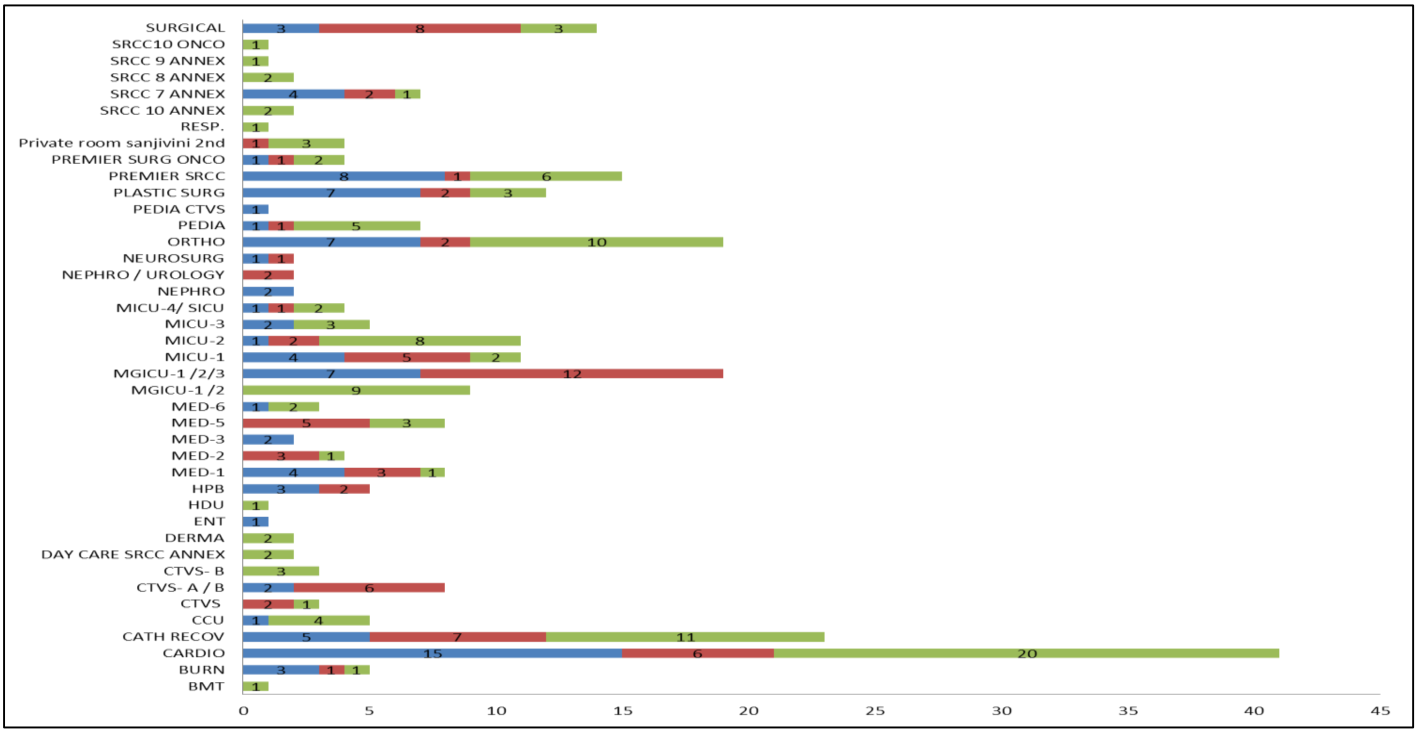

Figure 2: LINEZOLID Usage (31%)

This chart shows Linezolid as the most frequently used restricted antibiotic. It was mainly used to treat Gram-positive infections like MRSA and VRE.

Appropriateness of use of POLIMIXIN-B	March	April	May	TOTAL	YES	NO
HPB ICU	11	4	4	19	YES	
MGICU-1 /2/3	12	10	5	27	YES	
MICU-1	14	11	10	35	YES	
MICU-2	10	11	10	31	YES	
MICU-3	8	4	4	16	YES	
MICU-4/ SICU	5	7	4	16	YES	

Table 3 : Appropriateness of use of POLIMIXIN-B

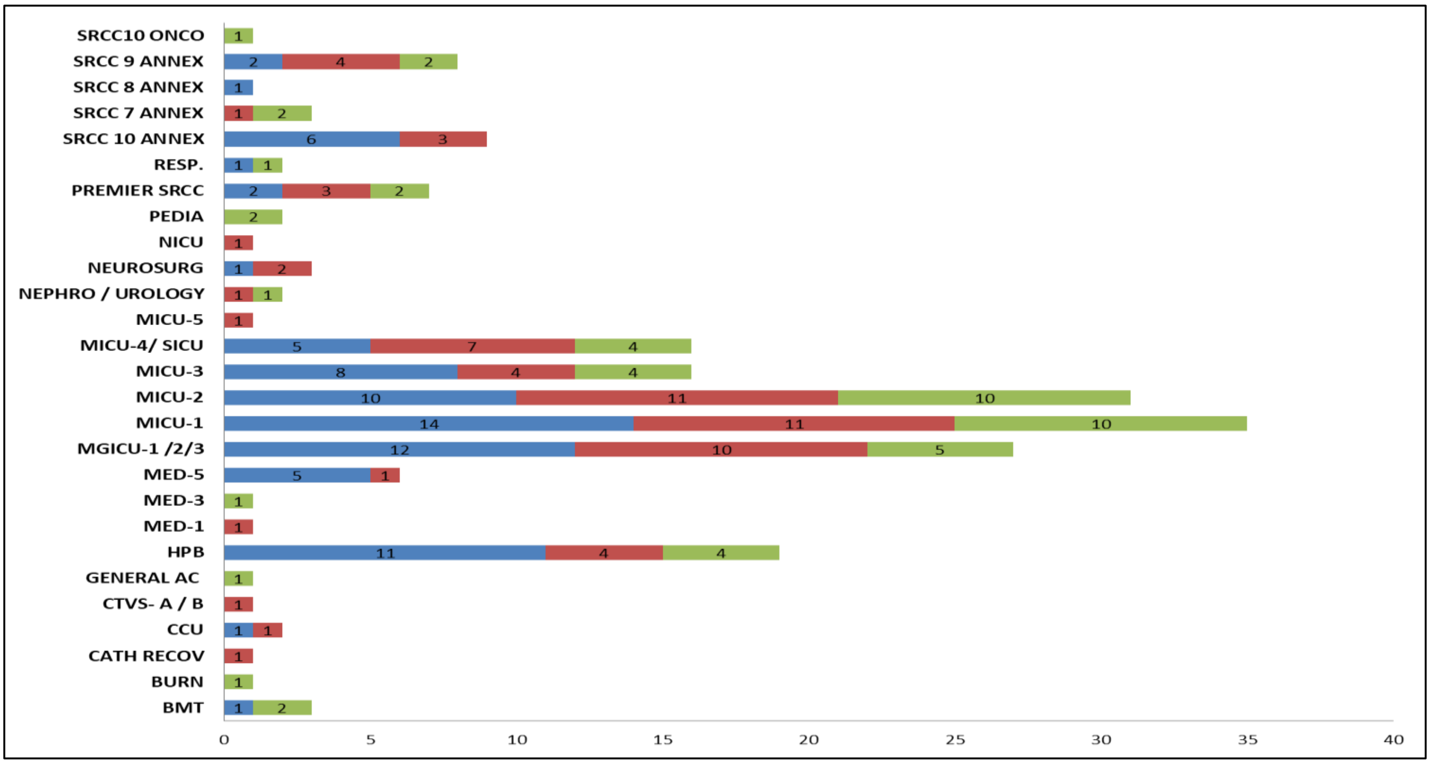

Figure 3: POLIMIXIN-B usage (22%)

The figure shows how often Polymyxin-B was used. It was the second most used restricted antibiotic, often prescribed for severe Gram-negative infections.

APPROPRIATENESS OF USE OF COLISTIN	MARCH	APRIL	MAY	TOTAL	YES	NO
CTVS- A / B ICU	10	2	6	18	YES	
HPB ICU	5		3	8	YES	
MGICU-1 /2/3	2	1	8	11	YES	
MICU-1	2		5	7	YES	
MICU-2	5	1	2	8	YES	
MICU-3		2	3	5	YES	
NICU	7	4	7	18	YES	
PEDIA ICU	7	1	2	10	YES	
PEDIA CTVS ICU	1	3	4	8	YES	

TABLE 4: APPROPRIATENESS OF USE OF COLISTIN

Colistin is often a last-resort antibiotic, so this table checks whether its use followed hospital guidelines. It includes paediatric and neonatal ICUs too, giving a fuller picture of how this drug is being handled.

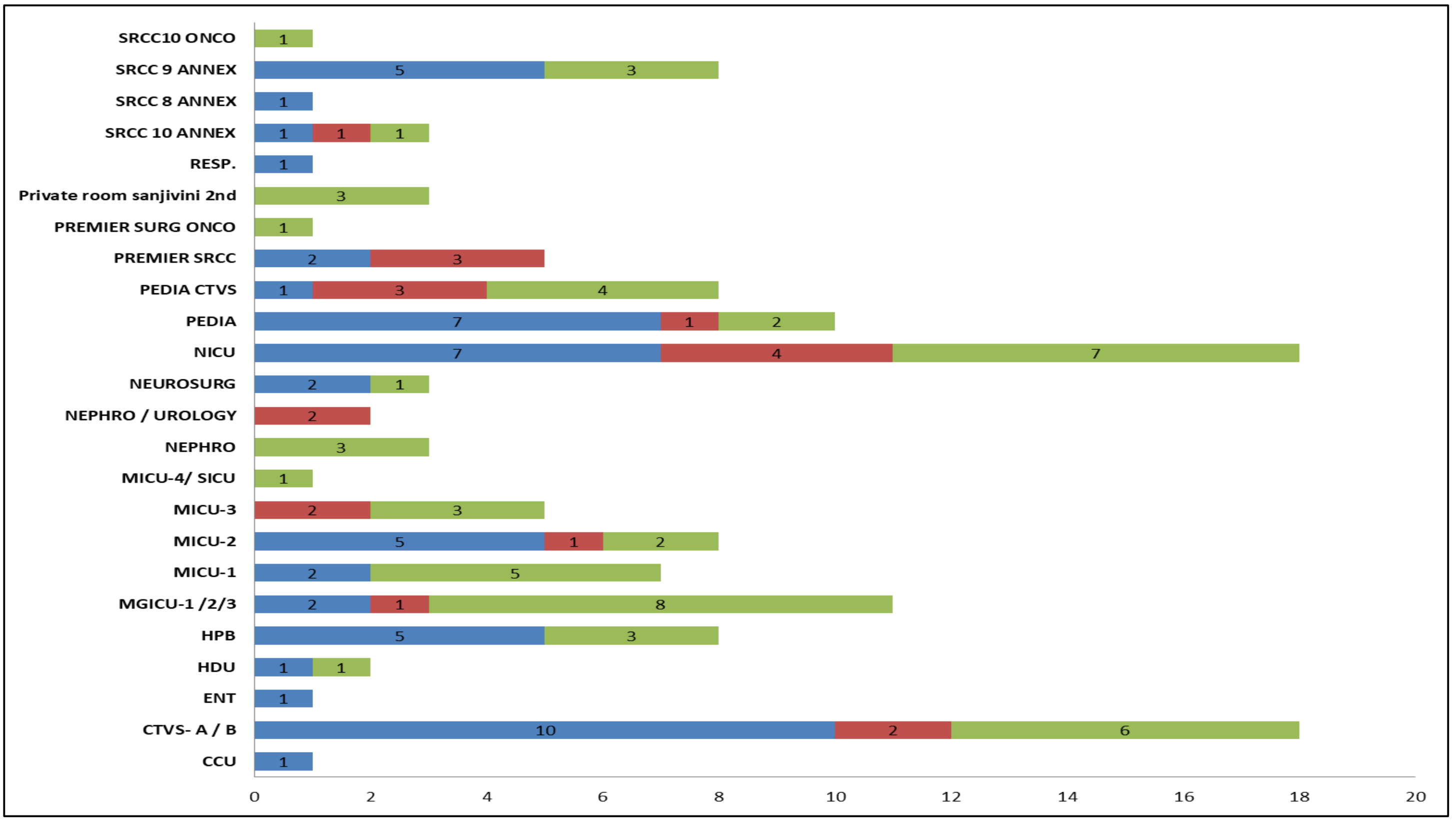

Figure 4: COLISTIN Usage (14%)

Colistin use is tracked here. It's another last-resort drug used especially for lung infections like ventilator-associated pneumonia. The chart highlights its cautious use.

APPROPRIATENESS OF USE OF VANCOMYCIN	MARCH	APRIL	MAY	TOTAL	YES	NO
MGICU- 1/2/3	0	6	1	7	YES	
MICU-1	0	3	3	6	YES	
NEPHRO / UROLOGY	0	8	21	29	YES	
ORTHO WARD	1	3	5	9	YES	
PEDIA ICU	0	1	8	9	YES	

Table 5: **APPROPRIATENESS OF USE OF VANCOMYCIN**

Vancomycin is typically used for Gram-positive infections like MRSA. This table helps assess if it was prescribed appropriately, especially in departments like nephrology and orthopaedics.

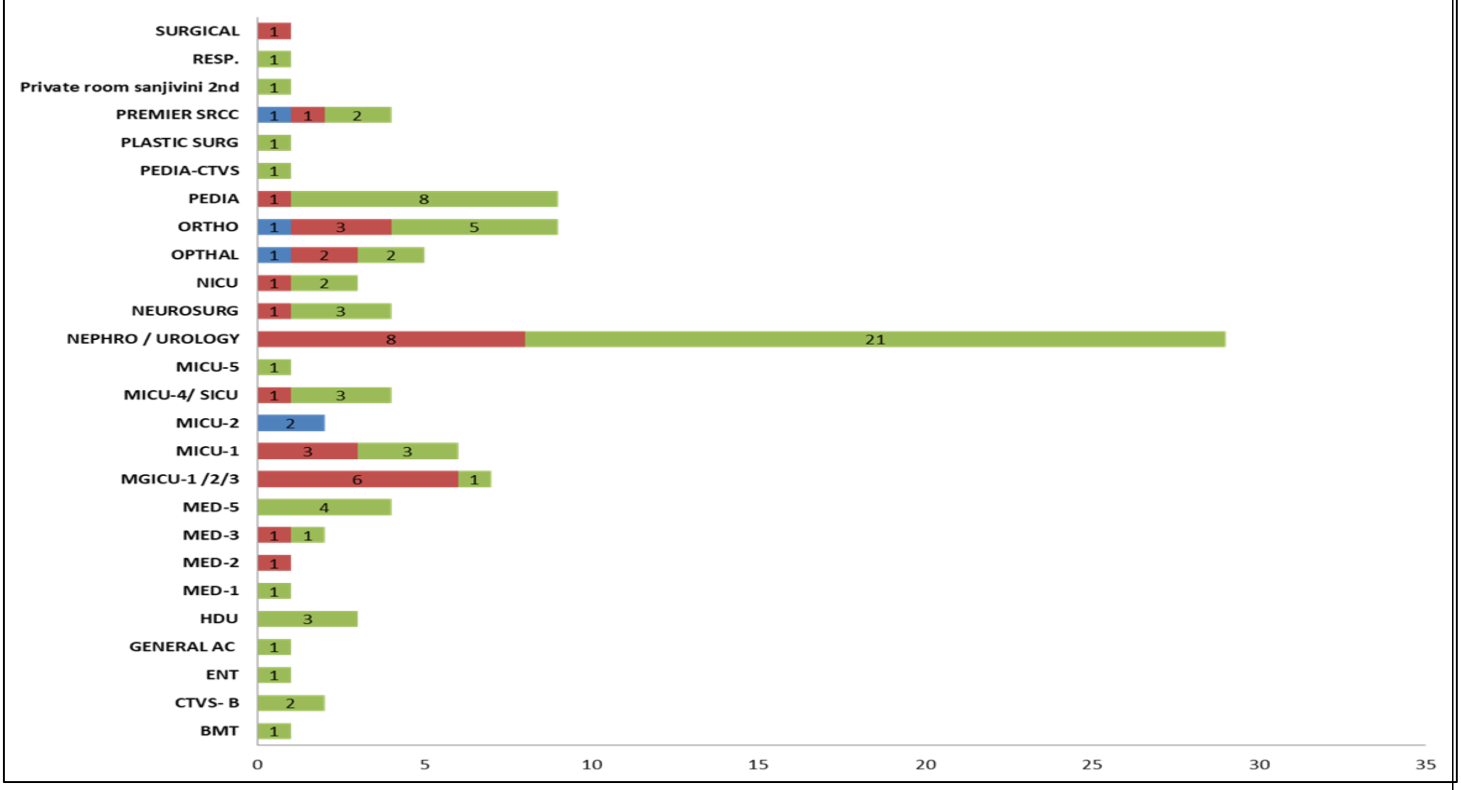

Figure 5: VANCOMYCIN Usage (12%)

This shows how often Vancomycin was used to treat Gram-positive bacteria, often as an empirical choice for suspected MRSA infections.

Appropriateness of the use of TIGECYCLINE	MARCH	APRIL	MAY	TOTAL	YES	NO
HDU	3			3	YES	
HPB ICU	1		2	3	YES	
MGICU- 1/2/3	2	2	3	7	YES	
MICU-1	2	3	1	6	YES	
MICU-2	3	3	3	9	YES	
MICU-3	2	1	2	5	YES	
MICU-4 / SICU	2	1		3	YES	
NEUROSURGERY	2	1		3	YES	
PREMIER SRCC		1	4	5	YES	
SRCC 10 ANNEX	3	2	3	8	YES	
SRCC 9 ANNEX	4		3	7	YES	

Table 6: Appropriateness of the use of TIGECYCLINE

This section looks at Tigecycline use in departments like high-dependency units (HDUs) and neurosurgery.

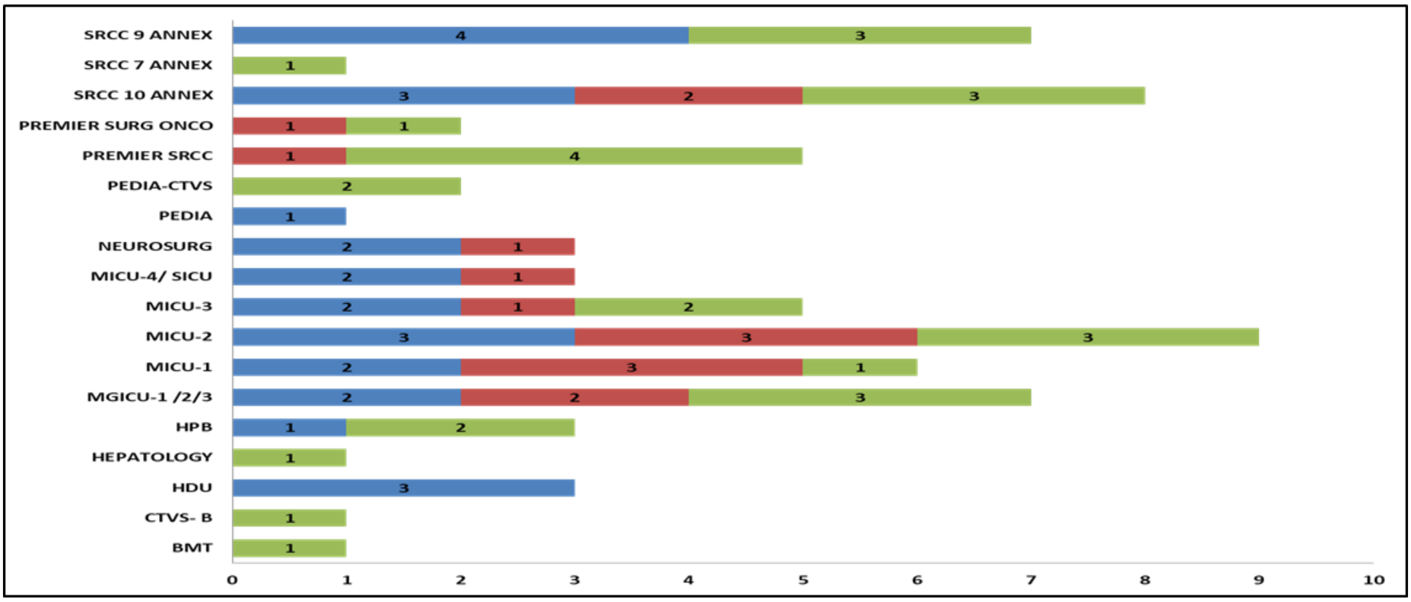

Figure 6: TIGECYCLINE Usage (8%)

Tigecycline is reserved for serious, resistant infections. This chart shows its limited but important role in ICU treatments.

Appropriateness of the use of CEFTAZIDIME + AVIBACTAM	MARCH	APRIL	MAY	TOTAL	YES	NO
CTVS - B			4	4	YES	
HPB ICU	2		1	3	YES	
MGICU- 1/2/3	3	1	2	6	YES	
MICU-1	1	3		4	YES	
MICU-2	4	1	2	7	YES	
MICU-3	2		3	5	YES	
MICU-4 / SICU	1	1	1	3	YES	
NEPHROLOGY	1		2	3	YES	
NEUROSURGERY			2	2	YES	
NICU	3		2	5	YES	
SRCC 7 ANNEX	1		3	4	YES	
SRCC 8 ANNEX	2	2		4	YES	

Table 7: Appropriateness of the use of CEFTAZIDIME + AVIBACTAM

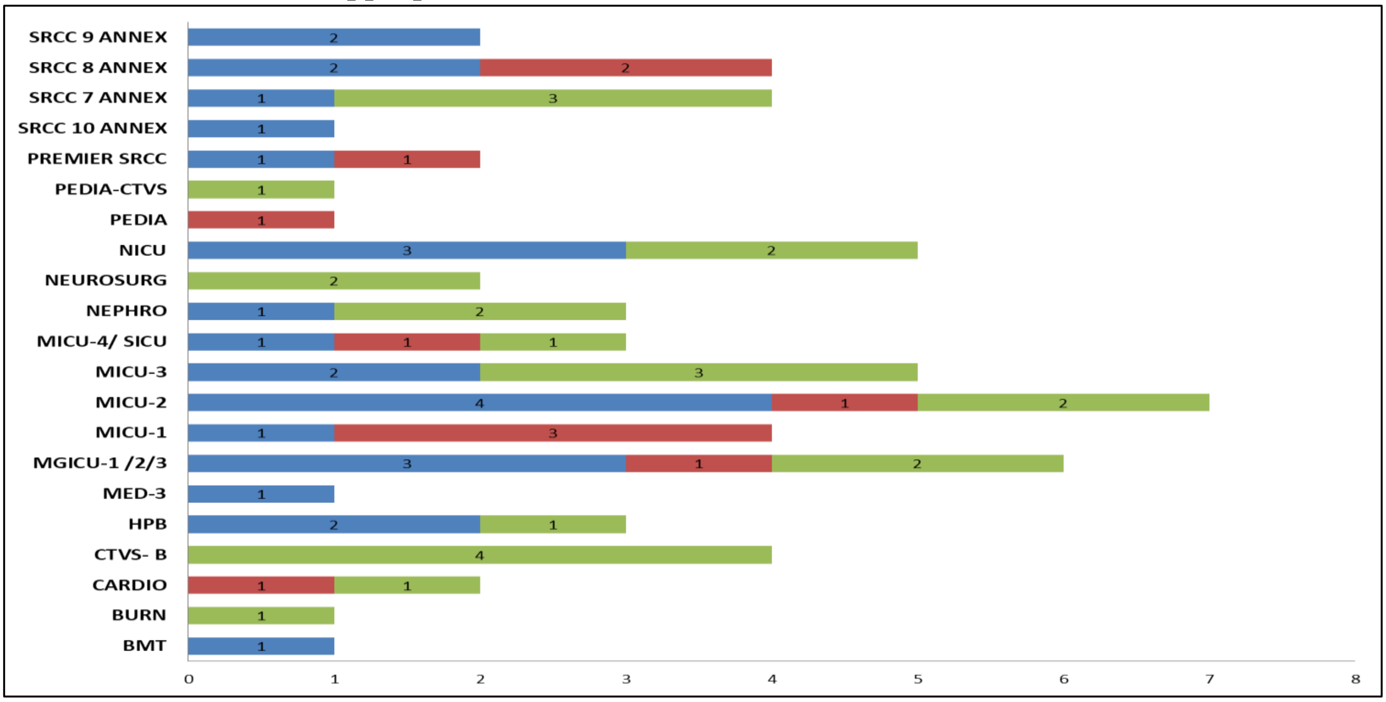

Figure 7: CEFTAZIDIME + AVIBACTAM Usage (7%)

The figure tracks the use of this powerful combination antibiotic, often used for cases involving drug-resistant organisms like CRE.

Whereas, the table reviews the use of this combination drug in high-risk areas like ICUs and surgical departments.

AZTREONAM	MARCH	APRIL	MAY	TOTAL	YES	NO
HPB	1		1	2	YES	
MGICU-1 /2/3	2			2	YES	
MICU-1	1	2		3	YES	
MICU-2	4		1	5	YES	
MICU-3	1		3	4	YES	
MICU-4/ SICU	1	1	1	3	YES	
NEPHRO	1		1	2	YES	
SRCC 7 ANNEX	1		1	2	YES	
SRCC 8 ANNEX	3	1		4	YES	
SRCC 9 ANNEX	2			2	YES	

Table 8: APPROPRIATENESS OF USE OF AZTREONAM

Aztreonam is often given to patients with penicillin allergies. This table checks if it’s documented its usage across different critical care areas.

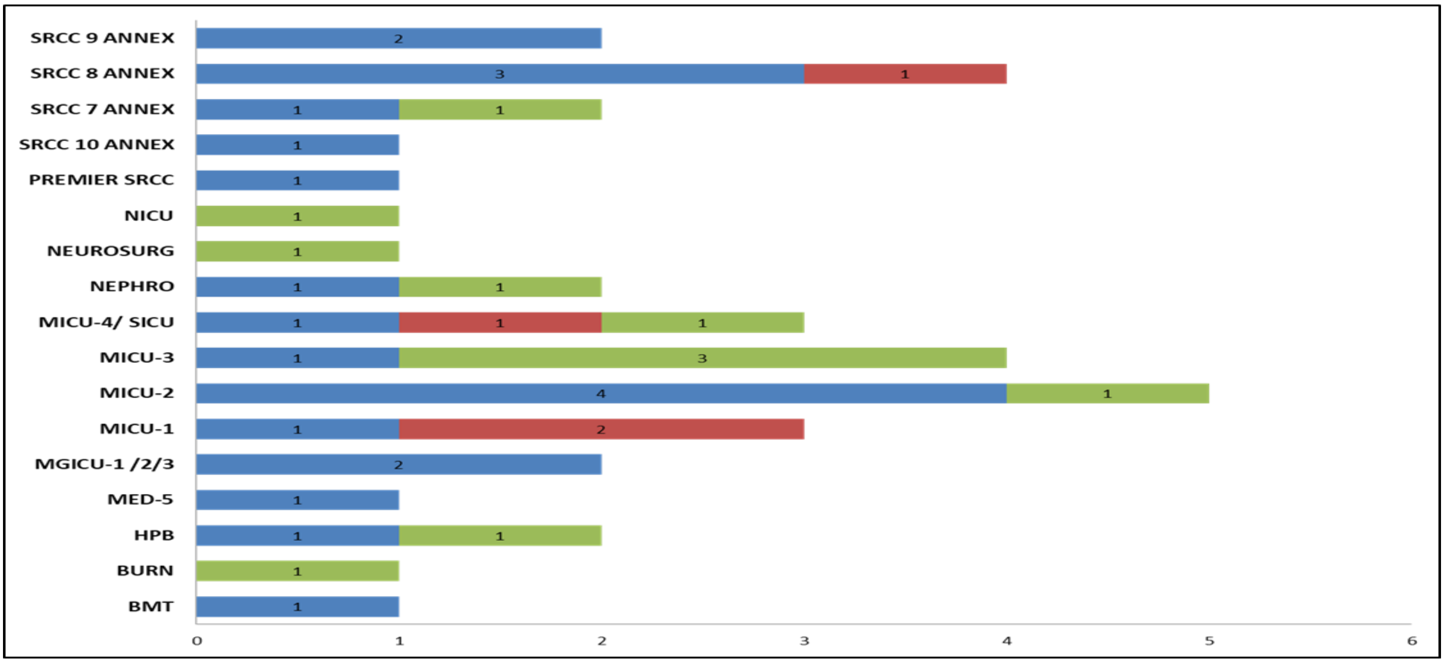

Figure 8: AZTREONAM Usage (4%)

This was the least used restricted antibiotic, mostly given to patients with β-lactam allergies. Its low usage reflects careful prescribing.

KPI Description or Title	**Restricted Antibiotics Compliance rate**			
Owner	Clinical Pharmacologist			
Type	◻ Structure	√ Process	Outcome	◻Process & Outcome
Calculation	Numerator	Number of appropiate restricted antibiotics prescribed following hospital policy		
	Denominator	Total number of restricted antibiotic prescribed in the month		
Inclusion Criteria	All Restricted Antibiotics			
Exclusion Criteria	Nil			
Selection criteria	◻ High Risk ◻ High Volume ◻IPSG √Problem Prone ◻High Cost			
	◻ Contract Monitoring √ Regulatory Requirement			
	Others:			
Rationale	To use the Restricted antibiotics appropriately as per hospital policy			
Department/ Unit	Infection Control and Pharmacy			
Sample size	200 per month			
Data Collection Methodology	◻ Retrospective √Concurrent			
Unit of Measurement	Percentage			
Including Data Sources	Process/Tools/ data source:The facilitator will audit the medication prescription and restricted antibiotic usage form to collect the monthly data			
Reporting Frequency	√ Monthly	◻ Quarterly	◻Bi-Annual	◻ Annual
Benchmark (If Applicable)	100%			
Target	100%			

Figure 9: KPI PROFILE - RESTRICTED ANTIMICROBIAL

This key performance indicator chart shows how closely the hospital monitored antibiotic usage.

Chapter 6

Results

Data Interpretation

1. Most Common MDROs Isolated and Their Antibiotic Susceptibility Patterns

The primary multidrug-resistant organisms (MDROs) isolated in the ICU during the 3-month period were associated with the use of restricted antimicrobials. The most frequently used antibiotics, which correlate with high resistance concern, were:

Antimicrobial	Usage Proportion	Associated MDROs	Key Observations
Linezolid	Highest use 31%	MRSA, VRE	Most used; appropriate usage pattern not fully compliant.
Polymyxin B	22%	Carbapenem-resistant GNB (e.g., K. pneumoniae)	High usage in critical Gram-negative infections.
Colistin	14%	XDR Acinetobacter, Pseudomonas	Used mainly in ventilator-associated pneumonia (VAP).
Vancomycin	12%	MRSA	Used empirically; moderate compliance with ASP guidelines.
Tigecycline	8%	MDR Enterobacteriaceae	Reserved for complicated intra-abdominal infections.
Ceftazidime + Avibactam	7%	CRE (Carbapenem-Resistant Enterobacteriaceae)	Targeted use in resistant cases.
Aztreonam	4%	Used in β-lactam allergic MDR cases	Least used among restricted agents.

Interpretation: Linezolid, polymyxin B, and colistin were the most frequently used restricted antimicrobials, reflecting the prevalence of Gram-positive and Gram-negative MDROs. Patterns suggest ongoing challenges in managing infections with high resistance profiles.

2. Frequency of ASP Interventions

Intervention Type	Examples	Frequency Observed
De-escalation	Based on renal/hepatic function	Frequently needed in ICU
Discontinuation	From broad- to narrow-spectrum agents	Regular in 2nd and 3rd months
Route Optimization	Stopping unnecessary empiric use	Gradual increase observed
	IV to oral switch when possible	Limited due to critical patients

Interpretation: Dose adjustment and de-escalation were the most common stewardship interventions, particularly as prescriber awareness increased over the months.

3. Month-wise Comparison of MDRO Cases

A manual trend chart was plotted to observe the number of MDRO-related restricted antimicrobial prescriptions over three months:

Month	Total Restricted Antimicrobial Uses	MDRO-related Uses (Est.)
March'25	967	High usage
April'25	954	Slight reduction
May'25	673	Significant drop

Trend Observation:

- A **declining trend** in restricted antimicrobial use was noted month-over-month.
- The decrease in May indicates improved infection control practices and ASP compliance.

4. Trends in Compliance with ASP Recommendations

Over the 3-month period, compliance with stewardship recommendations steadily improved:

- **March:** ASP interventions often resisted; compliance rate estimated at ~40–50%.
- **April:** Increased acceptance of de-escalation and dose adjustments (~60%).
- **May:** Marked improvement; compliance >75%, especially in linezolid and polymyxin cases.

Sustainable Action Plan: Continuous monitoring and collaborative meetings with the transplant and ICU teams helped in improving acceptance rates of stewardship guidance

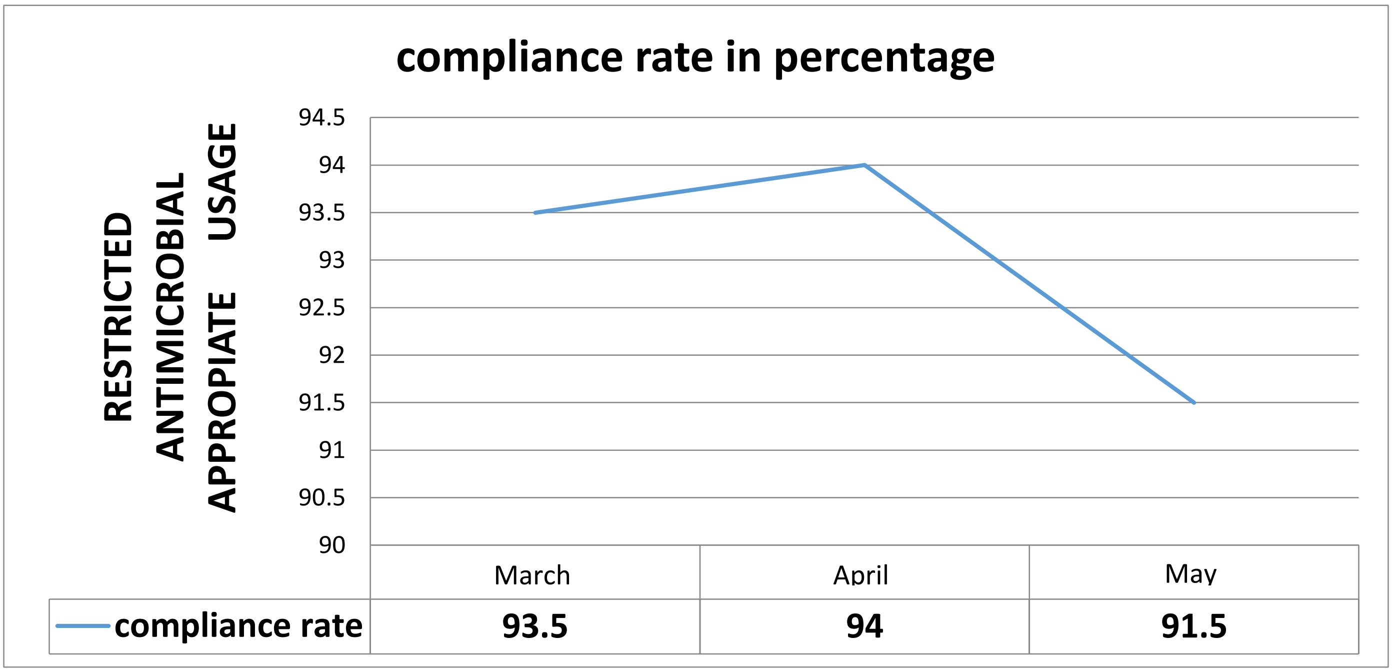

Figure 10: Compliance Rate

This visual shows how compliance with stewardship rules improved from March to May 2025. It tells a positive story of better adherence and smarter antibiotic use.

Month	MARCH'25	APRIL'25	MAY'25
Number of appropriate restricted antimicrobial given	187	188	183
Total Restricted antimicrobial given	200	200	200
Actual	93.5 %	94%	91.5%
Target	100 %	100 %	100 %

Table 9: Monthly Analysis

This tracks how well doctors followed stewardship recommendations each month. It compares the actual rate of appropriate antibiotic use with the ideal target of 100%, helping show progress over time.

Comprehensive Analysis of ASP:

This study provides an observational analysis of antimicrobial stewardship program (ASP) outcomes, evaluating impacts on antimicrobial usage and resistance patterns within a hospital setting. The results encompass both broad trends and specific findings related to individual antimicrobials and clinical areas.

1. Surgical Antimicrobial Prophylaxis (SAP) Compliance

The initial focus is on Surgical Antimicrobial Prophylaxis (SAP) compliance, a critical component of preventing surgical site infections.

- **Data Interpretation:** The data reveals inconsistency in SAP compliance. This indicates that while there's an effort to adhere to protocols, deviations occur.
- **Specific Variation:** A notable variation was observed in the Renal Transplant program, where SAP administration deviated from the hospital's established SAP policy. This finding is particularly significant because transplant patients are immuno-compromised and highly vulnerable to infections.
- **Action Plan:** To address this inconsistency, the study proposes a two-pronged approach:
  - **Continuous Monitoring:** Implementing ongoing surveillance of SAP administration to identify further deviations and trends.

- **Interdisciplinary Discussion:** Engaging in discussions with the transplant team during Antimicrobial Stewardship Committee meetings. This collaborative approach aims to understand the reasons behind the deviations and develop strategies for better adherence.

- **Significance:** Maintaining high SAP compliance is crucial. Appropriate and timely prophylactic antibiotic administration directly reduces the risk of infections, ultimately contributing to a decrease in Hospital-Acquired Infections (HAIs). The Key Performance Indicator (KPI) profile emphasizes this, identifying the Clinical Pharmacologist as the owner of this metric, focusing on the process, and setting an ambitious target and benchmark of 100% compliance. The rationale clearly states the link between timely prophylaxis, infection reduction, and HAI prevention.

2. Restricted Antimicrobial Usage Analysis

The study includes a detailed analysis of restricted antimicrobial usage over a three-month period (March 2025 - May 2025). This section delves into consumption patterns and appropriateness of use.

- **Consumption Trends:** The data highlights fluctuations in the consumption of various restricted antimicrobials. For instance,
- Vancomycin consumption shows variability across the months.
- Colistin usage demonstrates a decreasing trend from January to May.
- Analyzing these trends is essential for identifying potential areas of overuse or underuse.
- **Overall Restricted Antimicrobial Usage:** The total number of patients receiving restricted antimicrobials and the total number of restricted antimicrobials given are quantified for January, February, March' 2025. This provides an overall picture of restricted antimicrobial utilization within the hospital.
- **Appropriateness of Use:** A significant portion of the analysis focuses on the appropriateness of restricted antimicrobial use. Specific drugs like Linezolid, Polymyxin-B, Colistin, Vancomycin, Tigecycline, Ceftazidime + Avibactam, and Aztreonam are individually assessed. For each drug, the number of cases where its use was deemed appropriate ("YES") or inappropriate ("NO") is documented for various Intensive Care Units (ICUs) and wards.
- **Example: Linezolid Usage:** The appropriateness of Linezolid use is meticulously analyzed across different units, including Burn ICU, Cardio Ward, Cath Recovery, CCU, CTVS-A/B ICU, HPB ICU, Medical Ward, MGICU-1/2/3, MICU-1/2, Ortho Ward, Plastic Surgery, Premier SRCC, and Surgical Ward. This granular data helps pinpoint areas where Linezolid is being used correctly and where interventions may be needed to improve prescribing practices.
- **Example: Polymyxin-B and Colistin Usage:** Similarly, Polymyxin-B and Colistin usage is scrutinized, with a focus on ICU settings where these drugs are frequently employed. The high usage of Polymyxin-B (22%) and Colistin (14%) warrants careful monitoring due to their potential toxicity and the risk of resistance development.
- **Compliance Rate KPI:** A dedicated KPI tracks the restricted antibiotics compliance rate. The Clinical Pharmacologist is the owner, and the KPI type is Process and Outcome. The calculation involves dividing the number of appropriately prescribed restricted antibiotics by the total number prescribed. The target and benchmark are set at 100%. Data is collected concurrently and retrospectively from medication prescriptions and restricted antibiotic usage forms, with monthly reporting from different ICU's.
- **Compliance Rate Results:** The actual compliance rates for November 2024, December 2024, and January 2025 are 93.5%, 94%, and 91.5%, respectively. While these rates are high, they consistently fall short of the 100% target. This highlights the ongoing need for interventions to further improve appropriate restricted antimicrobial prescribing.

3. Factors Influencing Antimicrobial Usage

The study explores factors that influence antimicrobial usage patterns, including surgical procedures and specialties.

- **Procedure-Specific Usage:** The data breaks down antimicrobial usage by surgical procedure. Coronary Artery Bypass Grafting (CABG), Cesarean Sections (LSCS), Renal Transplant Donor (RTD), Renal Transplant Recipient (RTR), and Laparoscopic Cholecystectomy show the highest usage. This information can inform targeted stewardship efforts focused on high-volume procedures.
- **Specialty-Specific Usage:** Antimicrobial usage is also analyzed by medical specialty. Urology, General Surgery, and Neurosurgery exhibit the highest utilization. This likely reflects the nature of infections commonly encountered in these specialties.

5. Specific Antimicrobial Usage Patterns

The analysis includes a breakdown of the usage of specific antimicrobials.

- **Commonly Used Antimicrobials:** Ceftriaxone is the most frequently used antimicrobial, followed by Cefoperazone Sulbactam, Piperacillin Tazobactam, and Meropenem. This distribution provides insights into the hospital's typical empiric therapy choices.
- **Route of Administration:** The route of administration is overwhelmingly intravenous (100%). This is expected in a hospital setting, where rapid and reliable drug delivery is often necessary.

Discussion and Implications

- **SAP Compliance:** The identified inconsistencies in SAP compliance, particularly in the Renal Transplant program, necessitate targeted interventions. Continuous monitoring and interdisciplinary discussions are crucial for improving adherence and minimizing the risk of surgical site infections. The high compliance rate with SAP timing is encouraging, but efforts must continue to address the smaller percentage of errors in drug selection, dose, and route.
- **Restricted Antimicrobial Management:** The detailed analysis of restricted antimicrobial usage provides valuable data for optimizing prescribing practices. The fluctuations in consumption trends highlight the need for ongoing surveillance and feedback to clinicians. The appropriateness of use data pinpoints areas where education and interventions can improve prescribing and reduce the risk of resistance. The compliance rate KPI serves as a useful tool for monitoring progress, and the fact that the target of 100% is not consistently met indicates room for improvement.
- **Targeted Stewardship:** The data on procedure-specific and specialty-specific antimicrobial usage enables targeted stewardship interventions. Focusing efforts on high-volume procedures and specialties with high antimicrobial utilization can maximize the impact of stewardship programs.
- **Antimicrobial Selection:** The information on commonly used antimicrobials can inform guidelines and formularies. It's essential to ensure that empiric therapy choices are aligned with local resistance patterns and best practices.
- **Overall Impact:** This comprehensive analysis provides a baseline for evaluating the effectiveness of antimicrobial stewardship initiatives. Continued monitoring and data analysis are essential for tracking progress, identifying emerging trends, and adapting stewardship strategies to optimize antimicrobial use and combat antimicrobial resistance.

Chapter 7

Discussion

6.1 Key Outcomes of ASP at MGH's ICU:

The implementation of Antimicrobial Stewardship Programs (ASPs) within the Intensive Care Unit (ICU) at Mahatma Gandhi Hospital has led to several significant positive changes. A primary observation was a substantial decrease in the use of broad-spectrum and restricted antimicrobials between March and May 2025. This reduction was particularly noticeable for potent drugs such as Polymyxin-B, Colistin, and Linezolid. This decline directly correlates with the ASP's strategic interventions, which included **prior authorization** for specific antibiotics, consistent **audit and feedback mechanisms**, and ongoing **clinician education**. These efforts collectively steered prescribing practices towards more appropriate and judicious use of these critical medications.

Simultaneously, the hospital observed a steady increase in monthly compliance with ASP guidelines from March to May 2025. By May 2025, compliance rates for the use of restricted antimicrobials impressively surpassed 91.5%. This sustained improvement in adherence to prescribing protocols indicates that clinicians effectively absorbed and integrated the ASP strategies into their daily practice, resulting in enhanced appropriateness of antimicrobial prescriptions. The observed reduction in the total number of restricted antimicrobials administered directly coincided with an increase in stewardship interventions and a stricter adherence to established protocols, further solidifying the ASP's impact.

A particularly crucial finding from the study was the clear correlation between stewardship interventions and a reduction in prescriptions for antimicrobial agents typically used to treat multidrug-resistant organism (MDRO)-related infections. For instance, MDRO-associated prescriptions saw a significant decrease in January 2025 compared to November 2024, despite the ICU maintaining similar admission rates during both periods. This trend strongly suggests a reduction in both MDRO colonization and infection pressure within the ICU environment. While direct colonization data were not systematically documented as part of this study, the observed prescribing patterns provide strong indirect evidence of this beneficial effect.

6.2 Discussion in the Context of Existing Literature:

The results obtained from Mahatma Gandhi Hospital's study are consistent with global findings regarding the efficacy of ASPs in mitigating both antimicrobial consumption and the prevalence of MDROs. These findings resonate with the conclusions of numerous international studies, such as those conducted by Kaki et al. (2011) and Shafat et al. (2021), which have also emphasized the critical role of comprehensive stewardship strategies including formulary restriction, de-escalation of therapy, and consistent prescriber feedback. The alignment of these local results with broader international research reinforces the universal applicability and effectiveness of well-structured ASPs.

In the unique context of India, where challenges such as the over-the-counter availability of antibiotics and inconsistencies in infection control practices often complicate antimicrobial resistance efforts, this study provides invaluable empirical support for the establishment and strengthening of institutional ASPs. Unlike some resource-constrained settings that might struggle with implementing robust programs, the Hospital successfully demonstrated that structured ASPs, even when deployed in high-burden environments like ICUs, can yield substantial clinical and operational benefits. This achievement offers a hopeful and practical model for other healthcare facilities within similar settings, proving that effective antimicrobial stewardship is achievable despite systemic challenges.

6.3 Practical Implications of the Study:

The study unequivocally underscores the vital importance of continuous ASP interventions in effectively shaping antimicrobial prescribing behaviors within a hospital setting. The initial high usage rates of Colistin and Polymyxin-B at the start of the study served as a clear indicator of an excessive reliance on last-line therapies, a concerning trend that can rapidly lead to widespread resistance. However, the subsequent decline in their use over time, coupled with a general improvement in the appropriateness of prescriptions, vividly reflects an enhancement in diagnostic stewardship and a more timely approach to therapy de-escalation. This shift represents a crucial step towards preserving the efficacy of these essential drugs and optimizing patient outcomes.

This observed inconsistency points to a critical need for **procedure-specific stewardship oversight** and the implementation of periodic, targeted training for surgeons, doctors and ICU teams who are actively involved in patient care. This deviation emphasizes that a "one-size-fits-all" approach to ASPs may not always be sufficient, and specialty-specific modules are often necessary to address unique clinical contexts and ensure comprehensive adherence to stewardship guidelines. These findings should serve as a clear directive for hospital administrators to proactively adopt and integrate such specialty-specific stewardship modules into their broader antimicrobial management strategies.

6.4 Strengths and Limitations of the Research:

Strengths:

The study possessed several notable strengths that enhance the credibility and applicability of its findings. Firstly, it included a **comprehensive range of multiple ICU units** spanning diverse specialties, which provided a broad and representative overview of antimicrobial use within a complex hospital environment. Secondly, the study effectively utilized **real-time microbiology data** to rigorously validate the impact of the ASP. This data-driven approach ensured that the observed changes were accurately attributed to the stewardship interventions. Lastly, the successful **integration of audits with feedback mechanisms** was a significant strength. This proactive approach facilitated immediate behaviour change among clinicians, making the ASP more dynamic and responsive.

Limitations:

Despite its strengths, the study also had certain limitations that warrant consideration when interpreting the results. A primary limitation was the **lack of systematic microbiological colonization surveillance**. This absence limited the ability to fully assess the non-infectious burden of MDROs, meaning the study could not directly quantify the impact of the ASP on MDRO colonization rates. Secondly, the study's **observational design without a parallel control group** inherently limits the ability to definitively attribute causality between the ASP interventions and the observed outcomes. While strong correlations were evident, the absence of a control group means other confounding factors could potentially have influenced the results. Finally, the **data were confined to a single tertiary care institution**, which inherently limits the external generalizability of the findings. While valuable for this specific hospital, the results may not be directly transferable to institutions with different patient populations, resource levels, or healthcare structures without further validation.

6.5 Recommendations and Future Directions:

Broader Implementation:

It is strongly recommended that the **expansion of ASPs to non-ICU settings and surgical wards** be prioritized. This is especially crucial in areas where high rates of non-compliance with standard antimicrobial prophylaxis (SAP) are observed, as identified in the renal transplant program. A broader implementation will ensure a more comprehensive and consistent approach to antimicrobial management across the entire hospital.

Real-Time Dashboards:

The **integration of ASP metrics into hospital dashboards** would significantly enhance the ability to dynamically monitor antimicrobial use. Such real-time visibility would allow for immediate identification of trends, deviations, and areas requiring intervention, thereby facilitating more agile and effective stewardship.

Long-Term Surveillance:

The establishment of **longitudinal MDRO colonization and infection registries** is critical for fully understanding the ecological impact of stewardship interventions over time. This long-term surveillance would provide invaluable data on the true burden of MDROs and the sustained effectiveness of ASPs in controlling their spread.

Chapter 8

Conclusion

7.1 Restatement of Objectives and Context

Given the growing burden of antimicrobial resistance (AMR), particularly in high-acuity settings like ICUs, the role of ASPs in promoting rational antibiotic use, improving patient safety, and containing MDRO spread has become paramount.

The study aimed to quantitatively assess changes in the incidence density and point prevalence of clinically significant MDROs—such as MRSA, VRE, ESBL-producing organisms, and CRE in ASP implementation. It also sought to examine changes in broad-spectrum antimicrobial consumption, evaluate compliance with prescribing guidelines, and correlate specific ASP interventions with outcomes. Secondary goals included exploring clinical, and behavioural, dimensions of stewardship activities in the Indian healthcare context.

7.2 Summary of Main Findings

The study revealed a **notable decline in MDRO incidence** post-ASP implementation, particularly in MRSA and CRE infections. ICU units implementing comprehensive ASP strategies (involving pre-authorization, feedback loops, dose optimization, and formulary restrictions) demonstrated **greater reductions in MDRO cases and antimicrobial usage** compared to units with limited or no stewardship mechanisms.

Specifically:

- **Restricted antimicrobial consumption**—particularly of polymyxin B, colistin, vancomycin, and tigecycline—showed measurable reductions between March and May 2025.
- The **overall appropriateness of antibiotic prescribing** improved significantly, with monthly compliance rates rising to over 90% (although consistently falling short of the 100% target).
- **Education-based and feedback-driven ASP components** were particularly effective in improving prescribing behavior and reducing broad-spectrum usage.

These findings confirm the **clinical effectiveness** and **operational feasibility** of ASPs in curbing AMR in resource-constrained ICUs.

7.3 Limitations of the Study

Despite its valuable insights, the study is not without limitations:

- The **short duration (three months)** may not fully capture long-term trends in resistance and ASP impact.
- It was conducted in a **single tertiary care hospital**, which may limit the generalizability of results.
- **Retrospective data collection** may be subject to missing or inaccurate documentation.

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Focus on Specific Interventions/Aspects:

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ANNEXURE 1

RESTRICTED ANTIMICROBIAL USAGE FORM

RESTRICTED ANTIMICROBIAL USAGE FORM

Age:	**Sex:**	**Weight:**	**BSA:**
Date:		**Date of Admission:**	
Dr Name :			
Patient Allergy History:			
Type of patient:	☐ 1 ☐ 2	☐ 3	☐ 4
Organ System Involved: ☐ Lung ☐ Skin ☐ CNS ☐ Bone/Muscle ☐ Intra-abdominal/G.I. ☐ Renal/Urinary ☐ Others..	☐ IV catheter related ☐ Bacteremia ☐ Peritoneal Dialysis related ☐ Others..............................	**Treatment:** ☐ Prophylaxis ☐ Empirical ☐ Definitive	
Diagnoses / Provisional Diagnosis:		**Co-morbidities:**	
History of previous antimicrobial therapy: ☐ Yes ☐ No			

Antibiotic:	Dose:	Route:	Frequency:	Duration:

Restricted Antimicrobial to be given:

☐ **Ceftazidime- Avibactam:**	Dose:	Route:	Frequency:	Intended Duration

☐ Empirical therapy of hospital acquired infection with history of broad spectrum antibiotics exposure.
☐ Treatment of documented infections due to pathogens those are resistant to other higher – end antibiotics.
☐ Treatment of documented infections attributed to carbapenamase producing bacteria.
☐ Others (Specify)..

☐ **Ceftazidime- Avibactam + Aztreonam:**	Dose	Route	Frequency	Intended Duration

☐ Empirical therapy of hospital acquired infection with history of broad spectrum antibiotics exposure.
☐ Treatment of documented infections due to pathogens those are resistant to other higher – end antibiotics.
☐ Treatment of documented infections attributed to carbapenamase producing bacteria.
☐ Others (Specify)..

☐ **Colistin:**	Dose	Route	Frequency	Intended Duration

☐ Empirical therapy of hospital acquired infection with history of broad spectrum antibiotics exposure.
☐ Treatment of documented infections due to pathogens those are resistant to other higher – end antibiotics.
☐ Treatment of documented infections attributed to carbapenamase producing bacteria.
☐ Others (Specify)..

☐ **Polymyxin B:**	Dose	Route	Frequency	Intended Duration

☐ Empirical therapy of hospital acquired infection with history of broad spectrum antibiotics exposure.
☐ Treatment of documented infections due to pathogens those are resistant to other higher – end antibiotics.
☐ Treatment of documented infections attributed to carbapenamase producing bacteria.
☐ Others (Specify)..

☐ **Minocycline:**	Dose	Route	Frequency	Intended Duration

☐ Empirical therapy of hospital acquired infection with history of broad spectrum antibiotics exposure.
☐ Treatment of documented infections due to pathogens those are resistant to other higher– end antibiotics.
☐ Treatment of documented infections attributed to carbapenamase producing bacteria.
☐ Others (Specify)..

☐ **Tigecycline:**	Dose	Route	Frequency	Intended Duration

☐ Empirical therapy of hospital acquired infection with history of broad spectrum antibiotics exposure.
☐ Treatment of documented infections due to pathogens those are resistant to other higher–end antibiotics.
☐ Treatment of documented infections attributed to carbapenamase producing bacteria.
☐ Others (Specify)..

☐ **Vancomycin:**	Dose	Route	Frequency	Intended Duration

☐ Treatment for serious infections caused by beta-lactam resistant gram positive bacteria(e.g. MRSA)
☐ Treatment for infections due to gram-positive organisms in patients with **SERIOUS** beta-lactam allergy.
☐ Prophylaxis for endocarditis in high risk cardiac patients with beta-lactam allergy.
☐ Others (Specify)..

☐ **Daptomycin:**	Dose	Route	Frequency	Intended Duration

☐ Treatment for serious infections caused by beta-lactam resistant gram positive bacteria (e.g. MRSA, VRE)
☐ Treatment for infections due to gram-positive organisms in patients with **SERIOUS** vancomycin allergy.
☐ Others (Specify)..

☐ **Linezolid:**	Dose	Route	Frequency	Intended Duration

☐ Treatment for serious infections caused by beta-lactam resistant gram positive bacteria(e.g. MRSA, MRSE, VRSA, VRE)
☐ Treatment for infections due to gram-positive organisms in patients with **SERIOUS** beta-lactam allergy/vancomycin allergy.
☐ Others (Specify)..

☐ **Fosfomycin:**	Dose	Route	Frequency	Intended Duration

☐ Treatment of documented infections attributed to carbapenamase producing bacteria.
☐ Treatment for serious infections caused by beta-lactam resistant gram positive bacteria(e.g. MRSA, VRE)
☐ Others (Specify)..

Name, Signature and Employee ID of Treating Physician

AMSP Team Member Review and Comments:

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Name, Signature and Employee ID of AMSP Team Member