INDIAN COUNCIL OF MEDICAL RESEARCH

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NATIONAL INSTITUTE FOR RESEARCH IN BACTERIAL INFECTIONS

TECHNICAL REPORT ON TIER SPECIFIC CUSTOMIZATION OF ANTIMICROBIAL STEWARDSHIP PROGRAMME

- A FRAMEWORK DOCUMENT FOR IMPLEMENTATION

TECHNICAL REPORT

Antimicrobial Resistance Research and Evidence Synthesis for Stewardship Implementation and Surveillance Program Development Framework Assessment (AMRES Project)

सत्यमेव जयते

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Foreword

The global threat of antimicrobial resistance (AMR) is a defining challenge for modern medicine, undermining the efficacy of essential treatments and stalling progress across disciplines in health care. In India, the convergence of a high infectious disease burden and a surge in drug-resistant pathogens has created a public health emergency. Addressing this requires more than just clinical intervention; it demands a systematic approach.

The Indian Council of Medical Research (ICMR) has been at the forefront of efforts to address AMR through the establishment of the Antimicrobial Resistance Surveillance and Research Network (AMRSN), the development of stewardship guidelines, diagnostics and therapeutics. The AMRES (Antimicrobial Resistance Research and Evidence Synthesis for Stewardship Implementation and Surveillance Program Development Framework Assessment) project is a vital addition to these national initiatives.

This report provides a comprehensive situational analysis of antimicrobial stewardship (AMS) readiness across the various tiers of India's public health infrastructure. By evaluating the real-world capacity for monitoring antimicrobial use, analysing clinical prescription patterns, and assessing infection control protocols across primary, secondary, and tertiary care, it identifies critical gaps and scalable opportunities for improvement.

I extend my sincere commendation to the ICMR-National Institute for Research in Bacterial Infections (NIRBI) for their rigorous dedication to this vital activity. It is my hope that these findings will serve as a strategic foundation for data-driven policy decisions and inspire the development of operational stewardship models specifically tailored for resource-limited settings.

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PREFACE

Antimicrobial resistance (AMR) poses a formidable challenge to modern medicine and public health globally, threatening the effectiveness of life-saving antibiotics and jeopardizing decades of progress in infection control, surgery, cancer care, maternal and neonatal health. In India, where the burden of infectious diseases is already high, the rapid escalation of drug-resistant pathogens demands a systematic, evidence-informed, and multisectoral response.

ICMR - National Institute for Research in Bacterial Infections has been at the forefront of efforts to address AMR through the establishment of a National AMR Hub, that will promote research on newer diagnostics and therapeutics, rational antibiotic use and stewardship. The AMRES (Antimicrobial Resistance Research and Evidence Synthesis for Stewardship Implementation and Surveillance Program Development Framework Assessment) project is a vital addition to these initiatives.

This report presents a detailed situational analysis of readiness for antimicrobial stewardship across various tiers of India's public health system. By examining real-world capacity for antimicrobial use monitoring, prescription practices, and infection control mechanisms across tertiary, secondary, and primary care settings, it offers actionable insights into gaps and opportunities that must be addressed to strengthen stewardship.

I commend the entire team of AMRES Project and all participating institutions for their dedicated efforts in executing this important work. I take this opportunity to express my sincere gratitude to the Department of Health & Family Welfare, Govt. of West Bengal for their continued support and contribution. I hope this report will inform policy decisions, inspire operational antimicrobial stewardship models tailored to resource-limited settings, and ultimately contribute to building a more resilient health system capable of effectively responding to AMR.

Dated: 23rd March, 2026

(Santasabuj Das)
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MESSAGE

Dr. Dipankar Maji, Director, Hospital Administration& Planning,Department of Health & Family Welfare, Government of West Bengal

Antimicrobial resistance (AMR) is no longer a distant theoretical threat; it is a direct challenge to the operational integrity of modern medicine. We recognized that the erosion of antibiotic efficacy jeopardizes our most critical service lines—from surgical operations and intensive care facilitiesto maternal and neonatal care. Addressing this requires more than just clinical awareness; it demands a robust, logical framework.

The AMRES project is a collaborative effort of West Bengal State Health Department and ICMR-National Institute for Research in Bacterial Infections. While the ICMR's National Institute for Research in Bacterial Infections has long led the charge in surveillance, therapeutics and diagnostic research, the AMRES (Antimicrobial Resistance Research and Evidence Synthesis) project represents a critical shift toward implementation science. For health system, the value of this project lies in its "ground-truth" assessment of our system's readiness to implement antimicrobial stewardship program. This project assessed real-world infrastructure for tracking antimicrobial use; operational gaps; scope of Resource Alignment for fixing logistical or systemic bottlenecks.

The findings presented in this report serve as a blueprint for strengthening our health system tiersfor AMR containment through implementation of AMSP.

I extend my sincere appreciation to the AMRES Project team and our participating institutions in the districts of South 24 Parganas, Bankura & Malda. This document is not merely a document for the archives; it is an operational roadmap. By addressing the gaps identified herein, we will transition from reactive management to a proactive, resilient healthcare system capable of safeguarding the health of our citizens against the rising tide of drug-resistant pathogens.

01/4/26

(Dipankar Maji)

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BMOH – Block Medical Officer of Health , Infection Control Nurse

List of Abbreviations

Abbreviation	Full Form
AB	Antibiotic
AMR	Antimicrobial Resistance
AMSP	Antimicrobial Stewardship Program
AMRRSN	Antimicrobial Resistance research and Surveillance network
AST	Antimicrobial Susceptibility Testing
DDD	Defined Daily Dose
DOT	Days of Therapy
EHR	Electronic Health Record
EMR	Electronic Medical Record
GAP	Global Action Plan
HWCs	Health and Wellness Centres
ICMR	Indian Council of Medical Research
ICN	Infection Control Nurse
IEC	Information, Education and Communication
IPD	In-patient Department
IV	Intravenous
MO	Medical Officer
NABL	National Accreditation Board for Testing and Calibration Laboratories
NAP-AMR	National Action Plan on Antimicrobial Resistance
NIRBI	National Institute for Research in Biomedical Informatics
OECD	Organization for Economic Co-operation and Development
PHC	Primary Health Centre
POCT	Point of Care Testing
PPS	Point Prevalence Survey
SOP	Standard Operating Procedure
SWOT	Strengths, Weaknesses, Opportunities, and Threats
BMOH	Block Medical Officer of Health

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Acknowledgement

The AMRES project was conceptualized and implemented under the strategic guidance and support of the Indian Council of Medical Research (ICMR), New Delhi. We extend our deepest gratitude to Dr. Rajiv Bahl, Director General, ICMR, for his continued commitment to addressing antimicrobial resistance and for providing the institutional mandate for this important initiative.

We are especially grateful to Dr. Kamini Walia, Scientist G at ICMR, New Delhi, for her leadership, mentorship, and unwavering support throughout the project. Her scientific vision and technical inputs were instrumental in shaping the study's scope, tools, and analytical framework.

Our sincere thanks go to Dr. Santasabuj Das, Director & Scientist G, ICMR - National Institute for Research in Bacterial Infections, Kolkata, for providing the institutional leadership necessary to coordinate a project of this scale. We acknowledge the core research team at ICMR-NIRBI and Dept of Health and Family Welfare, Particularly State AMR Containment Cell, Govt of West Bengal for their tireless efforts in study design, data collection, analysis, and report writing.

We would like to thank all the hospital administrators and staff including microbiologists, pharmacists, clinicians, infection control nurses, and data entry operators across the participating sites. Their cooperation, openness, and time were critical to the success of this work.

We are also indebted to the field investigators and data managers whose dedication and meticulous work ensured the integrity and richness of the data. Special thanks to the qualitative research team for capturing the nuanced human and institutional factors that influence stewardship.

Finally, we acknowledge the contributions of the data analysis, documentation, and editorial teams who helped convert complex datasets into actionable insights and ensured the scientific rigor of this report. The AMRES project stands as a testament to collective effort and shared commitment toward a healthier, antibiotic-resilient future for India.

Scope of the Report

India has taken significant policy strides most notably through the National Action Plan on AMR and the expansion of laboratory-based surveillance under the ICMR-AMR network, however, key implementation gaps persist. Existing containment strategies remain disproportionately focused on tertiary-level institutions and laboratory data. This narrow lens tends to overlook the broader systemic determinants of resistance, including community-level prescribing behaviors, limited diagnostic access, and gaps in stewardship readiness across primary and secondary care settings (Laxminarayan & Chaudhury, 2016).

This report is a core output of the AMRES study, conceptualized and led by ICMR-NIRBI in its capacity as the National AMR Hub. The study was initiated as a strategic course correction to reframe AMR containment as a systems-level implementation challenge. Drawing from principles of systems thinking (Greenhalgh & Papoutsi, 2018), AMRES approaches AMR not as an isolated microbiological phenomenon but as a complex outcome shaped by the interaction of policy, practice, infrastructure, and human behavior.

Study Objectives

The AMRES study was guided by two overarching objectives:

i. To map patterns of antimicrobial resistance, antimicrobial consumption, and prescription practices across multiple levels of the public health system (primary, secondary, and tertiary care) and antibiotic consumption behaviour in adjoining community in West Bengal.

ii. To assess the operational, organizational, and behavioral readiness for implementing Antimicrobial Stewardship Programs (AMSPs), with a specific focus on public healthcare providers across the tiers, whose practices significantly influence antimicrobial use patterns.

Methodological Framework

To address these objectives, the AMRES study employed a mixed-method, convergent parallel multi-tiered design that is unprecedented in the Indian AMR research context. Data collection spanned twelve government health facilities across different levels of care and three geographically distinct areas. Quantitative data were obtained through prescription evaluation, microbiological analysis of appropriate biological specimens for common infections, facility-level assessments, community survey and survey among the doctors. Qualitative data were gathered via in-depth interviews with healthcare providers, infection control nurses, administrators to understand the structural and behavioral determinants of antimicrobial use, need and scope of customized antimicrobial stewardship implementation across three tiers of healthcare delivery system.

A distinctive feature of AMRES was its adoption of (Barker et al., 2017; Sahoo et al., 2014) WHO-endorsed tools such as the Anatomical Therapeutic Chemical (ATC)/Defined Daily Dose (DDD) classification system and the focus-of-infection approach (Pathak et al., 2012; Sözen et al., 2013), facilitating alignment between antimicrobial indication and usage and allowing for benchmarking across facilities and tiers of care.

Contribution and Strategic Relevance

The AMRES study represents a paradigm shift in the design and execution of AMR research in India. By integrating microbiological data with doctor behavior, facility-level infrastructure, and community perceptions, it presents a comprehensive, systems-oriented understanding of AMR. It moves beyond static surveillance to explore how stewardship can be operationalized in real-world contexts, particularly in under-resourced settings where implementation challenges are most acute (Charani et al., 2019; Tamhankar et al., 2018).

This report integrates findings from all components of the study and offers a foundational framework for strengthening antimicrobial resistance (AMR) containment across India's diverse healthcare landscape. Specifically, it:

a. Examines antimicrobial prescribing patterns for common infections, resistance of isolated oraganisms across the continuum of care from medical colleges to primary health centres.

b. Evaluates the readiness of institutions and human resources to implement antimicrobial stewardship programmes (AMSPs)

c. Identifies critical barriers to diagnostic access and stewardship governance.

d. Explores socio-behavioural drivers of antimicrobial use and documents potential community-level solutions through qualitative enquiry.

e. Assesses the feasibility of embedding stewardship tools into routine clinical practices and operational systems.

By synthesizing these insights, the report generates actionable recommendations for designing stewardship interventions tailored to local contexts. Ultimately, this report is not merely descriptive but strategic. It contributes a detailed blueprint for transitioning from reactive, laboratory-driven containment to proactive, system-wide stewardship. It aligns with India's broader health system reforms and seeks to embed AMR mitigation within the fabric of service delivery, workforce training, supply chain regulation, and community engagement.

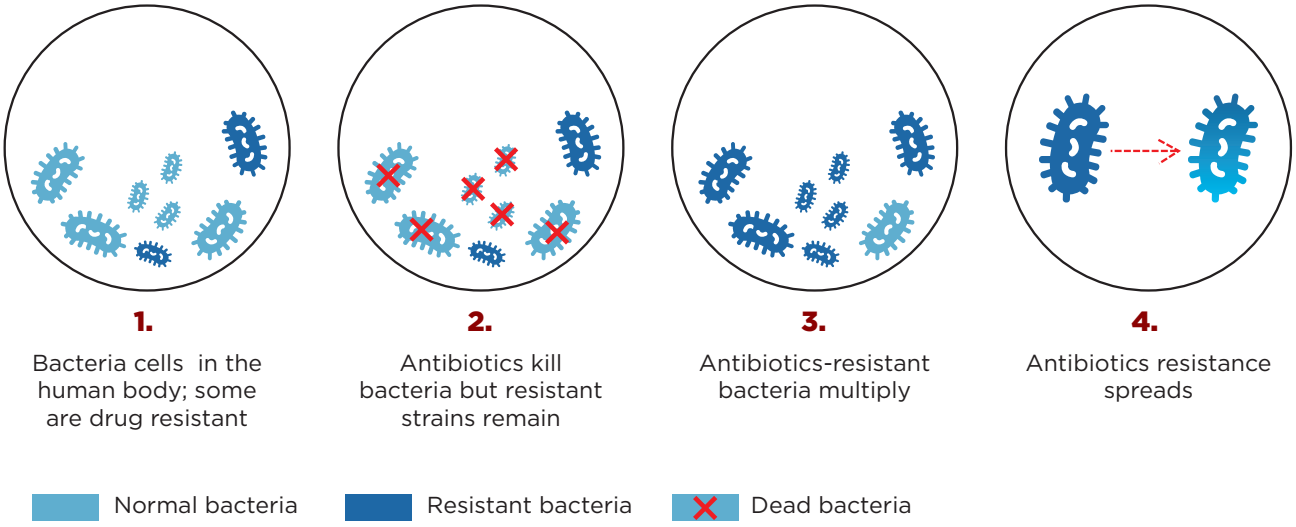

Figure 1: How antimicrobial resistance occurs

Chapter 1

Introduction

Antimicrobial resistance (AMR) is a global public health emergency that threatens to reverse decades of progress in infectious disease control and modern medical care. It occurs when microorganisms including bacteria, viruses, fungi, and parasites develop the capacity to resist the effects of antimicrobial agents that were once effective against them. AMR compromises the ability to prevent and treat a wide range of infections, resulting in prolonged illness, increased treatment costs, longer hospital stays, therapeutic failures, and elevated mortality (WHO, 2014).

Global estimates suggest that AMR was associated with nearly 4.95 million deaths in 2019, with 1.27 million deaths directly attributable to drug-resistant bacterial infections(Murray et al., 2022). If unchecked, this number could escalate to 10 million lives lost per year by 2050, with an estimated cumulative economic loss of USD 100 trillion(O'Neill, 2016). These projections underscore the need for coordinated multisectoral action, especially in low- and middle-income countries (LMICs) where the burden of infectious diseases remains high and antimicrobial misuse or overuse is widespread.

In India, the AMR crisis is especially acute. The country is the world's largest consumer of antimicrobials (Laxminarayan & Chaudhury, 2016), driven by factors such as over-the-counter sales, empirical and non-guideline-based prescribing, widespread use of antimicrobials in agriculture and aquaculture, and suboptimal infection prevention and control (IPC) in healthcare settings (Kotwani & Holloway, 2011; Walia et al., 2019). In addition, lack of diagnostic facilities at primary care level compels doctors to treat patients empirically based on clinical presentation which may in many cases cause misuse or overuse of antimicrobials exacerbating the risk of resistance.

The animal and agricultural sectors further contribute to the amplification of resistance. Antimicrobials are used not only for therapeutic purposes but also for growth promotion and prophylaxis in poultry, livestock, and aquaculture. Residues from these antimicrobials can enter the human food chain, particularly when withdrawal periods before slaughter are not observed. Moreover, antimicrobial-laden animal excreta and effluents from pharmaceutical industries are often discharged untreated into the environment. These practices facilitate the emergence and horizontal transfer of resistance genes in environmental bacteria, turning rivers, soil, and effluent treatment plants into major environmental reservoirs of resistance (Ahmed et al., 2024; UNEP Report, 2023; Zhao et al., 2024).

Initiating multisectoral measures for containment of AMR has become Indias' one of the major challenge in this containment journey. India's response has primarily focused on hospital-based microbiological surveillance. Initiatives such as the National Action Plan on AMR (NAP-AMR) and the ICMR-AMR surveillance network have improved laboratory capacity and data collection. However, these efforts remain concentrated in tertiary care facilities, and rarely capture prescribing practices or resistance patterns in primary health centres, community clinics where much of India's antimicrobial use occurs (Charani et al., 2019; Mamo & Alemu, 2020; Singh et al., 2019).

Moreover, stewardship implementation has been inconsistent. There is limited integration of AMSP into hospital governance, weak regulatory enforcement, and little attention to doctor behavior, diagnostic capacity, or patient demand at the primary care level. In the absence of functional AMR containment systems, irrational antimicrobial use persists, even in facilities aware of national guidelines(Akpan et al., 2016).

Addressing AMR, therefore, requires a shift from pathogen-centric surveillance to health systems-oriented research. It demands a comprehensive approach that integrates facility-level prescribing data, community health-seeking behavior, availability of diagnostics, provider training, and system readiness for implementing stewardship interventions.

Without understanding and addressing these real-world drivers, even the best clinical guidelines and surveillance systems will fail to translate into effective AMR containment. To respond to these systemic challenges, the Indian Council of Medical Research–National Institute of Research on Bacterial infections (ICMR-NIRBI) launched the AMRES (Antimicrobial Resistance Research & Evidence Synthesis) study under its mandate as the National AMR Hub. The AMRES study aims to generate granular, implementation-relevant evidence by examining antimicrobial use across tiers of healthcare and associated community settings in West Bengal, India. It explores provider and system-level factors influencing prescribing behavior and stewardship feasibility. Considering these complexities, the need for a structured, multi-tiered investigation into antimicrobial use and stewardship implementation scope across diverse healthcare settings became evident. The AMRES study was designed to address this evidence gap, and the following section outlines its scope, objectives, methodology, and intended contribution to AMR containment efforts in India.

1.1. Global Scenario of Antimicrobial Resistance (AMR)

AMR is now recognized by the World Health Organization (WHO) as one of the top ten global public health threats. The 2019 Global Burden of Disease (GBD) study revealed that bacterial AMR was directly responsible for an estimated 1.27 million deaths and associated with nearly 4.95 million deaths worldwide (Murray et al., 2022); figures that surpass those attributed to HIV/AIDS or malaria in the same year. Without urgent mitigation, projections suggest that AMR could lead to 10 million deaths annually by 2050, accompanied by a cumulative economic loss of up to USD 100 trillion (Naghavi et al., 2024; Prestinaci et al., 2015; Wang et al., 2025).

The global drivers of AMR are complex and interlinked. High-income countries face challenges in hospital-acquired resistant infections and inappropriate prescribing in outpatient settings. In contrast, low and middle-income countries (LMICs) contend with broader structural issues including unrestricted access to antimicrobials, widespread use of antimicrobials in agriculture, poor infection prevention and control, and limited access to diagnostic tools. Notably, the unregulated availability of antimicrobials without prescriptions is a dominant risk factor in many LMICs (Damisie et al., 2019; Waseem et al., 2019).

Surveillance efforts, though expanded in recent years, remain uneven. The WHO's Global Antimicrobial Resistance Surveillance System (GLASS), initiated in 2015, has improved reporting mechanisms but faces participation and data quality challenges, particularly from countries with underdeveloped laboratory systems. Critical gaps also persist in linking surveillance data with actionable interventions in health systems and communities.

AMR is not confined to human health alone. The One Health approach integrating human, animal, and environmental health has gained international traction due to the recognition that resistant organisms and resistance genes can transmit across sectors. Antimicrobials used in livestock for therapeutic and non-therapeutic purposes contribute to the selection pressure for resistant bacteria, which may enter human populations via food chains, environmental runoff, or direct contact (Laxminarayan & Chaudhury, 2016; Walia et al., 2019).

Globally, pathogens of critical concern include carbapenem-resistant Enterobacteriaceae, multidrug-resistant Acinetobacter baumannii, and methicillin-resistant Staphylococcus aureus (MRSA), which account for a significant proportion of deaths and treatment failures in intensive care units (WHO, 2017). The pipeline for new antimicrobials remains limited, and pharmaceutical incentives for antimicrobial development continue to be weak. Meanwhile, behavioral and cultural determinants of antimicrobial use such as perceived patient expectations, fear of litigation, or lack of stewardship training remain under-addressed in both high- and low-resource contexts (Byrne et al., 2019; Lee et al., 2018). In summary, the global response to AMR demands not only enhanced surveillance and drug development but also a shift toward behaviorally informed stewardship models, harmonized regulatory frameworks, and integrated One Health strategies tailored to regional epidemiological realities.

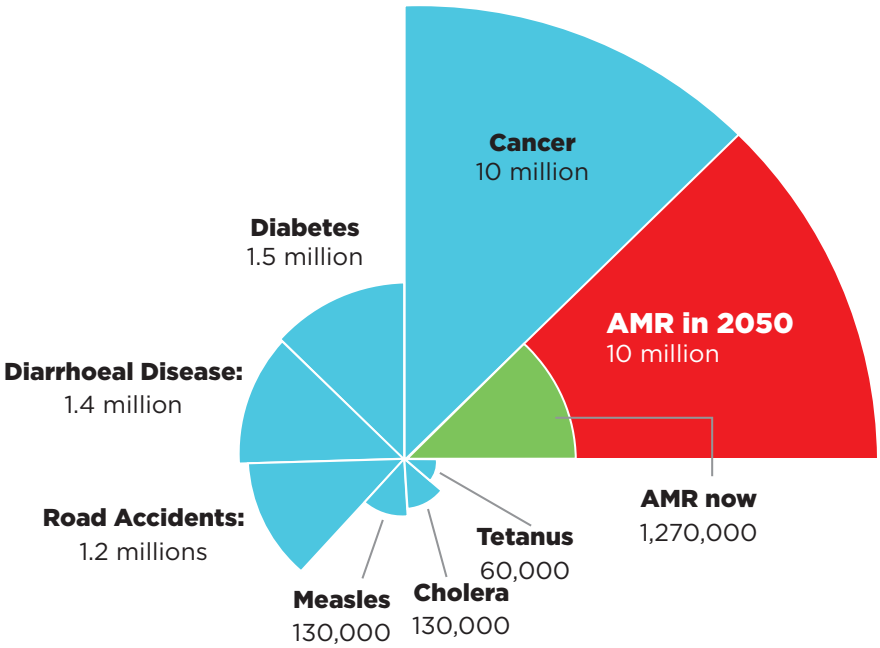

Figure 2: Major causes of death every year compared to AMR death predictability in 2050

1.2. Epidemiological and Systemic Burden of AMR in India

India's AMR landscape reflects a convergence of high infectious disease prevalence, excessive antimicrobial consumption, and systemic regulatory and infrastructural gaps. With an estimated per capita antimicrobial use exceeding global averages and a dominant reliance on empirical treatment pathways, India is particularly vulnerable to the acceleration and transmission of resistant pathogens (Kotwani & Holloway, 2011). The country has implemented key policy initiatives, including the NAP on AMR and the ICMR's national surveillance programs. However, these efforts remain largely concentrated to tertiary healthcare settings, with minimal penetration into the lower tiers of hospitals (Singh et al., 2019). Unlike in many high-income countries, where AMR is primarily a hospital-acquired phenomenon, in India, resistant infections are often acquired in outpatient or community contexts (Barker et al., 2017). For over 70% of India's population, primary healthcare facilities serve as the first point of contact for treatment. However, these facilities often lack essential diagnostic infrastructure, leading to widespread empirical antibiotic use (Ayushman Bharat Comprehensive Primary Health Care through Health and Wellness Centers Operational Guidelines, 2018; Strategy for New India @ 75, 2018; Vision-2035-Public-Health-Surveillance-in-India, 2020). Additionally, alongside these infrastructural limitations, the multifaceted nature of AMR spanning clinical, behavioral, regulatory, and environmental dimensions compounds the challenge of containment, necessitating coordinated action across political, institutional, and community levels (Debnath et al., 2024; Mathew et al., 2020; Walia et al., 2019).

Estimating the burden of AMR in India is constrained by fragmented data, limited laboratory capacity, and low integration of surveillance at lower levels of care. Nonetheless, available data depict a troubling trend. High resistance rates have been reported for first-line treatments such as fluoroquinolones, cephalosporins, and aminoglycosides, as well as for last-resort agents like colistin and carbapenems (Laxminarayan & Chaudhury, 2016). In neonatal intensive care units (NICUs), nearly 50–70% of bloodstream infections are caused by multidrug-resistant organisms (Singh et al., 2019). Community-acquired infections like urinary tract infections, diarrheal diseases, respiratory infections now frequently involve resistant strains, particularly of E. coli, Klebsiella pneumoniae, and Staphylococcus aureus. Studies from urban hospitals and district facilities show escalating resistance even in outpatient prescriptions, indicating the spread of resistance beyond inpatient care(Pathak et al., 2012; Tamhankar et al., 2018). The economic toll is equally significant. Delays in treatment, prolonged hospital stays, repeat consultations, and increased use of expensive second-line antimicrobials lead to high out-of-pocket expenditure (OOPE), especially in the absence of universal insurance coverage (Mamo & Alemu, 2020).

1.2.1. Impacts of AMR on Public Health and Clinical Outcomes

The impact of AMR on India's population is disproportionately severe for vulnerable groups like newborns, children under five, pregnant women, elderly individuals, and those with chronic conditions such as diabetes, cancer, or HIV. These populations face elevated risks of treatment failure and adverse outcomes due to their reduced physiological resilience and frequent exposure to healthcare settings(Lee et al., 2018; Singh et al., 2019). AMR also exacerbates social and economic inequalities. In rural areas, limited diagnostic infrastructure and scarce access to trained health personnel result in frequent use of broad-spectrum antimicrobials without confirmatory testing. This not only accelerates resistance but also leads to poor health outcomes due to misdiagnosis and delayed effective treatment(Sahoo et al., 2014). Moreover, the economic consequences like prolonged illness, income loss, school absenteeism for children, and catastrophic health spending undermine household productivity and perpetuate cycles of poverty (Dadgostar, 2019; Mamo & Alemu, 2020; Ouakrim et al., 2020).

Culturally, patient expectations for quick cures, loss to follow-up often lead to antimicrobial overprescription. Qualitative studies show that people may consider antimicrobials as "strong medicines" and demand them even for viral or non-bacterial conditions (Byrne et al., 2019). This creates a feedback loop where social norms reinforce inappropriate antimicrobial use, further worsening the resistance landscape. In short, AMR in India is not only a clinical challenge but also a population-level threat that magnifies existing health disparities and impedes socioeconomic development.

1.2.2. Major Structural and Operational Gaps in AMR Containment in Public Healthcare Delivery System

This section presents findings from the AMRES study's qualitative analysis, which captured on-ground insights from a range of healthcare stakeholders across public health facilities in West Bengal. The assessment involved in-depth interviews with doctors, infection control nurses (ICN) and support staff, and hospital administrators at primary, secondary, and tertiary care levels. Their perspectives revealed systemic weaknesses that must be addressed to strengthen India's AMR response.

1. **Lack of structured training and role-specific awareness:**

Across cadres, healthcare workers demonstrated limited understanding of AMR protocols. Infection Control Nurses (ICNs) often carried out tasks without formal training, relying on informal tools such as WhatsApp-based checklists. Junior doctors and interns primarily followed senior consultants' prescribing patterns, with minimal exposure to antimicrobial stewardship principles. Support staff involved in hygiene and waste disposal lacked basic IPC training. These gaps highlight the absence of systematic, cadre-specific training programs to build stewardship awareness and competence.

2. **Inadequate access to diagnostics and essential antimicrobials:**

Several facilities reported frequent stock-outs of essential antimicrobials, compromising adherence to standard treatment guidelines. Diagnostic capacity was also limited, particularly in primary and secondary settings. The absence of NABL-accredited laboratories and culture-sensitivity testing constrained evidence-based prescribing. Doctors reported treating infections empirically due to lack of timely lab results, increasing the risk of inappropriate antimicrobial use.

3. **Poor coordination between departments:**

Functions critical to AMR containment like prescribing, diagnostics, pharmacy supply, and infection control operated in silos. Coordination between ICNs and clinicians was minimal, and inter-departmental workflows were poorly defined. results, increasing the risk of inappropriate antimicrobial use.

4. **Weak monitoring and administrative oversight:**

Most hospitals lacked systems for regular prescription audits, documentation reviews, or AMSP-related supervision. Implementation of AMR guidelines remained voluntary and unmonitored, limiting accountability. Administrative officials acknowledged that while state-level guidelines had been circulated, uptake at the facility level was uneven due to limited human resources and unclear enforcement mandates.

5. **Low motivation and lack of institutional support:**

Infection control duties were often assigned as additional responsibilities without dedicated time, recognition, or incentives. ICNs and nursing staff reported low morale, citing absence of formal acknowledgement for their AMR-related work. This led to limited engagement and reduced effectiveness of IPC and AMSP activities.

These findings underscore that addressing AMR in India requires not only technical interventions, but also structural reforms that improve coordination, accountability, and staff engagement at the facility level.

1.2.3. Strategic Directions for Strengthening AMR Response

Based on the above gaps and stakeholder insights from the AMRES project's is qualitative assessment, the following priority actions are proposed to strengthen AMR containment in India. These interventions align with national and global best practices and are designed for feasibility within public sector health systems.

1. **Institutionalize cadre-specific training on AMR and stewardship:**

Healthcare staff at all levels including doctors, nursing staff, pharmacists, and support workers require regular, structured training tailored to their roles. Training must cover rational antimicrobial use, prescription audit practices, IPC measures, and interpretation of antibiograms. Clear delineation of responsibilities can enhance compliance and accountability.

2. **Strengthen diagnostic access and antimicrobial supply chains:**

Investments in laboratory infrastructure including NABL-accredited labs and point-of-care diagnostics—are critical for enabling evidence-based prescribing. Facility-level procurement systems should ensure uninterrupted access to essential antimicrobials, with stock monitoring linked to stewardship oversight.

3. **Establish multidisciplinary AMR committees and communication protocols:**

Dedicated AMR committees should be constituted in all public hospitals to oversee stewardship activities. These committees must include representatives from clinical departments, infection control, pharmacy, and administration. Regular meetings, shared SOPs, and integrated workflows can enhance coordination and program adherence.

4. **Introduce routine prescription audits, monitoring and feedback mechanisms:**

Facilities must institutionalize monthly prescription audits, review meetings, and feedback loops. Findings should be documented, discussed with doctors, and linked to performance improvement. Clear reporting structures and administrative follow-up can drive compliance with AMR guidelines.

5. **Promote leadership-driven cultural change in prescribing norms:**

Senior clinicians and department heads must actively promote rational antimicrobial use and model evidence-based prescribing. Empowering junior doctors and nursing staff to participate in clinical decision-making can support a more open, guideline-aligned culture of care.

6. **Recognize and incentivize AMR-related contributions:**

Introducing recognition mechanisms such as AMR champion awards, performance appraisals, and public appreciation can improve morale and engagement. Infection control staff, pharmacy leads, and ward-level stewards should be acknowledged for their contributions to AMSP implementation.

These system-wide solutions are grounded in real-world challenges identified during the AMRES study. Their adoption can help transition India's AMR response from guideline dissemination to meaningful, facility-level practice.

STRATEGIC DIRECTIONS FOR STRENGTHENING AMR RESPONSE

Institutionalize cadre-specific training on AMR and stewardship

Healthcare staff at all levels require tailored training on rational antimicrobial use, prescription audit practices, IPC measures, and antibiograms

Strengthen diagnostic access and antimicrobial supply chains

Investments in laboratories and robust procurement systems are critical for stewardship

Establish multidisciplinary AMR committiees and communication protocols

Dedicated AMR committees and integrated workflows can enhance program coordination

Introduce routine prescription audits, monitoring and feedback mechanisms

Facilities must institutionalize monthly audits and link findings to performance improvement

Promote leadership-driven cultural change in prescribing norms

Senior clinicians must promote rational antimicrobial use and model evidence-based prescribing

Recognize and incentivize AMR-related contributions

Recognition mechanisms such as AMR champion awards can improve morale and engagement

Figure 3: Strategic directions for strengthening AMR response

Chapter 2

Antimicrobial Stewardship Programme (AMSP) in India

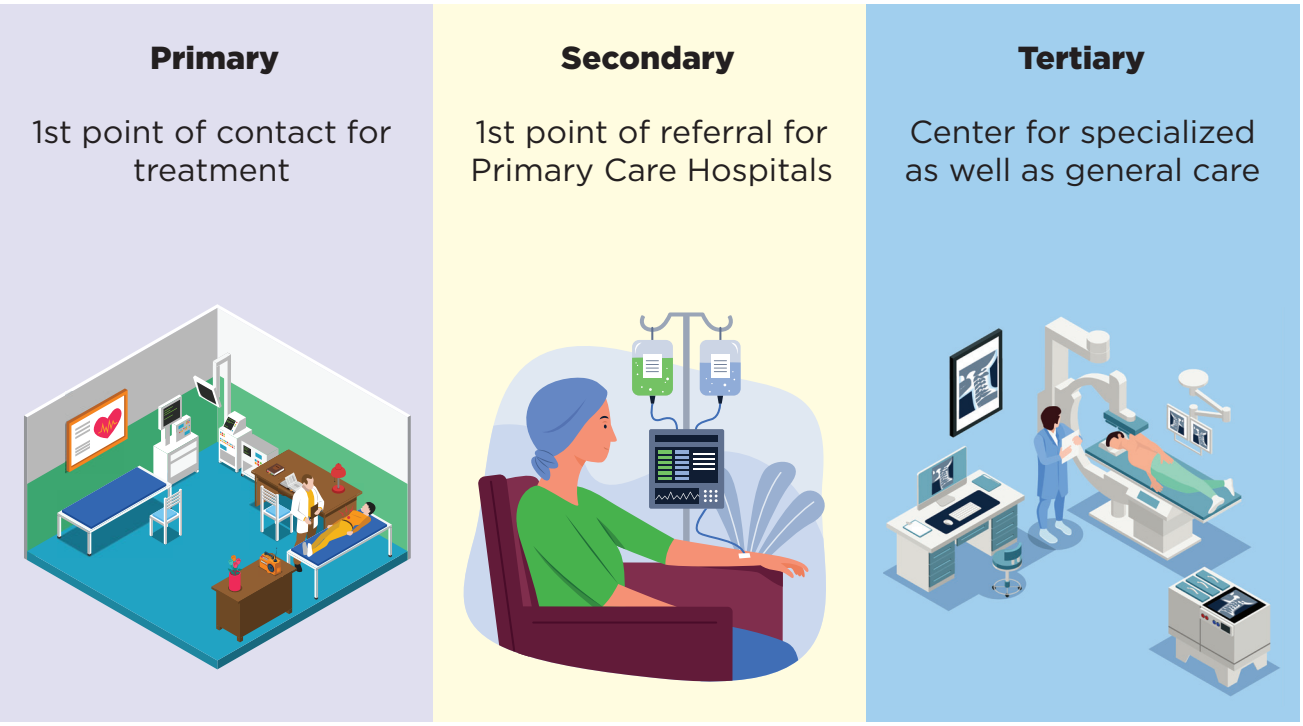

Figure 4: Differences between Primary, secondary and tertiary care hospitals

2.1. From Tertiary to Primary: Building a Tiered AMSP Framework for India

Antimicrobial resistance (AMR) in India presents a complex public health challenge spanning the entire healthcare continuum. The country is the largest global consumer of antimicrobials, with an estimated annual use of nearly 13 billion units (Van Boeckel et al., 2014). This high volume of consumption, often driven by empirical and unregulated prescribing practices, contributes significantly to the growing resistance burden. However, despite the scale of the problem, efforts to implement Antimicrobial Stewardship Programmes (AMSPs) are uneven. Most AMSP activities are focused on tertiary care hospitals, where specialized infrastructure, diagnostics, and trained personnel are present. In contrast, the primary and secondary care facilities which cater to most of the India's population continue to face major gaps. These include limited diagnostic capacity, lack of laboratory surveillance systems, inadequately functioning hospital infection control committee, and inadequate training in rational antimicrobial use, all of which hinder the effective rollout of AMSP in these settings (Debnath et al., 2024). This disparity underscores the urgent need for tailored stewardship strategies that extend beyond tertiary centers and address the unique operational and resource constraints of lower-tier healthcare facilities.

India's public health system is organized into a tiered structure, with each level, primary, secondary, and tertiary having distinct resource capacities and functional roles. At the primary care level, which includes sub-centres, Primary Health Centres (PHCs), and Health and Wellness Centres (HWCs), and Community Health Centres (CHCs) clinical management is typically syndromic. The reliance on syndromic approaches stems from several systemic limitations: a lack of point-of-care diagnostics, minimal access to microbiological testing, and a shortage of adequately trained health personnel (Debnath et al., 2024). In the absence of diagnostic support, healthcare providers often resort to empirical treatment. This is further shaped by patient demand, time constraints, and the widespread availability of over-the-counter (OTC) antimicrobials, which allows individuals to self-medicate without medical supervision (Singh et al., 2019). As a result, antimicrobial use at the primary level is frequently inappropriate, both in terms of indication and choice of drug. Broad-spectrum agents, particularly those categorized under the WHO Watch group, are often used for conditions that are likely viral. Moreover, non-adherence to available standard treatment guideline (STG); lack of awareness regarding role of de-escalation and WHO categorization of antimicrobials accelerates the development of resistant organisms, undermines the effectiveness of available treatments, and creates additional challenges for antimicrobial stewardship in the community setting.

At the secondary level of India's public health system comprising sub district and district level hospitals, the infrastructure and clinical services are generally improved than primary care setting. These facilities often have access to basic diagnostic laboratories, which, in principle, could support more evidence-based clinical management. However, systemic limitations persist. Microbiology lab setup, access to trained microbiologists is often irregular, along with laboratory services being untimely and inconsistently integrated with clinical decision-making processes. As a result, culture and sensitivity testing, where available, rarely guides antimicrobial therapy in real time (Ahmed et al., 2024; Chung et al., 2013; Mathew et al., 2020). In this context, antimicrobial prescribing remains predominantly empirical. Clinicians, facing uncertainty and time pressures, frequently escalate to broader-spectrum agents without microbiological confirmation. The lack of timely laboratory data, combined with inadequate diagnostic stewardship, leads to the pre-emptive use of second- and third-line antimicrobials often from the WHO Watch and Reserve categories. Digital tools that could aid in stewardship, such as electronic prescribing system, formulary alerts, or integrated antibiogram dashboards, are largely absent in these settings. Efforts to institutionalize antimicrobial stewardship components such as prescription audits, time out, formulary restrictions, or infection control linkages are patchy and not systematized. Where such activities do occur, they are often dependent on external support, either from technical partners or state-driven pilot programs (Chung et al., 2013). Formal AMSP committees, where established, are frequently under-resourced, lack routine funding, and operate without full multidisciplinary participation and limited to tertiary tier hospitals. These structural gaps weaken the ability of secondary and primary -level facilities to implement consistent and effective stewardship practices, further entrenching inappropriate antimicrobial use.

Tertiary care institutions in India, including medical colleges and apex referral hospitals, are comparatively better equipped to implement structured Antimicrobial Stewardship Programmes (AMSPs). These facilities typically benefit from access to trained clinical microbiologists, infectious disease (ID) specialists, dedicated pharmacy personnel, and electronic health record (EHR) systems that facilitate stewardship activities. Such resources enable the deployment of AMSP components, including prospective audit-and-feedback mechanisms, formulary restrictions, antimicrobial de-escalation protocols, and the use of cumulative antibiograms to guide empiric therapy (Akpan et al., 2016). Despite this capacity, inappropriate antimicrobial use remains a persistent challenge, even in tertiary settings. Several factors contribute to this problem. The high acuity of admitted patients, often with complex and severe infections, encourages broad-spectrum empirical therapy. Defensive prescribing practices, driven by fear of clinical deterioration or medico-legal consequences, further exacerbate the tendency to overuse potent antimicrobials. Additionally, the absence of standardized, institution-wide AMSP protocols and weak enforcement mechanisms result in wide variations in practice, even within the same hospital. Surveillance and restriction of last-resort agents, such as carbapenems and colistin, are often inadequate, increasing the risk of resistance to

critically important antimicrobials (Gandra et al., 2017). Another critical limitation lies in the operational structure of stewardship teams. Many functions without formal administrative support, designated time, or adequate staffing to carry out regular audits, feedback sessions, or training. As a result, stewardship activities are inconsistently implemented and often limited in scale or sustainability. Without institutional commitment and systemic integration into clinical governance, even well-resourced AMSP frameworks risk falling short of their intended impact.

A uniform, one-size-fits-all approach for implementation of prescribed Antimicrobial Stewardship Programme (AMSP) interventions does not account for the significant structural, operational, and resource-based differences across India's healthcare system (Pulcini et al., 2019). Evidence from the ICMR-NIRBI AMRES study reinforces this point by demonstrating clear variability in antimicrobial prescribing patterns, diagnostic capacity, and stewardship readiness across primary, secondary, and tertiary tiers. Quantitative findings from the study revealed that the Access-to-Watch ratio, an indicator recommended by the World Health Organization to assess the quality of antimicrobial use fell below the target threshold of 1.5 in both primary (0.9) and secondary (0.8) care settings. This indicates a troubling trend: frequent overuse of Watch-category antimicrobials for conditions that should be managed with narrower-spectrum Access-group drugs. Such patterns may increase the risk of resistance development and reflect a systemic departure from rational prescribing norms. Compounding this issue, many facilities lacked access to updated treatment guidelines, either at the national or state guideline. In the absence of standardized protocols, clinical decisions often defaulted to individual discretion, frequently unsupported by evidence. Routine mechanisms for prescription audits, feedback to prescribers, or monitoring of antibiotic use were largely nonexistent (Debnath et al., 2024). These findings underscore the need for AMSPs that are context-sensitive tailored to the resource environment, human capacity, and clinical demands of each tier. Stewardship frameworks must move beyond tertiary-focused models and be adapted to function effectively in lower-tier settings, where the risks of inappropriate use are high, but the stewardship infrastructure is weak.

Beyond infrastructure and resource limitations, antimicrobial stewardship readiness in India is significantly shaped by behavioral patterns and systemic dynamics that vary across healthcare tiers. These contextual influences play a critical role in how antimicrobials are prescribed and managed in real-world settings.

In primary care, antimicrobial use is often influenced by a combination of weak regulatory oversight, and high patient expectations for immediate relief, lack of diagnostic facilities. Many patients seek care from unqualified providers or chemists, where antibiotics are frequently dispensed without prescriptions. Even in formal settings, trained providers operate under time and resource constraints, often opting for broad-spectrum agents based on symptoms alone. These choices are reinforced by community perceptions that associate faster symptom resolution with stronger antibiotics, regardless of the underlying cause of illness.

In secondary care settings, empirical escalation of antimicrobial therapy is a rational and often necessary response to diagnostic uncertainty. Facilities at this level typically lack real-time access to culture and sensitivity results, leading clinicians to initiate broader-spectrum antibiotics pre-emptively to avoid treatment failure. In the absence of functioning audit-feedback systems or microbiological guidance, prescribers rely heavily on clinical judgment, often without the support needed to safely de-escalate therapy once more information becomes available.

Tertiary care institutions, while relatively well-resourced, face a different set of challenges. The use of last-resort antimicrobials such as carbapenems and colistin is often excessive and not always justified by microbiological evidence. Infectious disease (ID) consultations, which could guide appropriate use, are not routinely integrated into patient management, and decision-support tools like antibiograms or prescribing dashboards are underutilized, even where available (Akpan et al., 2016; Gandra et al., 2017; Mathew et al., 2020). These missed opportunities are particularly concerning, given the role of tertiary centers in setting clinical norms and training future healthcare providers.

Together, these behavioral and systemic drivers reinforce irrational antimicrobial use across the health system. Addressing them requires tailored interventions, not only technical inputs, but also strategies that engage prescriber behavior, improve patient awareness, and strengthen institutional accountability at each level of care.

To address the diverse challenges of antimicrobial stewardship across India's health system, it is essential to design and institutionalize AMSPs that are tailored to the specific needs and capacities of each tier. A standardized approach cannot account for the operational realities and clinical constraints faced at different levels of care.

In primary care settings, AMSP efforts should begin with formation of an accountable committee; equipping the nurses, medical officers, pharmacists with practical tools for decision-making/aiding in decision making. Training should focus on the use of syndromic management algorithms for frequently encountered conditions and emphasize the importance of avoiding unnecessary antibiotic use. Dissemination of simplified, pictorial Standard Treatment Guidelines (STGs), developed in regional languages, can support this process. Implementation can be further supported enabling point-of-care access to guidance even in remote areas.

At the secondary care level, AMSPs should prioritize the formalization of governance and monitoring structures. Formation of a multidisciplinary team and setting up accountability in each sub district or district hospital can help implementation of AMSP. Regular audits of antibiotic prescriptions, supported by local data and tailored feedback, are essential for identifying patterns of irrational use. District-wide antibiograms, even if updated periodically, can help guide empirical therapy more accurately. Strengthening laboratory networks and introducing audit tools adapted for low-resource environments will help embed AMSP processes into routine clinical workflows.

In tertiary care institutions, where infrastructure and human resources are relatively better developed, AMSPs should be fully operationalized. Stewardship teams must include physicians, microbiologists, pharmacists, and infection prevention professionals. These teams should implement core stewardship interventions such as preauthorization requirements for restricted antibiotics, routine de-escalation reviews, and the use of digital dashboards that integrate prescribing data with microbiological reports. Importantly, tertiary centres must also take on a leadership role within the broader health system. Under a hub-and-spoke model, they can act as regional training and mentoring hubs for district and block-level facilities, building capacity and consistency across levels under the AMRES framework.

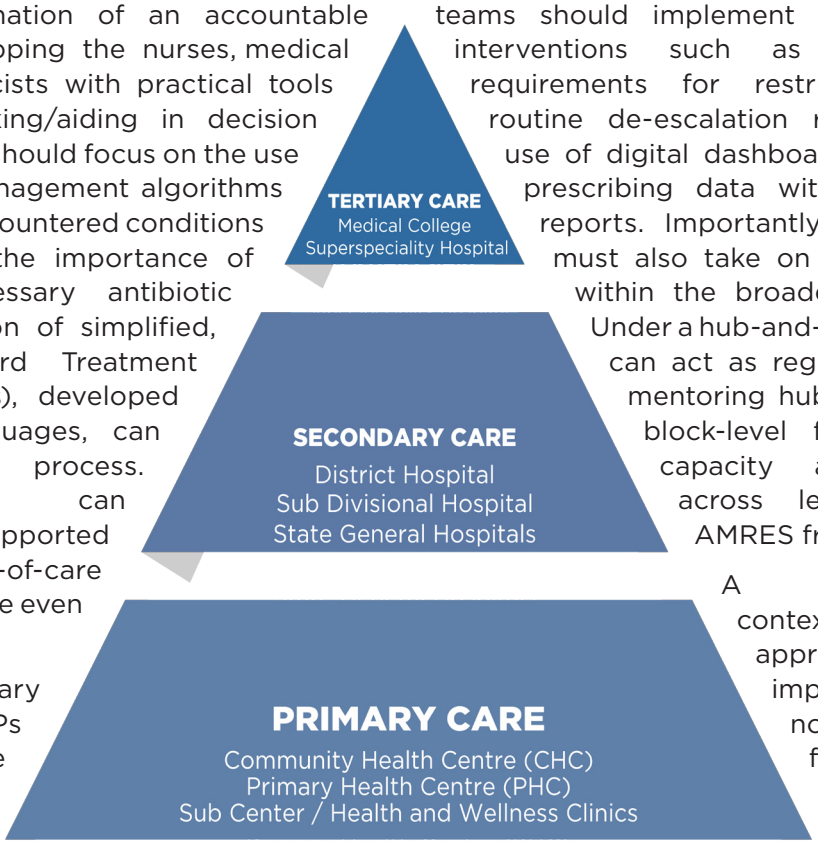

Figure 5: The Indian healthcare pyramid

A tiered and contextualized approach to AMSP implementation is not only necessary for clinical impact, it is also crucial for cost-effectiveness, sustainability, and local ownership.

Given the structural and functional heterogeneity across India's healthcare system, stewardship models must remain flexible and responsive to local realities, while aligning with national priorities for antimicrobial resistance containment.

2.2. From Policy to Practice: Establishing AMSP Infrastructure in India

India's recognition of antimicrobial resistance (AMR) as a national health priority began formally with the launch of the National Policy on Containment of Antimicrobial Resistance in 2011. This policy articulated the urgency of coordinated multisectoral actions, with a strong emphasis on surveillance, regulation, and stewardship. Building on this, the Government of India released the National Action Plan on AMR (NAP-AMR 2017–2021), which laid out a comprehensive roadmap for AMR containment. The Plan emphasized the development of Antimicrobial Stewardship Programmes (AMSPs) across the healthcare system, especially in tertiary care institutions. The Indian Council of Medical Research (ICMR) has been instrumental in operationalizing these commitments through initiatives such as the Antimicrobial Resistance Surveillance and Research Network (AMRSN), which established sentinel surveillance sites across the country to monitor resistance trends(Walia et al., 2019), and the Antibiotic Stewardship, Prevention of Infection and Control (ASPIC) programme, which focused on building capacity for rational antibiotic use through national training workshops and hospital-based interventions (Chandy et al., 2014).Despite these policy instruments, systemic implementation gaps remain. Published literature and findings from ICMR-supported facilities indicate that while many tertiary care hospitals have infection control guidelines, only a fraction have formalized AMSP policies, and even fewer have implemented them in practice. In district and sub-district hospitals, these numbers are significantly lower, with AMSP often limited to ad hoc audits or voluntary initiatives.

Despite these efforts, systemic and operational challenges continue to hinder the widespread adoption of AMSP interventions. Published evaluations and facility-based findings from ICMR-supported programmes suggest that while many tertiary hospitals possess infection control guidelines, only a subset have institutionalized AMSPs with dedicated governance structures, audit systems, and intervention protocols. Actual implementation of stewardship principles such as prospective audit and feedback, formulary restriction, and culture-guided therapy is limited to a handful of teaching hospitals and elite private centres. In district and sub-district hospitals, stewardship activities remain sporadic, ad hoc, and largely dependent on individual initiative rather than embedded institutional policy. These disparities are further exacerbated by structural and financial constraints, especially in the public health sector.

The institutional barriers to AMSP implementation in India are multifaceted. First, inadequate funding for microbiological diagnostics and laboratory strengthening limits the ability of clinicians to confirm infections and guide treatment decisions. Second, the absence of dedicated Infectious Disease (ID) specialists or clinical pharmacists in most public hospitals impairs the multidisciplinary execution of stewardship functions. Third, low awareness of AMS principles among general practitioners and clinical specialists often results in habitual empirical prescribing and limited uptake of existing treatment guidelines. Lastly, regulatory mechanisms governing antimicrobial procurement and use remain weak, particularly in sub-national procurement chains, where irrational fixed-dose combinations (FDCs) and non-formulary drugs are still readily available.

To address these bottlenecks, India must adopt a systemic, tier-adapted AMSP strategy that aligns with its ongoing health system strengthening programmes under the National Health Mission (NHM), Pradhan Mantri Jan Arogya Yojana (PMJAY), and the Ayushman Bharat Health and Wellness Centres (AB-HWCs) initiative. The need for such an integrated, whole-of-system approach was reiterated in the Compiled Report of National Expert Consultations for Developing NAP-AMR 2.0, published by ICMR in 2022. These national consultations brought together experts from across sectors including human health, veterinary sciences, environmental agencies, academia, and regulatory bodies and identified operational priorities for AMR control in the coming decade.

Key recommendations from these consultations included mandating AMSPs and infection prevention and control (IPC) committees in all public hospitals, especially at the district and sub-district levels. The report also called for strengthening of diagnostic capacities at lower tiers, development of tier-specific training modules, and establishment of state-level AMR cells to coordinate implementation and reporting. Importantly, participants emphasized the integration of AMR indicators into hospital

accreditation systems (e.g., NABH, Kayakalp) and health financing mechanisms (e.g., PMJAY) to enhance accountability and incentivize stewardship adherence. The consultations also stressed the importance of embedding One Health-based AMR surveillance across the human, animal, and environmental sectors, and urged regulatory reforms to curb the irrational sale and distribution of antimicrobials, particularly unsafe FDCs.

Complementing this vision, the AMRES framework developed by ICMR-NIRBI advocates a hub-and-spoke model, wherein tertiary care hospitals serve as regional training and mentorship hubs for district and primary facilities. This model encourages scalable, context-appropriate stewardship practices through capacity building, technical handholding, and use of simplified tools for data collection and feedback. Such a model not only facilitates structured stewardship rollout but also promotes local ownership, sustainability, and alignment with existing healthcare delivery mechanisms. The hub also can help in culture & sensitivity to provide periodic local antibiogram.

In sum, the transition from policy to practice in antimicrobial stewardship requires more than technical tools it demands systemic reorientation, financing, decentralization, and institutional accountability. With NAP-AMR 2.0 and frameworks such as AMRES in place, India has a timely opportunity to institutionalize stewardship as a core pillar of its health system and operationalize AMR containment as a national priority at every level of care.

2.3. Reference Frameworks Guiding Antimicrobial Stewardship in India

Over the past decade, a number of national institutions most notably the Indian Council of Medical Research (ICMR), Ministry of Health and Family Welfare (MoHFW), and collaborating state health departments have released a suite of technical and operational documents to guide the design and implementation of Antimicrobial Stewardship Programmes (AMSPs) in India. These reference frameworks serve as a foundational knowledge base for healthcare providers, administrators, and public health managers seeking to institutionalize stewardship within different levels of the health system.

The ICMR AMSP Guidelines (2022) remain the most comprehensive and tier-adapted national framework for AMSP implementation. These guidelines outline both core and supplemental stewardship strategies suitable for various health facility levels. Core strategies include prospective audit and feedback, formulary restriction for critical antimicrobials, and integration of prescription surveillance into routine clinical governance. Supplemental strategies include diagnostic stewardship, IV-to-oral conversion protocols, and the use of clinical pathways. Importantly, these guidelines provide tier-specific checklists, enabling PHCs, CHCs, district hospitals, and tertiary care centres to self-assess readiness and tailor interventions according to available resources and human capacity.

The National Guidelines for Infection Prevention and Control in Healthcare Facilities, MoHFW 2020 Training Modules complement the stewardship agenda by outlining best practices for preventing hospital-acquired infections (HAIs), which are a significant driver of antimicrobial use. These guidelines cover infrastructure standards for isolation rooms, environmental cleaning, waste management, and surveillance of high-risk pathogens, which are directly linked to AMR containment. Given that IPC and AMS are inherently interdependent, implementation of IPC protocols is a prerequisite for effective stewardship, particularly in resource-constrained facilities.

The ICMR has developed condition-specific treatment recommendations such as for bloodstream infections, sepsis, and ventilator-associated pneumonia based on antimicrobial resistance surveillance data from the ICMR-AMRSN network. These documents provide pathogen-specific and syndrome-specific guidance for empiric antibiotic therapy and are intended to support clinical decision-making, especially in facilities lacking local antibiograms or ID expertise. Their use is especially critical for peripheral facilities and secondary hospitals that lack in-house microbiology services or rapid diagnostic tools. By standardizing first-line therapies for common infections such as community-acquired pneumonia, urinary tract infections, and sepsis, these protocols help reduce unnecessary escalation to broad-spectrum and Reserve group antimicrobials.

In 2023, ICMR also supported the development of State-level Antibiotic Guidelines (State Antibiotic Guidelines, Version 1.0 – 2023), in collaboration with various State Health Departments and medical colleges. These documents were tailored to regional resistance profiles and local prescribing practices, and are intended to support district hospitals and block-level facilities in making informed therapeutic decisions. They promote the use of locally generated antibiograms, when available, and align closely with national formulary policies and essential drug lists.

Taken together, these reference frameworks underscore that antimicrobial stewardship is not a standalone activity but a cross-cutting function that must be embedded within the larger continuum of patient care, infection control, clinical diagnostics, pharmacy services, and hospital supply chain management. Their successful uptake depends not only on availability, but also on adaptation to local realities, regular training of clinical teams, and enforcement through regulatory mechanisms.

2.4. Available guidelines and Standard Operating Procedures for Customizing Tier Specific AMSP and its implementation

- Antimicrobial Stewardship Program Guideline published by ICMR, 2018
- Guidance on Diagnosis & Management of Carbapenem Resistant Gram-negative Infections published by ICMR, 2022
- Treatment Guidelines for Antimicrobial Use in Common Syndromes-2nd edition published by ICMR, 2019, 2022
- National Essential Diagnostics List, published by ICMR 2019
- Standard Operating Procedures - Bacteriology-2nd edition, published by ICMR, 2019
- Standard Operating Procedures - Mycology Laboratories-2nd edition published by ICMR, 2019
- National Guidelines for Infection Prevention and Control in Healthcare Facilities, National Centre for Disease Control, Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India, January 2020
- Antimicrobial stewardship programmes, in healthcare facilities in LMIC a practical toolkit, Published by WHO, 2019

  https://iris.who.int/bitstream/handle/10665/329404/9789241515481-eng.pdf?sequence=1&isAllowed=y
- National Action Plan on Antimicrobial Resistance (NAP-AMR) Module for Prescribers, Published by NMC, 2024

  https://www.nmc.org.in/wp-content/uploads/2024/06/AMR%20Module%20for%20Prescribers.pdf
- National Action Plan on Antimicrobial Resistance (NAP-AMR) Module for non-Prescribers, Published by NMC, 2024
- State Antibiotic Guideline, Government of West Bengal, 2023

A critical examination of the existing national and global guidelines reveals a structured yet variably implemented framework for tier-specific Antimicrobial Stewardship Programme (AMSP) deployment in India's public health system. The ICMR Antimicrobial Stewardship Program Guideline (2018) serves as the cornerstone policy, detailing institutional mechanisms such as the formation of AMS committees, implementation of formulary restrictions, and audit-feedback cycles. While this guideline is comprehensive for tertiary and large secondary care facilities, its operational feasibility in primary care settings remains limited, primarily due to the absence of in-house microbiology capacity and dedicated pharmacological oversight. The Treatment Guidelines for Antimicrobial Use in Common Syndromes – 2nd Edition (2019) provide empirically grounded, syndrome-wise algorithms intended to standardize antimicrobial therapy. These are highly relevant across all tiers but rely heavily on clinical diagnostic accuracy and access to first-line antimicrobials, both of which are inconsistently available at the primary level.

The Guidance on Diagnosis and Management of Carbapenem-Resistant Gram-negative Infections (2022) reflects ICMR's focus on addressing high-risk resistance patterns, with diagnostic and treatment pathways aligned to tertiary-level infrastructure. However, its integration into secondary-level hospitals is constrained by limited access to molecular diagnostics and sensitivity testing. Moreover, while the National Essential Diagnostics List (2019) and the SOPs for Bacteriology and Mycology Laboratories (2nd Editions, 2019) aim to standardize laboratory protocols, their

practical implementation is often hindered by inadequate laboratory accreditation, absence of automated testing systems, and shortages of trained microbiologists, particularly outside urban centres.

Infection prevention remains a critical but siloed component of stewardship efforts. The National Guidelines for Infection Prevention and Control in Healthcare Facilities (2020), developed by NCDC, provide a structured IPC framework encompassing hand hygiene, surveillance, isolation precautions, and environmental cleaning. Despite their alignment with AMSP objectives, IPC measures are rarely integrated into AMS committees or linked with antimicrobial audit systems, leading to fragmented implementation and missed opportunities for infection-linked antimicrobial control.

Recent additions such as the National Action Plan on AMR Modules for Prescribers and Non-Prescribers (NMC, 2024) signal a welcome shift towards role-specific, modular training. These modules emphasize rational prescribing, pharmacovigilance, and non-prescriber engagement, and are well-positioned to address the knowledge-practice gap in both medical and allied health staff. Complementarily, the WHO Practical Toolkit on AMSP Implementation in LMICs (2019) advocates for context-sensitive, resource-adapted stewardship strategies, such as initiating AMS through prescription audits and pharmacist-led interventions in low-resource hospitals. These resources represent a growing global consensus on the need for scalable stewardship models that are adaptable to local constraints.

However, significant systemic gaps persist. First, while the policy architecture is strong, implementation fidelity varies considerably across tiers due to mismatches between guideline expectations and on-ground resource realities particularly the lack of diagnostic support, trained personnel, and digital infrastructure at primary and secondary levels. Second, the absence of interoperable data systems limits the use of antibiograms and prescribing trend analyses to guide AMS interventions. Third, linkages between AMSP and other vertical programmes such as IPC, laboratory strengthening, procurement, and quality improvement remain weak, leading to duplication of efforts and poor accountability. Lastly, monitoring and evaluation mechanisms for stewardship are not uniformly embedded in institutional performance frameworks, and reporting remains inconsistent even in facilities where AMS structures have been initiated.

In sum, the available guidelines form a technically sound backbone for the design and adaptation of AMSPs across India's tiered public health infrastructure. Yet, their operational potential can only be fully realized through coordinated investments in human resources, infrastructure, cadre-specific training, and embedded governance systems that ensure institutional ownership, regular audit cycles, and actionable data use. Strategic alignment across diagnostic, pharmaceutical, and clinical service delivery components will be essential to convert this robust policy landscape into measurable improvements in antimicrobial use and resistance containment.

To facilitate the translation of policy into practice, ICMR and its network of partner institutions have developed a detailed set of Standard Operating Procedures (SOPs) to support AMSP execution across various types of healthcare facilities. These SOPs provide structured operational guidance for all phases of stewardship from programme setup to data analysis and performance improvement.

1. The SOPs begin with the constitution of AMS Committees, specifying the composition, roles, and responsibilities of AMS leads, clinical microbiologists, hospital pharmacists, infection prevention personnel, and administrative representatives. The formation of these multidisciplinary committees is essential to ensure oversight, continuity, and inter-departmental coordination.

2. Formulary management is another cornerstone of the SOPs. The protocols outline criteria for selecting antimicrobials for institutional formularies, preauthorization processes for Reserve group agents (e.g., colistin, meropenem), and documentation of indication-based prescribing. These steps are especially critical in tertiary care institutions, where antimicrobial consumption tends to be high and oversight is often fragmented.

3. To promote data-driven improvement, the SOPs provide prescription audit tools including audit forms, scoring systems, and feedback templates. These tools are intended for periodic review of empiric and targeted antibiotic use, appropriateness of therapy, adherence to guidelines, and opportunities for de-escalation. Facilities are encouraged to form AMS audit subgroups that conduct reviews either manually or using available digital platforms.

4. Antibiogram development is another essential component of the stewardship framework. The SOPs include step-by-step guidance on data collection from laboratory information systems, validation procedures, stratification of resistance patterns by ward or infection type, and dissemination strategies to prescribers. Pooled district-level antibiograms are recommended in settings where individual facility data are insufficient.

5. To support de-escalation, the SOPs describe clear clinical pathways for transitioning from intravenous to oral antimicrobials, narrowing the spectrum based on culture reports, and stopping antimicrobials when non-bacterial causes are confirmed. These protocols are especially important for preventing prolonged use of broad-spectrum antimicrobials in intensive care and post-surgical wards.

6. Finally, training and capacity-building modules are embedded in the SOP package. These include standard slide decks, pre/post assessments, case vignettes, and checklists for evaluating AMS knowledge and practice. Target audiences include physicians, nurses, pharmacists, and microbiology lab technicians. Tier-specific adaptation of training content is emphasized for instance, primary care training focuses on syndromic management and community engagement, while tertiary training includes audit tools and advanced diagnostics.

Recognizing the heterogeneity of healthcare settings in India, the SOPs emphasize flexibility in implementation. District hospitals lacking electronic health records (EHRs) are advised to utilize paper-based audit tools, employ mobile-based communication platforms for stewardship feedback, and adapt antibiogram formats from nearby tertiary centres. In contrast, tertiary care institutions can leverage EHR-integrated stewardship dashboards, enabling automated prescription flagging, real-time decision support, and linkage with microbiology and pharmacy systems.

The convergence of these SOPs, national guidelines, and policy mandates supported by the AMRES framework offers India a unique opportunity to implement context-specific, scalable, and sustainable AMSP models across healthcare tiers. If effectively institutionalized, these protocols can enhance clinical outcomes, reduce irrational antibiotic use, and build long-term health system resilience against AMR.

Chapter 3

Tier-Specific Framework: Antimicrobial Stewardship as an Integral Component of Health Systems

Antimicrobial resistance (AMR) poses a significant threat to global and national health security. In response, Antimicrobial Stewardship Programmes (AMSPs) have emerged as core strategies to optimize antimicrobial use and limit the emergence and spread of resistant pathogens. These programmes are not standalone technical solutions. Rather, they represent a foundational component of safe, effective, and accountable healthcare systems.

In India, the health system operates through a tiered structure comprising primary, secondary, and tertiary care levels. Each tier differs in terms of service scope, diagnostic infrastructure, clinical capacities, and health workforce availability. These differences necessitate tailored stewardship strategies that reflect the operational context of each level of care. A standardized approach to AMSP implementation is not feasible across this gradient. The structural realities of resource-constrained primary health centres, mid-capacity district hospitals, and fully equipped medical colleges demand differentiated models that are practical, scalable, and relevant to local clinical needs.

For AMSPs to be effective, they must be integrated into the routine functioning of the health system rather than introduced as parallel, isolated initiatives. This includes embedding stewardship actions within clinical workflows, supply chain management, human resource planning, and monitoring systems. At the same time, AMSPs should be closely aligned with the broader objectives of the Indian public health system, particularly universal health coverage, quality improvement, and rational use of medicines.

An integrated stewardship framework also supports multiple public health goals. It enhances diagnostic reasoning, may reinforce infection prevention and control (IPC), promotes evidence-informed prescribing, and strengthens accountability in service delivery. Through these functions, AMSP contributes to improved patient outcomes, reduced healthcare costs, and sustained antimicrobial effectiveness. Moreover, stewardship efforts should support and reinforce existing programmes under the National Health Mission (NHM), the National Action Plan (NAP) on AMR, and digital health initiatives like Ayushman Bharat Digital Mission (ABDM).

This chapter outlines a tier-specific AMSP framework, structured around the distinct functional realities of India's healthcare tiers. It proposes an operational model that anchors stewardship as a system function, details core elements to be adapted across levels, and suggests mechanisms for integration with ongoing health sector reforms. The objective is to enable a coordinated and context-sensitive stewardship response that strengthens health systems while addressing AMR sustainably.

3.1. Tier-Specific Considerations

India's public health system is organized into three distinct levels: primary, secondary, and tertiary. Each level serves a unique purpose within the healthcare delivery framework. These tiers vary significantly in terms of infrastructure, staffing patterns, diagnostic capabilities, and the complexity of care provided. Therefore, antimicrobial stewardship efforts must be tailored to reflect the functional realities at each level. A uniform stewardship model applied across all tiers would likely fail to address the specific needs in view of strengths and constraints of each setting. Designing tier-specific stewardship ensures that interventions are both relevant and feasible, thereby improving the likelihood of uptake and sustained implementation.

The structure of the AMSP (Antimicrobial Stewardship Programme) committee as suggested by WHO[1] is flexible and context-specific, designed to accommodate the functional realities and resource availability across different tiers of the health system. It is not fixed, and may be adapted according to institutional capacity and staff availability. Broadly, three structural options may be considered: (1) a multidisciplinary team comprising more than two healthcare professionals, commonly seen in tertiary hospitals; (2) a simplified team consisting of a prescriber and a nurse or pharmacist, typically suitable for secondary-level or smaller hospitals; or (3) an AMS champion such as a physician, nurse, or pharmacist who leads the stewardship programme with access to expert consultation when needed. In addition to the formal AMS team, other health-care professionals (e.g. from internal medicine, ICU, surgery, pharmacy, nursing, or health informatics) may be engaged in AMS activities as per the facility's AMS action plan and priority areas. Furthermore, a clearly defined mechanism for collaboration between AMS and IPC (Infection Prevention and Control) programmes is essential. This may be formally documented and, in low-resource settings, the AMS and IPC functions may be merged into a single joint committee to streamline coordination and resource use.

Tertiary Level: Medical Colleges and Super-Specialty Hospitals

Tertiary care facilities are the most well-equipped places in the public health system. These institutions usually have advanced labs, full-time clinical microbiologists, infectious disease specialists (may or may not be present), trained pharmacists, and electronic medical record keeping systems. The number of cases both simple and complex ones and use of medication including antimicrobials for their management calls for structured , data-driven stewardship practices.

In general, necessary facilities present in a tertiary care center may be divided under three headings:

- Infrastructure
- Diagnostic facilities
- Personnel

There are specific government laid guidelines on specifications of infrastructure depending on services they provide. The tertiary care centers are supposed to provide both the general as well as specialized treatment and hence, they are equipped with infrastructure required for management of general conditions to critical care under different departments.

Tertiary care hospitals provide both general and specialized laboratory and imaging services. Presence of microbiological diagnostic laboratories at tertiary tiers makes the antimicrobial therapy at that level far more objective and rationale.

Staffing pattern and number again varies depending on the range of services provided by the hospital. Generally a tertiary care center is equipped with both general duty doctors, specialists and in case of teaching hospital, Internees, resident doctors play a vital role in providing patient care. Nursing staff, technical staff, laboratory staff, administrative staff, cleanliness management staff are the core of maintaining quality patient care services in a tertiary tier hospital. Though there is a guideline on the number of staff depending on range of service and bed number, often it remains unmet for each category. In this current backdrop of laid guidelines on infrastructure, diagnostic facility, human resources, implementation of all AMSP interventions are not possible even at tertiary level. Method of identifying implementable package of AMSP interventions at present scenario at tertiary level:

[1] Antimicrobial stewardship programmes, in healthcare facilities in LMIC a practical toolkit, Published by WHO, 2019 https://iris.who.int/bitstream/handle/10665/329404/9789241515481-eng.pdf?sequence=1&isAllowed=y

A Delphi method was obtained to reach the consensus regarding the package of AMSP interventions. The problem statement was identified through a convergent parallel study conducted at three tiers of hospitals across three districts of West Bengal. First three rounds of survey for identification of AMSP package from the prescribed set in NAP AMR 2.0 were conducted among varied group of experts across tiers including the end users. The fourth and fifth rounds were conducted with homogenous expert group from this relevant field to set the closing criterion and reach to a consensus based on plurality and feasibility of implementation.

The AMSP interventions feasible to be implemented are:

- Prospective Audit & Feedback
- Antimicrobial time out
- Clinical Guideline & pathways
- Laboratory surveillance & feedback
- Information, Education & Communication
- Formulary restriction
- Antimicrobial consumption patterns

SWOT analysis of present infrastructure, diagnostic facilities, staffing pattern was an integral part of the last two rounds of survey. Based on the AMR Module for Prescribers and the tier-specific SWOT analysis, we selected five core AMSP interventions prospective audit and feedback, antimicrobial timeout, antimicrobial consumption analysis, formulary restriction, and use of guidelines and clinical pathways as foundational across all tiers. These were prioritized due to their strong alignment with NAP-AMR 2.0, feasibility within existing systems, and potential to strengthen institutional prescribing practices. While audit mechanisms and guidelines exist in many settings, they are largely unstructured or underutilized; reinforcing them was deemed both impactful and realistic. Timeout and formulary restriction, though less practiced, are essential for controlling inappropriate use and can be implemented with standard operating procedures and basic training. Consumption analysis was selected to support both surveillance and procurement alignment. Supplemental interventions such as laboratory surveillance and IEC were contextually included primarily in secondary and tertiary tiers based on infrastructure availability and workforce readiness. This phased and tier-specific approach ensures the stewardship response is both grounded and scalable.

[2] National Action Plan on Antimicrobial Resistance (NAP-AMR) Module for Prescribers, Published by NMC, 2024 https://www.nmc.org.in/wp-content/uploads/2024/06/AMR%20Module%20for%20Prescribers.pdf

Table 1: SWOT Analysis for implementation of Antimicrobial Stewardship Interventions in Tertiary Tier Healthcare Settings

Intervention[3]	Strength	Weakness
Prospective Audit & Feedback	• Antibiotic policy document of State Health Department in place • Individual hospital based antibiotic policy is in place • Audit is on-going, though unstructured • Availability of audit guidelines and audit checklist • Presence of AMSP committee • Presence of specialist doctors to conduct prescription audit and also to provide handholding support to the lower tier hospitals	• Audit implementation is unstructured • Lack of awareness regarding process of feedback system among doctors
	Opportunity	**Threat**
	• Linking audit indicators with hospital quality assurance indicators • Integration of technology in audit and feedback process	• Setting accountability to the auditors • Documentation overload for external quality assurance • Patient overload due to non-systematic referrals may complicate the process of implementation of the intervention.
Antimicrobial Timeout	**Strength**	**Weakness**
	• Mention of antimicrobial timeout as an AMSP intervention in NAP AMR 2.O • Availability of different unit system in the departments • Presence of residents, qualified nursing staff and faculties	• The process of executing antimicrobial time out in IPDs is not mentioned in NAP AMR 2.O • Lack of awareness among the doctors and nursing staff regarding antimicrobial timeout • Hierarchical barriers in communicating the need of 48 hours antibiotic review to attending medical officer / physicians / doctors • Nursing staff, being involved in multiple tasks leading to lack of motivation • Lack of formal training regarding AMSP intervention among both doctors and nursing staff • Lack of adequate engagement of the hospital leadership • Lack of supervision from the higher authority like district/state
	Opportunity	**Threat**
	• Use of timeout as an indicator for quality of hospital patient care • Integration of technology in patient management and monitoring • Presence of Infection Control Nurse (ICN) who can train and supervise other nursing staff while implementing intervention	• Increasing workload creates hindrances in implementation • Implementation challenges due to understaffing and burnout

[3] National Action Plan on Antimicrobial Resistance (NAP-AMR) Module for Prescribers, Published by NMC, 2024 https://www.nmc.org.in/wp-content/uploads/2024/06/AMR%20Module%20for%20Prescribers.pdf

Intervention[3]	Strength	Weakness
Clinical Guidelines and Pathways	• ICMR & State Antibiotic Guidelines are available • Regular updation of guidelines and policies	• Lack of awareness regarding its availability • Lack of formal training on updated guidelines & policies • Perceived disagreement of the doctors with the content of the guidelines • Rigidity in bringing change in common practice by doctors • Empirical treatment is being followed due to lack of diagnostic laboratory services • Adherence to guidelines due to lack of diagnostic infrastructure
	Opportunity	Threat
	• Presence of national level AMR surveillance creating scope for regular updation of guidelines • Inclusion of technology for central management of pharmacy stock as per guidelines	• Setting accountability to the auditors • Documentation overload for external quality assurance • Due to patient overload due to non-systematic referrals, maintaining the whole process may make the implementation of this intervention difficult
Laboratory Surveillance & Feedback	Strength	Weakness
	• Presence of laboratory infrastructure with qualified microbiologists • Creating their own database on AST reports of common bacteria	• Absence of any in house laboratory surveillance for bacterial pathogens
	Opportunity	Threat
	• Creating scope for NABL accreditation • Installation of high end equipment	

Intervention[3]	Strength	Weakness
Information , Education & Communication (IEC)	• Presence of AMR guidelines • Training platforms for different programmes are available which can be leveraged for AMSP as well	• No formal training of AMR or AMSP • Lack of adequate engagement from the leadership
	Opportunity	**Threat**
	• Incorporating technology for designing self-paced adult learning module on AMR AMSP • Linking AMR training to career development of doctors and nursing staff • Presence of existing IEC cell can be leveraged to develop IEC materials related to AMR	• Gap in communication with higher centres • Lack of motivation • Involvement of additional cost for conducting regular workshop and training programmes
Preauthorization	**Strength**	**Weakness**
	• Presence of updated treatment guidelines • Presence of specialists / senior doctors for further consultation	• Non availability of antibiotic order form • Lack of awareness about benefit of preauthorization among doctors • The general prescribing patterns are inclined towards use of higher generations of antibiotic empirically • This process demands quick response from consulting doctors and preauthorization committee
	Opportunity	**Threat**
	• Pharmacist may be used for establishing the communication among the preauthorization team and the prescribing doctor • Incorporation of technology	• Resource intensive process
Antimicrobial consumption patterns	**Strength**	**Weakness**
	• Availability of electronic data base for medicine stock maintenance • Presence of pharmacist, and pharmacologist wherever available	• Absence of implementation of universal e-prescription • Illegible hand writing leading to dispensing problems • Non utilization of prescription data for antibiotic consumption analysis
	Opportunity	**Threat**
	Updating of existing database for archival of necessary information to analyze antibiotic dispensing patterns	• Requires skilled human resouces

Table 2: Tiered Action Framework for Strengthening Antimicrobial Stewardship in Tertiary Healthcare Settings

Component	Immediate Action (1 year) Quick-start actions using current capacity	Mid-Term Action (3 years) Structured rollout with systems and supervision	Long-Term Action (3-5 years) Integrated into institutional policies and digital systems
Prospective Audit & Feedback	• Standardize audit tools and formats • Sensitize doctors and AMSP committee on structured feedback • Appoint focal audit leads	• Digitize audit forms and link to hospital QI indicators • Conduct structured monthly audit-feedback meetings • Clarify roles and accountability	• Integrate audit-feedback into EMR/QI dashboards • Link audit outcomes to hospital accreditation or internal reviews
Antimicrobial Timeout	• Display antimicrobial timeout SOPs visibly in departments • Conduct sensitization for doctors and nursing staff • Identify ICNs to support compliance	• Develop unit-level timeout protocols • Train doctors and nursing staff through dedicated sessions • Monitor via unit-level trackers	• Integrate timeout into EMR with automatic reminders • Use timeout adherence as a core patient care quality metric
Clinical Guidelines	• Disseminate current ICMR/state guidelines hospital-wide • Organize CME to introduce them	• Conduct department-level consensus-building sessions • Train junior staff through case studies based on adherence to guidelines	• Institutionalize a guideline update mechanism linked to AMR surveillance • Align pharmacy procurement with guideline compliance
Laboratory Surveillance & Feedback	• Compile existing AST data and display cumulative antibiograms • Identify gaps in routine pathogen surveillance	• Begin quarterly AST reporting and feedback sessions • Explore external mentorship or PPP support for strengthening microbiology	• Work towards NABL accreditation • Create live-access hospital antibiograms integrated into prescribing workflows
IEC & Training	• Leverage existing IEC/training platforms for AMR sessions • Share updated guidelines and SOPs via digital media	• Develop self-paced modules on AMR/AMSPs • Train internal trainers for department-level peer education	• Institutionalize AMR/AMSPs training in hospital HR policy • Tie training completion to appraisals or leadership eligibility
Preauthorization	• Introduce restricted antibiotic list and communicate policy • Development of simplified antibiotic order forms	• Set up a responsive preauthorization team • Train pharmacists to coordinate between doctors and preauth committees	• Embed preauthorization alerts into EMR • Monitor compliance and impact on outcomes; refine process for speed and efficiency
Antimicrobial Consumption	• Initiate manual tracking of select antibiotic classes from stock records • Review patterns in internal pharmacy meetings	• Analyze prescribing indicators using DDD/DOT metrics • Pilot universal e-prescription in targeted units	• Build institutional AMU dashboards • Integrate AMU data into AMSPs review cycles and link to procurement decisions

Secondary Level: District and Sub-District Hospitals

Secondary care facilities have fewer resources than tertiary centers but serve a large part of the population, especially in semi-urban and rural areas. Diagnostic capabilities are often limited, and the availability of trained specialists varies widely. Despite these challenges, implementing stewardship at the secondary level is both necessary and possible if the model is adapted to the local context. Key stewardship actions suitable for this tier include:

- **Using syndromic treatment guidelines** to simplify decision-making for common infections, especially when lab confirmation is not available.
- **Conducting monthly prescription audits** with structured checklists to assess adherence to guidelines and detect patterns of overuse or misuse.
- **Using antibiograms** from nearby tertiary referral centers to guide empirical therapy when local microbiological data is unavailable.
- **Providing periodic AMSP training programs** for doctors, supported by state health departments or linked academic institutions.
- **Integrating stewardship with IPC protocols** to prevent healthcare-associated infections that may result in unnecessary or prolonged antibiotic use.

At this level, including facility administrators and nursing leadership in program oversight is beneficial, given their influence over routine operational decisions.

Table 3: SWOT Analysis for implementation of Antimicrobial Stewardship Interventions in Secondary Tier Healthcare Settings

Intervention[3]	Strength	Weakness
Prospective audit & feedback	• Antibiotic policy document of State Health Department in place • Process of audit on-going, though unstructured • Availability of audit guidelines and audit checklist	• Audit process is irregular and unstructured • Lack of awareness about need, process and advantages of prescription audit and feedback process among the doctors • Lack of awareness regarding process of feedback system among doctors • Timeliness of prescription audit is not defined • Resource persons identification • Acceptability of the pharmacist by local hospital administration as auditors
	Opportunity	**Threat**
	• Implementation of tier specific AMSP • Documentation of prescription audit and feedback may be used as evidence of quality of services provided in the hospitals • Surprise prescription audit by experts or trained auditors • Create a pool of trained prescription auditors • Integration of technology in audit and feedback process • Decentralized training of doctors regarding need, process and advantage of prescription audit • Using pharmacist as the resource person in audit process if pharmacologist is unavailable • Define frequency formats and antimicrobial uses • Introduction of incentives to the doctors for good quality prescriptions	• Setting accountability to the auditors • Peer-Led audit • Escalation of documentation & reporting

Intervention[3]	Strength	Weakness
Antimicrobial timeout	• Mention of antimicrobial timeout as an AMSP intervention in NAP AMR 2.0 • Availability of qualified nursing staffs who can perform the activities related to antimicrobial timeout	• The process of executing antimicrobial time out at IPDs of different tier hospitals not being mentioned in NAP AMR 2. • Lack of awareness among both the doctors and nursing staff regarding antimicrobial timeout • Absence of treatment unit concept in lower tier hospitals • Hierarchical barriers in communicating the need of 48 hours antibiotic review to attending medical officers • Inadequate nursing staff, being involved in multiple tasks, lack of motivation • Lack of formal training regarding AMSP intervention • Lack of supervision from the higher authority • Increasing workload creates hindrances in implementation • Implementation challenges due to understaffing and burnout • Absence of basic lab facilities for executing antimicrobial timeout
	Opportunity	Threat
	• Strengthening training for AMSP intervention • Use of timeout as an indicator for quality of hospital patient care • Integration of technology in patient management and monitoring • Presence of Infection Control Nurse (ICN) who can train, supervise other nursing staff while implementing intervention	• Increasing workload creates hindrances in implementation • Implementation challenges due to understaffing and burnout
Clinical guidelines and pathways	Strength	Weakness
	• ICMR & State Antibiotic Guidelines are available • Availability of Updated guidelines and policies	• Lack of awareness regarding its availability • Lack of formal training on updated guidelines & Policies • Perceived disagreement of the doctors with the contain of the present guidelines • Rigidity in bringing change in common practice by doctors
	Opportunity	Threat
	• Presence of national level AMR surveillance creating scope for regular updation of guidelines • Inclusion of technology for central management of pharmacy stock as per guidelines	• Mismatch of the mentioned medicines in the guideline with the hospital supplied medicine

Intervention[3]	Strength	Weakness
Laboratory surveillance & feedback	• Availability of basic laboratory set up for conducting point of care testing (POCT) • Qualified laboratory technician is available	• Non-availability of microbiological culture setup • Lack of motivation
	Opportunity	**Threat**
	• Existing PPP model for other diagnostic services where necessary • Creating their own data base on AST reports • Linkage with the nearest or closest tertiary care centre creates the opportunity to capacitate the primary hospitals to generate their own antibiogram	• Out of pocket expenditure creates a hindrance in the success of PPP model • Quality of the reports generated by the PPP model • Non-availability of continued resources for laboratory maintenance • Absence of any laboratory surveillance for bacterial pathogens due to limited capacity
Information , Education & Communication (IEC)	**Strength**	**Weakness**
	• Presence of AMR guidelines are available • Training platforms for different programmes are available which can be leveraged for AMSP as well	• No formal training of AMR or AMSPs • Lack of adequate engagement from the leadership
	Opportunity	**Threat**
	• Incorporating technology for designing self-paced adult learning module on AMR AMSPs • Linking AMR training to career developments of doctors and nursing staff • Presence of existing IEC cell can be leveraged to develop IEC materials related to AMR	• Gap in communication with higher centres • Lack of motivation • Involvement of additional cost for conducting regular workshop and training programmes
Preauthorization	**Strength**	**Weakness**
	• Presence of updated treatment guidelines • Presence of specialists / senior doctors for further consultation	• Non availability of antibiotic order form • Lack of awareness about benefit of formulary restriction among doctors • The general prescribing patterns inclines towards use of higher generations antibiotic without much evidence
	Opportunity	**Threat**
	• Pharmacist may be used for establishing the communication	• Resistance from doctors through this mechanism • Process demanding quick response from consulting doctors • Delay in responding the quarries placed to the preauthorization committee leading to unfavorable patient outcome • Resource intensive process

Table 4: Tiered Action Framework for Strengthening Antimicrobial Stewardship in Secondary Healthcare Settings

Component	Immediate Action (1 year) Quick-start actions using current capacity	Mid-Term Action (3 years) Structured rollout with systems and supervision	Long-Term Action (3-5 years) Integrated into institutional policies and digital systems
Prospective Audit & Feedback	• Disseminate audit SOPs and checklists • Sensitize doctors through internal meetings/workshop • Identify pharmacists as interim auditors	• Disseminate audit SOPs and checklists • Sensitize doctors through internal meetings/workshop • Develop a pool of trained auditor	• Disseminate audit SOPs and checklist • Sensitize doctors through internal meetings/workshop • Identify pharmacists as interim auditors
Antimicrobial Timeout	• Conduct sensitization for doctors and nursing staff • Display SOPs and process visuals • Engage ICNs	• Conduct sensitization for doctors and nursing staff • Display SOPs and process visuals • Engage ICNs	• Conduct sensitization for doctors and nursing staff • Display SOPs and process visuals • Engage ICNs
Clinical Guidelines	• Distribute updated ICMR/State AMR guidelines in print/digital • Orient doctors and nursing staff through staff meetings	• Distribute updated ICMR/State AMR guidelines in print/digital • Orient doctors and nursing staff through staff meetings	• Distribute updated ICMR/State AMR guidelines in print/digital • Orient doctors and nursing staff through staff meetings
Laboratory Surveillance & Feedback	• Use existing POCT for basic diagnostics • Regularly document and display what is available • Quality assurance for diagnostic lab monitoring and evaluation	• Use existing POCT for basic diagnostics • Regularly document and display what is available • Quality assurance for diagnostic lab monitoring and evaluation	• Use existing POCT for basic diagnostics • Regularly document and display what is available • Quality assurance for diagnostic lab monitoring and evaluation
IEC & Training	• Share AMR related messages via digital media, display posters/ circulate flyers or pamphlets • Leverage ongoing trainings to include AMR concepts	• Share AMR related messages via digital media, display posters/ circulate flyers or pamphlets • Leverage ongoing trainings to include AMR concepts	• Share AMR related messages via digital media, display posters/ circulate flyers or pamphlets • Leverage ongoing trainings to include AMR concepts
Formulary Restriction	• Circulate restricted antibiotic list and prescribing SOPs • Raise awareness through senior doctors' endorsement	• Circulate restricted antibiotic list and prescribing SOPs • Raise awareness through senior doctors' endorsement	• Circulate restricted antibiotic list and prescribing SOPs • Raise awareness through senior doctors' endorsement

Primary Level: Sub-Centres (SCs),), Health and Wellness Centres (HWCs), Primary Health Centres (PHCs) and Block Primary Health Centres (BPHCs/CHCs)

Primary care facilities are the backbone of India's health system, especially in rural and underserved areas. These settings usually don't have microbiology labs, and doctors or Mid-Level Health Providers (MLHPs) manage patients with limited support. Clinical decisions are often based on symptoms rather than lab tests. However, this level of care offers important opportunities for stewardship, particularly in reducing unnecessary or inappropriate antibiotic prescriptions for self-limiting infections. Key stewardship actions at the primary level include:

- **Using visual job aids and treatment guidelines** tailored to common infections like upper respiratory infections, diarrhea, and urinary tract infections.
- **Employing pictorial charts and dosage tools** to ensure correct antibiotic selection, dosing, and duration, especially when multiple providers (including AYUSH practitioners and nurses) are involved.
- **Establishing referral protocols** for suspected drug-resistant or treatment-refractory cases to ensure timely escalation of care.
- **Conducting community-level awareness** activities through ASHAs and ANMs, focusing on the risks of self-medication, incomplete antibiotic courses, and over-the-counter antimicrobial use.
- **Engaging with informal healthcare providers and pharmacists**, many of whom act as primary care providers in remote areas. Basic training on rational antibiotic dispensing and AMR messaging can extend stewardship influence beyond formal facilities.

While the technical complexity is lower at the primary level, the potential for system-wide impact is high due to the large volume of outpatient consultations and the widespread use of antibiotics at this level.

Table 5: SWOT Analysis for implementation of Antimicrobial Stewardship Interventions in Primary Tier Healthcare Settings

<table>
<tr><th>Intervention[3]</th><th>Strength</th><th>Weakness</th></tr>
<tr><td rowspan="3">Prospective Audit & Feedback</td><td>• The antibiotic policy document of State Health Department is in place.
• Audit is on-going, though unstructured.
• Audit guidelines and audit checklist is available. (Reference)</td><td>• The audit process is irregular and unstructured.
• There is lack of awareness about need, process and advantages of prescription audit and feedback process among the doctors.
• There is lack of awareness regarding process of feedback system among doctors.
• Timeliness of prescription audit is not defined
• Resource persons identification
• Acceptability of the pharmacist by local hospital administration as auditors</td></tr>
<tr><th>Opportunity</th><th>Threat</th></tr>
<tr><td>• Implementation of tier specific AMSP
• Documentation of prescription audit and feedback may be used as evidence of quality of services provided in the hospitals
• Surprise prescription audit by experts or trained auditors
• Create a pool of trained prescription auditors
• Integration of technology in audit and feedback process
• Decentralized training of doctors regarding need, process and advantage of prescription audit
• Using pharmacist as the resource person in audit process if pharmacologist is unavailable
• Define frequency formats and antimicrobial uses
• Introduction of incentives to the doctors for good quality prescriptions</td><td>• Setting accountability to the auditors
• Peer-Led audit
• Escalation of documentation & reporting</td></tr>
</table>

<table>
<tr><th>Intervention[3]</th><th>Strength</th><th>Weakness</th></tr>
<tr><td rowspan="3">Antimicrobial Timeout</td><td>• Mention of antimicrobial timeout as an AMSP intervention in NAP AMR 2.0
• Availability of qualified nursing staffs who can perform the activities related to antimicrobial timeout</td><td>• The process of executing antimicrobial time out at IPDs of different tier hospitals not being mentioned in NAP AMR 2.
• Lack of awareness among both the doctors and nursing staff regarding antimicrobial timeout
• Absence of treatment unit concept in lower tier hospitals
• Hierarchical barriers in communicating the need of 48 hours antibiotic review to attending medical officers
• Inadequate nursing staff, being involved in multiple tasks, lack of motivation
• Lack of formal training regarding AMSP intervention
• Lack of supervision from the higher authority
• Increasing workload creates hindrances in implementation
• Implementation challenges due to understaffing and burnout
• Absence of basic lab facilities for executing antimicrobial timeout</td></tr>
<tr><th>Opportunity</th><th>Threat</th></tr>
<tr><td>• Strengthening for training regarding AMSP intervention
• Use of timeout as an indicator for quality of hospital patient care
• Integration of technology in patient management and monitoring
• Presence of Infection Control Nurse (ICN) who can train, supervise other nursing staff while implementing intervention</td><td>• Increasing workload creates hindrances in implementation
• Implementation challenges due to understaffing and burnout</td></tr>
</table>

Intervention[3]	Strength	Weakness
Clinical Guidelines and Pathways	• ICMR & State Antibiotic Guidelines are available • Regular updation of guidelines and policies	• Lack of awareness regarding its availability • Lack of formal training on updated guidelines & policies • Perceived disagreement of the doctors with the content of the guidelines • Rigidity in bringing change in common practice by doctors • Empirical treatment is being followed due to lack of diagnostic laboratory services • Adherence to guidelines due to lack of diagnostic infrastructure
	Opportunity	**Threat**
	• Presence of national level AMR surveillance creating scope for regular updation of guidelines • Inclusion of technology for central management of pharmacy stock as per guidelines	• Mismatch of the mentioned medicines in the guideline with the hospital supplied medicine
Laboratory Surveillance & Feedback	**Strength**	**Weakness**
	• Availability of basic laboratory set up for conducting point of care testing (POCT) • Qualified laboratory technician is available	• Non-availability of microbiological culture setups • Lack of motivation
	Opportunity	**Threat**
	• Existing PPP model for other diagnostic services where necessary • Creating their own data base on AST reports of common bacteria • Linkage with the nearest or closest tertiary care centre creates the opportunity to capacitate the primary hospitals to generate their own antibiogram	• Out of pocket expenditure creates a hindrance in the success of PPP model • Quality of the reports generated by the PPP model • Non-availability of continued resources for laboratory maintenance • Absence of any laboratory surveillance for bacterial pathogens due to limited capacity
Information , Education & Communication (IEC)	**Strength**	**Weakness**
	• Presence of AMR guidelines are available • Training platforms for different programmes are available which can be leveraged for AMSP as well	• No formal training of AMR or AMSPs • Lack of adequate engagement from the leadership
	Opportunity	**Threat**
	• Incorporating technology for designing self-paced adult learning module on AMR AMSPs • Linking AMR training to career developments of doctors and nursing staff • Presence of existing IEC cell can be leveraged to develop IEC materials related to AMR	• Gap in communication with higher centres • Lack of motivation • Involvement of additional cost for conducting regular workshop and training programmes

Table 6: Tiered Action Framework for Strengthening Antimicrobial Stewardship in Primary Healthcare Settings

Component	Immediate Action (1 year) Quick-start actions using current capacity	Mid-Term Action (3 years) Structured rollout with systems and supervision	Long-Term Action (3-5 years) Integrated into institutional policies and digital systems
Prospective Audit & Feedback	• Disseminate audit guidelines and SOPs • Identify and train available pharmacists as interim resource persons • Raise awareness among doctors through facility meetings/workshop	• Define standard formats and frequency for audits • Develop a pool of trained auditors at block/district level • Introduce peer-led audit reviews	• Define standard formats and frequency for audits • Develop a pool of trained auditors at block/district level • Introduce peer-led audit reviews
Antimicrobial Timeout	• Conduct orientation sessions for doctors and nursing staff • Develop posters/charts and simplified collated SOPs for timeout • Identify ICNs to support supervision	• Conduct orientation sessions for doctors and nursing staff • Develop posters/charts /digital display and simplified collated SOPs for timeout • Identify ICNs to support supervision	• Conduct orientation sessions for doctors and nursing staff • Develop digital display and simplified collated SOPs for timeout • Identify ICNs to support supervision
Clinical Guidelines	• Raise awareness on available updated antibiotic guidelines (ICMR/ State) for HCWs (doctors, nursing staff and pharmacist) • Orient staff on availability and purpose	• Raise awareness and evaluate knowledge on available updated antibiotic guidelines (ICMR/State) for HCWs (doctors, nursing staff and pharmacist) • Orient staff on availability and purpose	• Raise awareness and evaluate knowledge on available updated antibiotic guidelines (ICMR/State) for HCWs (doctors, nursing staff and pharmacist) • Orient staff on availability and purpose
Laboratory Surveillance & Feedback	• Utilize existing POCT for basic tests (CBC, CRP, urine R/E, malaria, dengue) • Quality assurance for diagnostic lab monitoring and evaluation	• Utilize existing POCT for basic tests (CBC, CRP, urine R/E, malaria, dengue) • Quality assurance for diagnostic lab monitoring and evaluation	• Utilize existing POCT for basic tests (CBC, CRP, urine R/E, malaria, dengue) • Quality assurance for diagnostic lab monitoring and evaluation
IEC & Training	• Disseminate AMR materials via posters/ circulate flyers or pamphlets • Integrate AMR topics into ongoing training sessions Organize special AMR campaigns and circulate public awareness messages	• Disseminate AMR materials via digital media, display posters/ circulate flyers or pamphlets • Integrate AMR topics into ongoing training sessions	• Disseminate AMR materials via digital media, display posters/ circulate flyers or pamphlets • Integrate AMR topics into ongoing training sessions

Tiered Readiness and Systemic Convergence in AMSP Implementation Across India's Public Health System

The implementation of Antimicrobial Stewardship Programmes (AMSPs) across India's public health system organized into primary, secondary, and tertiary tiers presents both a challenge and an opportunity. While the structural and functional characteristics of each tier differ significantly, a comparative SWOT analysis reveals common systemic enablers and constraints shaping the trajectory of stewardship efforts across all levels. The following narrative builds on tier-specific SWOT assessments and visual implementation maps to present both grounded observations and overarching patterns in AMSP readiness.

Tier-Specific Insights from SWOT Analysis

Primary Tier

At the primary care level, the stewardship agenda is at a formative stage. Although policy frameworks, audit checklists, and basic guidelines are in place, their translation into practice remains inconsistent. Key barriers include the absence of trained staff, diagnostic infrastructure, and routine feedback systems. Prescriptions are largely empirical, antimicrobial time-outs are rarely practiced, and pharmacists are underutilized in stewardship processes. Despite these constraints, this tier holds promise for early wins through simplified audit formats, point prevalence surveys, and pharmacist-led task-sharing models. However, unless training is institutionalized and linked to supervisory structures, implementation will remain sporadic and unsystematic.

Secondary Tier

The secondary tier demonstrates greater structural readiness. AMSP committees, access to formal guidelines, and partial diagnostic resources are typically present. However, stewardship practices such as audits and preauthorization lack standardization and often suffer from unclear timelines and weak feedback loops. Diagnostic capacity is insufficient for real-time surveillance, and guideline adherence is undermined by drug-stock mismatches and low doctor buy-in. Nevertheless, this tier offers strategic leverage for strengthening AMSPs through modest but targeted investments in laboratory capacity, digital tools for audit and formulary management, and tier-specific training linked to professional growth.

Tertiary Tier

At the apex of the system, tertiary facilities exhibit the strongest AMSP infrastructure. Dedicated AMSP committees, access to updated guidelines, availability of pharmacologists and specialists, and surveillance capacity provide a solid foundation. However, implementation challenges persist. High patient volumes, poor audit standardization, limited digitization, and fragmented laboratory surveillance reduce the effectiveness of existing efforts. Prescription monitoring is inconsistent, electronic prescribing systems are rare, and stewardship actions are not yet fully embedded into institutional quality assurance mechanisms. Tertiary centers are well-positioned to serve as technical anchors for lower tiers, but this potential remains underleveraged in the absence of mandate-driven integration and performance-linked stewardship metrics.

Cross-Tier Synthesis: Converging Patterns and Systemic Gaps

Despite contextual differences, the SWOT-based implementation profiles across the three tiers reveal a striking degree of structural similarity. This convergence highlights that AMSP success in India is less dependent on tier-specific solutions and more contingent on addressing system-wide deficiencies.

Strengths are consistently anchored in policy-level support, availability of national/state guidelines, and partial infrastructural readiness. Foundational tools and governance mechanisms are present across all tiers, indicating that AMSPs have been formally adopted within institutional frameworks.

Weaknesses reflect widespread deficiencies in training, awareness, documentation, and feedback systems. Even in tertiary hospitals, stewardship processes remain fragmented, while in lower tiers, they are mostly nascent. These challenges are particularly evident in audit and timeout implementation, which remain underdeveloped due to capacity and leadership gaps.

Opportunities such as technology integration, decentralized training, peer-led audits, and pharmacist involvement are visible across all levels. However, they remain partially realized. The institutionalization of these opportunities is hampered by unclear ownership, inconsistent mandates, and lack of scale-up mechanisms.

Threats are uniformly under-addressed. Issues such as doctor resistance, lack of incentives, diagnostic limitations, and infrastructure mismatches are frequently reported but rarely acted upon. This quadrant represents the lowest implementation status across all tiers, pointing to a systemic gap in risk mitigation and governance accountability.

Implications for Action

To strengthen AMSP implementation in India's public sector, stewardship efforts must be both tier-responsive and system-integrated. The primary tier requires foundational support in training, supervision, and referral diagnostics. The secondary tier needs protocol standardization, surveillance investment, and workforce incentives. The tertiary tier demands institutionalization through digital integration, cross-departmental accountability, and performance-linked stewardship indicators.

Crucially, bi-directional learning must be formalized : tertiary facilities should support downward capacity-building while also integrating field-level innovations and contextual practices from lower tiers. Stewardship architecture should prioritize horizontal coherence and vertical scalability to ensure that AMSP implementation is not only compliant, but adaptive, equitable, and impactful.

These findings align with the strategic objectives of India's NAP-AMR 2.0 and the WHO Global Action Plan on AMR, reinforcing the need for tier-differentiated but system-harmonized stewardship interventions embedded within routine health service delivery.

3.2 Core Framework Elements Across Tiers

A tier-specific antimicrobial stewardship framework needs a consistent yet flexible set of core components that can work well in different healthcare settings. These components must match the capabilities of each tier, from well-equipped tertiary hospitals to resource-limited primary health centres. While the stewardship principles stay the same, their implementation must fit the infrastructure, staff, and service delivery methods of each level. The following core elements are essential for establishing AMSP across all tiers.

a. Leadership and Governance

Effective stewardship needs strong institutional ownership and clear roles at every administrative level. At the state and district levels, health departments should appoint stewardship focal points to coordinate implementation, provide oversight, and align with broader AMR strategies. Tertiary care facilities should set up formal AMSP nodal units, usually led by a senior clinician or microbiologist and supported by pharmacists and IPC personnel. These units guide clinical audits, develop facility-specific antibiograms, and ensure adherence to antibiotic policies. In primary care settings, where leadership capacity is limited, the Medical Officer-in-Charge (MOIC) or Mid-Level Health Provider (MLHP) should oversee basic stewardship tasks. Their role includes implementing treatment guidelines, maintaining simple audit logs, and coordinating awareness activities.

b. Training and Capacity Building

Ongoing training is crucial for creating a skilled workforce that can handle stewardship tasks. Training should be customized to the roles and environments at each level of care. In tertiary hospitals, Continuing Medical Education (CME) programs, e-learning modules, and clinical case conferences can help deepen knowledge in antimicrobial selection, diagnostics, and resistance trends. At the secondary level, training should focus on following protocols, interpreting audits, and practicing infection control. For primary care providers, simpler modules that emphasize managing symptoms, safe prescribing, and patient counseling are more suitable. Cascade training models, where teams trained at tertiary hospitals train district-level counterparts, who then train PHC staff, offer a scalable approach for India's health system.

c. Monitoring and Feedback

Tracking how antibiotics are used and providing feedback is key to changing prescribing habits. However, the tools and data systems must match the facility's capacity. In tertiary centers, electronic health records can precisely track antibiotic use with indicators like Defined Daily Dose (DDD) per 1,000 patient-days, allowing for detailed trend analysis and benchmarking. District hospitals might use simple manual audit forms or Excel-based logs to track antibiotic use by department. Primary health centers, where

digital systems are rare, can use printed registers to record prescriptions and flag deviations from treatment guidelines. No matter the method, regular feedback whether through dashboards, summary reports, or supervisory discussions is crucial for maintaining accountability and continuous improvement.

d. Guidelines and Protocols

Every healthcare facility should follow Standard Treatment Guidelines (STGs) to ensure evidence-based and rational prescribing. These guidelines need to be tailored to the facility's diagnostic capabilities, common diseases, and available medications.

In tertiary and district hospitals, state-endorsed guidelines and national protocols should be adapted using facility-specific antibiogram data. This helps in making informed decisions based on local resistance patterns. On the other hand, Primary Health Centres (PHCs) and Health and Wellness Centres (HWCs) should use simplified visual tools like pictorial wall charts and quick-reference booklets. These tools should clearly highlight first-line antibiotic choices, dosages, and treatment durations.

Having context-specific protocols reduces confusion among healthcare providers, ensures uniformity in prescribing practices, and makes supervision easier. This approach helps in maintaining consistency and improving the overall quality of care across different levels of the healthcare system.

e. Community and Patient Engagement

The way patients behave and how the community views antibiotics play a big role in how much they are used. Especially at the primary level, it's important to include community-focused efforts in stewardship. Frontline workers like Accredited Social Health Activists (ASHAs) and Auxiliary Nurse Midwives (ANMs) should be trained to give clear and practical messages about the dangers of self-medicating, not finishing treatments, and using antibiotics for viral infections. These messages should also be reinforced by healthcare providers during outpatient visits. In areas where informal healthcare providers and pharmacists are common, basic engagement strategies like orientation meetings or informational materials can help align their practices with stewardship principles. By reaching out beyond clinical facilities, community engagement helps create an environment where antibiotics are used responsibly and sustainably.

3.3 Integration with National Health Programmes

For antimicrobial stewardship programmes (AMSPs) to be sustainable and scalable, they must be embedded within the broader architecture of India's national health strategies. Aligning AMSP implementation with existing national initiatives enables better coordination, resource optimization, and policy coherence. The National Action Plan on Antimicrobial Resistance (NAP-AMR) provides the overarching policy framework for stewardship activities, calling for multisectoral action across human health, animal health, and the environment. AMSPs implemented at the facility level should directly contribute to the goals and monitoring priorities outlined in the NAP-AMR.

The National Health Mission (NHM), which supports service delivery across primary, secondary, and tertiary levels, offers a platform to institutionalize AMSP within routine public health services. AMSP indicators and functions such as prescription audits, treatment guideline adherence, and training coverage can be integrated into Quality Assurance Committees and supportive supervision protocols under NHM. Similarly, Kayakalp, a facility-level quality certification programme under NHM, can incorporate AMSP indicators into its infection control and medication safety domains.

Digital health initiatives present additional opportunities to support stewardship. The Ayushman Bharat Digital Mission (ABDM), which promotes health data interoperability and patient record linkage, includes standards for Electronic Health Records (EHRs). Tertiary hospitals and digital-enabled facilities can integrate stewardship functions such as antibiotic alerts, consumption dashboards, and auto-flagging of restricted drug use into their EHR systems in alignment with ABDM guidelines.

Furthermore, Health Management Information Systems (HMIS) and and state-level data portals can include stewardship-related metrics such as antibiotic consumption rates, number of audits conducted, or training sessions held. This integration enables tracking of AMSP implementation and facilitates data-driven decision-making at state and national levels.

Telemedicine platforms can serve as mentorship tools, especially for lower-tier facilities. Remote support from tertiary AMSP units to PHCs and district hospitals can help interpret prescription data, resolve clinical dilemmas, and update providers on revised guidelines. Likewise, mobile applications and online learning platforms can support training, supervision, and audit documentation in resource-constrained settings.

By aligning AMSPs with national programmes and digital health infrastructure, stewardship efforts become more feasible, measurable, and embedded within the routine functioning of India's healthcare system.

3.4 Antimicrobial Stewardship as a Core Component of Health System Strengthening

Antimicrobial stewardship must be seen as a fundamental part of strengthening the health system, not as an optional or separate intervention. A framework that is specific to each tier of healthcare is necessary to ensure that AMSP implementation is relevant, feasible, and effective across India's diverse healthcare settings. Each level of care, tertiary, secondary, and primary has its own unique infrastructure, diagnostic capabilities, human resources, and service delivery responsibilities. Therefore, stewardship strategies must be customized to fit these specific realities.

In tertiary care settings, AMSPs can take advantage of specialist expertise and digital systems to conduct real-time audits and manage complex cases. These facilities usually have advanced labs, full-time clinical microbiologists, infectious disease specialists, trained pharmacists, and electronic medical records. The complex cases they handle and the high use of antimicrobials require strong and data-driven stewardship practices.

In secondary care settings, the focus should be on structured guidelines, periodic audits, and simplified decision-support tools. Secondary care facilities have fewer resources than tertiary centers but serve a large part of the population, especially in semi-urban and rural areas. Diagnostic capabilities are often limited, and the availability of trained specialists varies widely. Despite these challenges, implementing stewardship at the secondary level is both necessary and possible if the model is adapted to the local context.

At the primary level, where empirical management is common, job aids, treatment algorithms, and community engagement become the primary tools for improving antibiotic use. Primary care facilities are the backbone of India's health system, especially in rural and underserved areas. These settings usually don't have microbiology labs, and doctors or Mid-Level Health Providers (MLHPs) manage patients with limited support. Clinical decisions are often based on symptoms rather than lab tests. However, this level of care offers important opportunities for stewardship, particularly in reducing unnecessary or inappropriate antibiotic prescriptions for self-limiting infections.

Across all tiers, the core components of effective stewardship include leadership, provider training, monitoring and feedback, adherence to standard treatment protocols, and community awareness. These components must be tailored to local capacity while ensuring alignment with national AMR priorities. Integration with ongoing health programmes, digital health platforms, and quality assurance mechanisms enhances the sustainability and scale of stewardship interventions.

A tier-appropriate AMSP framework, supported by coordinated governance, surveillance, and training, can help institutionalize antimicrobial stewardship as a routine health system function. This approach provides a scalable and sustainable foundation for containing antimicrobial resistance and ensuring rational, quality-driven care across India's public health system.

3.5 Mapping Strengths, Weaknesses, Opportunities, and Threats for Antimicrobial Stewardship in India's Tiered Public Health System

India's public health system, organized across primary, secondary, and tertiary tiers, offers a complex but necessary structure for implementing Antimicrobial Stewardship Programmes (AMSPs). A comparative analysis of AMSP readiness using SWOT frameworks across these tiers reveals shared policy intent but diverging levels of operational maturity, technical capacity, and institutional accountability. The findings call for differentiated yet coordinated stewardship strategies that align with each tier's structural realities and functional constraints.

At the primary tier, although state-level policies, basic audit tools, and generic guidelines are in place, their translation into routine practice remains weak. The stewardship agenda is constrained by an absence of trained personnel, diagnostic capacity, and formal accountability structures. Prescriptions are predominantly empirical, audits are sporadic, and antimicrobial time-outs are nearly absent due to inadequate staffing and infrastructural limitations. The doctor base is unaware or unconvinced of the purpose and utility of stewardship interventions, in part due to poor alignment between available stock and recommended regimens. Opportunities lie in task-sharing models using pharmacists for audits, digitizing audit formats, and developing localized antibiograms through point prevalence surveys, even if initiated with basic tools. However, unless training is institutionalized and tied to supervisory mandates, implementation will remain inconsistent and symbolic.

The secondary tier shows greater structural potential, marked by the presence of AMSP committees, formal guidelines, and some diagnostic and laboratory resources. However, the implementation quality remains uneven. Audits and antimicrobial review processes lack standardization, timelines, and feedback loops. Diagnostic infrastructure, though partially available, is insufficient for real-time surveillance or generating reliable antibiograms. Doctor resistance to guidelines owing to perceived impracticality or drug-stock mismatches undermines adherence. Despite these challenges, secondary facilities represent a strategic convergence point where modest investments in laboratory strengthening, structured audit protocols, and career-linked AMR training can yield tangible returns. Integration of e-preauthorization tools and pharmacy-driven formulary management should be prioritized here, where both human and technological resources are partially available but underutilized.

At the tertiary tier, stewardship infrastructure is most developed, with specialist-led AMSP committees, access to updated guidelines, and capacity for training and surveillance. However, high patient volumes, unstructured audit processes, poor data archiving, and absence of electronic prescribing systems continue to hinder operational effectiveness. Prescription audits are inadequately supervised, antimicrobial time-outs are not reliably practiced, and inter-departmental communication silos impede timely feedback and action. Notably, even at this level, laboratory surveillance is fragmented, and antibiograms are not generated or used systematically across departments. Tertiary facilities are best positioned to act as technical anchors for the lower tiers, but this potential remains underleveraged in the absence of formal mandates and resource allocation. Investment in digitized stewardship platforms, electronic prescription tracking, and integration of stewardship metrics into institutional quality audits are immediate actions required to ensure accountability.

Across all tiers, the most persistent threat is the disconnect between policy mandates and operational systems particularly in terms of diagnostics, digital health integration, training standardization, and procurement alignment. Doctor resistance, driven by clinical autonomy and workload concerns, further complicates implementation. Moreover, the absence of dedicated budget lines, incentives, or performance indicators linked to stewardship reinforces institutional apathy.

To advance AMSP implementation within India's tiered public health system, actions must be tier-specific but system-integrated. The primary tier requires foundational investments in training, simplified audit formats, and diagnostic referrals. The secondary tier needs structured stewardship protocols, workforce incentives, and scalable surveillance models. The tertiary tier must transition from pilot implementation to institutionalization through robust governance, cross-departmental accountability, and digital integration. Importantly, the stewardship architecture must include bi-directional learning across tiers, leveraging tertiary expertise to build capacity downward and surfacing local innovations upward for scale.

This tier-wise SWOT synthesis demonstrates that stewardship success in India will not emerge from uniform strategies but from targeted, contextually grounded interventions embedded within the existing health system hierarchy.

Chapter 4

Monitoring & Evaluation of AMS Interventions

Monitoring and Evaluation (M&E) refers to a set of systematic and structured processes aimed at assessing how well a program or intervention is being implemented and whether it is achieving its intended outcomes. It encompasses two interrelated functions: monitoring, which involves the continuous collection, analysis, and use of data to track progress against defined targets, and evaluation, which focuses on assessing the relevance, effectiveness, efficiency, impact, and sustainability of an intervention over time. Together, these processes provide a framework for adaptive management, allowing stakeholders to identify implementation gaps, guide program improvements, and enhance accountability (WHO, 2011; OECD, 2002).

In the context of Antimicrobial Stewardship (AMS), M&E plays a vital role in strengthening the effectiveness and integrity of stewardship efforts across all levels of the health system. AMS interventions such as dissemination of standard treatment guidelines, routine prescription audits, implementation of antibiotic formulary restrictions, capacity-building of doctors, and integration of decision-support tools require continuous oversight to ensure fidelity to implementation and measurable changes in antimicrobial use. Robust M&E frameworks help in systematically tracking the performance of these interventions, enabling timely identification of bottlenecks, inconsistencies, or unintended consequences (WHO, 2019).

Moreover, M&E systems in AMS generate critical data on antimicrobial consumption (e.g., DDDs per 1000 patient-days), adherence to prescribing guidelines, and resistance patterns information essential for assessing behavior change and policy impact. When implemented effectively, M&E ensures that stewardship programs are not static but evolve in response to local data, emerging threats, and resource realities. It supports a culture of evidence-based decision-making, ensures rational use of antimicrobials, and contributes meaningfully to national and global AMR containment efforts (ICMR, 2023; Ho et al., 2024).

How M&E Helps in Assessing AMS Interventions

Tracking Implementation Fidelity: Monitoring and Evaluation (M&E) systems help ensure that AMS interventions are being implemented as intended. This includes tracking whether activities like prescription audits, feedback cycles, and training sessions occur regularly and meet defined standards. By monitoring such fidelity, program managers can detect early deviations, identify implementation gaps, and maintain consistency in stewardship practices across health facilities (WHO, 2019; ICMR, 2023).

Measuring Impact and Outcomes: M&E enables assessment of whether AMS interventions are improving antibiotic use and contributing to reduced resistance. This involves measuring indicators such as antibiotic consumption (e.g., DDDs per 1000 patient-days), DOT (Day of Therapy) adherence to treatment guidelines, and resistance trends in priority pathogens. Outcome monitoring is essential to understand if stewardship actions are driving intended behavior change and infection control improvements (Ho et al., 2024).

Supporting Continuous Quality Improvement: M&E promotes adaptive learning by providing regular feedback to stewardship teams. Audit results and usage data can guide targeted training, update protocols, and trigger corrective actions. This fosters a culture of accountability and helps facilities continually refine their AMS strategies based on real-time evidence (WHO, 2011).

Resource Allocation and Policy Support: Evidence from M&E informs decision-makers on where to direct resources whether for training, laboratory capacity, or infrastructure. It also supports rational procurement planning and policy development, including updating formularies or enforcing regulation on antibiotic sales. M&E data thus builds the case for sustained investment in AMS (ICMR, 2023).

Integration into National Programs: Well-functioning M&E systems allow for alignment of local stewardship efforts with state and

national strategies, including reporting to platforms like ICMR's AMR surveillance network. This integration ensures that AMS programs contribute to broader public health goals, such as the State Action Plan on AMR, and facilitates coordinated response planning across levels of the health system (WHO, 2019).

Role of State-Level and District AMS Sub-Committees

To operationalize AMS and its monitoring effectively, dedicated structures are needed at both state and district levels. The state-level AMS committee is responsible for strategic oversight, capacity-building, intersectoral coordination, and guideline adaptation. It also reviews M&E data from across districts to guide statewide planning. At the district level, AMS sub-committees are the core implementation units. They support facility-level teams, ensure data collection and review, facilitate audits and training, and escalate issues to the state. Embedding these sub-committees within existing governance platforms like District Health Societies strengthens accountability and ensures stewardship is not a one-off project but a continuous system priority. Together, these bodies institutionalize AMS within the health system and ensure sustainability beyond project timelines (ICMR, 2023; WHO, 2019).

Table 7: AMS Interventions: Implementation Framework

Intervention – Core Component	Intervention – Supplementary Component	Input	How to do it	Advantages[1]	Possible barriers[2]
Prescription audit & feedback		There should be a clear policy decision at the institutional or administrative level that defines the appropriate frequency and timeliness for conducting prescription audits.	A clear policy decision should be developed at the state or institutional level to define the timeliness and frequency of conducting prescription audits across healthcare facilities.	• Essential to doctors' education • Provides specific feedback on what antibiotics they prescribe and how they prescribe them. • Identifies antibiotic prescribing challenges in the unit, and shows the impact of AMS interventions on antibiotic prescribing and use (e.g. de-escalation, duration). • Data may include information on indication for treatment, prescribed antibiotic(s), dosage, interval, administration route, timing of administration of first dose and duration if collected after stop of treatment. • Can be performed from very basic (only indication and antibiotics prescribed per patient) to more advanced	• Time-consuming. • Can be perceived as intrusive • Opposition from doctors and lack of facility support for implementing it. • May not happen if doctors are not prompted or comfortable with making changes.
		It is important to establish a state or district-level audit committee that oversees the implementation and monitoring of prescription audits across health facilities.	Personnel for the formation of the prescription audit committee should be identified from across all tiers of the health system to ensure appropriate representation and functionality.		
		The audit committee should include at least one external member, such as an academic or clinical expert, to ensure objectivity and provide independent oversight.	During any prescription audit visit to an institute, the presence of an external member is mandatory to maintain the authenticity, neutrality, and credibility of the audit process.		
		All relevant staff members should be adequately informed and trained on the prescription audit guidelines to ensure consistency and compliance in implementation.	Members of the Antimicrobial Stewardship (AMS) committee must receive training on the available prescription audit guidelines to ensure proper implementation and adherence.		
		A structured feedback mechanism must be established within the institute to communicate audit findings to doctors and guide improvements in prescribing practices.	The head of the institution must take responsibility for communicating the audit findings to all relevant doctors and nursing staff to promote accountability and corrective actions.		
		Each healthcare institute should establish an Antimicrobial Stewardship (AMS) committee responsible for overseeing audit activities, guiding rational antimicrobial use, and promoting best practices	Every institute, across all tiers of care, should have an AMS committee in place; the composition of this committee may vary depending on the institute's available resources and context [ref].		

Intervention – Core Component	Intervention – Supplementary Component	Input	How to do it	Advantages[1]	Possible barriers[2]
Antimicrobial timeouts & Parenteral to oral conversion & De-escalation		Training on the concept of the 4Ds - right Drug, Dose, Duration, and De-escalation should be provided to all doctors and nursing staff to effectively implement antimicrobial timeouts.	In-person workshops for doctors and nursing staff should be conducted in a staggered manner across each district or CD block by the state-level AMR team to support the implementation of Antimicrobial Stewardship Program (AMSP) interventions.	• Can reduce costs for broad-spectrum antibiotics and potentially reduces AMR and further facility and patient costs. • A relatively easy target for AMS interventions. • Cost savings on antibiotics and potentially reduces AMR. • Reduces adverse events (e.g. nephrotoxicity, gastrointestinal side effects). • May reduce prolonged exposure to IV drugs	• Need for trained nursing staff • May not occur if doctors are not comfortable making changes. • Requires that microbiology sampling be done correctly, as well as quality-assured microbiology testing, timely release of results and good communication with trained doctors
		Random monitoring of antimicrobial prescriptions should be carried out by a designated member of the Antimicrobial Stewardship (AMS) committee to ensure compliance with timeout protocols.	Each institute may assign the responsibility of monitoring AMSP activities to senior nursing staff, the nursing superintendent, or the Infection Control Nurse (ICN), as they will be integral members of the AMS committee.		
		Nursing staff should be assigned specific responsibilities to identify and flag prescriptions where an antimicrobial timeout is due, facilitating timely review and adjustment.	Nursing staff assigned to inpatient department (IPD) duties must be formally instructed by the institutional head to raise a flag whenever an antimicrobial timeout is indicated.		

[1] Antimicrobial stewardship programmes, in healthcare facilities in LMIC a practical toolkit, Published by WHO, 2019 https://iris.who.int/bitstream/handle/10665/329404/9789241515481-eng.pdf?sequence=1&isAllowed=y

[2] Antimicrobial stewardship programmes, in healthcare facilities in LMIC a practical toolkit, Published by WHO, 2019 https://iris.who.int/bitstream/handle/10665/329404/9789241515481-eng.pdf?sequence=1&isAllowed=ypdf?sequence=1&isAllowed=y

Intervention – Core Component	Intervention – Supplementary Component	Input	How to do it	Advantages[1]	Possible barriers[2]
Guidelines and clinical pathways		Updating existing guidelines or preparing new guidelines on antimicrobial use is essential to ensure that prescribing practices remain evidence-based, context-specific, and aligned with current resistance patterns and stewardship goals.	• The availability of existing antimicrobial use guidelines provides a foundational reference for rational prescribing practices in healthcare settings. • Updating these guidelines by generating a local antibiogram based on prevalent infections is essential, which can be achieved through a Public-Private Partnership (PPP) model or with technical support from the microbiology departments of district hospitals or medical colleges. • A local mechanism should be established by partnering with nearby NABL-accredited laboratories or medical college labs to send clinical samples for culture and sensitivity (C/S) and antimicrobial susceptibility testing (AST) every six months, thereby facilitating the generation of a local antibiogram. • Low-cost point-of-care diagnostic tests should be used in cases where empirical antibiotic prescriptions are considered, such as urine dipsticks for urinary tract infections, total leukocyte count with neutrophil-to-lymphocyte (N/L) ratio, C-reactive protein (CRP), malaria rapid diagnostic tests (RDTs), dengue NS1 antigen, and scrub typhus IgM tests.		• Possible disagreement of doctors with the contents of guideline • Absence of Perceived need of any requirement for bringing change in common practice

Intervention – Core Component	Intervention – Supplementary Component	Input	How to do it	Advantages[1]	Possible barriers[2]
Information, education and communication (IEC)		A standardized training module on Antimicrobial Stewardship (AMS) should be developed to build the capacity of healthcare providers in rational antimicrobial use.	The state AMR cell should locally adapt the available Antimicrobial Stewardship Program (AMSP) training modules [reference], ensuring they are relevant to the state-specific healthcare context and needs.		• Lack of dedicated fund for AMS workshops • Lack of motivation among staff for participation in such workshops
		Regular workshops should be conducted for AMS committee members to strengthen their understanding and implementation of stewardship interventions.	In-person workshops should be organized for all AMS committee members, with participation linked to career growth opportunities and incorporating both core and supplementary AMS interventions, including indicators for Access, Watch, and Reserve (AWaRe) antibiotic group consumption.		
		Antimicrobial stewardship principles should be integrated into the medical education curriculum to ensure early sensitization and long-term adherence among future healthcare professionals.	Antimicrobial stewardship training should be an integral part of the MBBS and postgraduate medical curricula to ensure foundational knowledge among future practitioners. Attendance in AMS workshops should be made mandatory for postgraduate students and linked to eligibility for appearing in final examinations.		

Intervention – Core Component	Intervention – Supplementary Component	Input	How to do it	Advantages[1]	Possible barriers[2]
Antimicrobial consumption pattern		The antimicrobial consumption pattern can be evaluated using the following five data sources: • Pharmacy dispensing data, which provides information on the quantity and types of antimicrobials issued; • Health-care facility purchasing data, which reflects the overall antimicrobial procurement trends; • Nursing charts (paper-based), which capture bedside administration details in non-digital settings; • Electronic drug administration data, which offers real-time records of administered antimicrobials; and • E-prescribing records, which document the doctor's intent and help assess compliance with prescribing guidelines.	• Data from all five sources - (1) pharmacy dispensing records, (2) healthcare facility purchasing data, (3) nursing charts, (4) electronic drug administration data, and (5) e-prescribing records should be systematically analyzed to understand antimicrobial consumption patterns across different groups of antimicrobials. • This analysis should include calculation of the Access-to-Watch ratio for each institute, which can serve as a key prescribing quality indicator, particularly for monitoring outpatient department (OPD) antimicrobial use.	• Indicators derived from these data may be linked to hospital quality assurance • Scope of revisiting hospital supply list for modification • Can reduce costs for broad-spectrum antibiotics, and potentially reduces AMR and further facility and patient costs.	• Absence of modern electronic data base which may be used for generation of report as necessary • Absence of universal implementation of e prescription • Requires trained pharmacist to do this • Time consuming activity
Laboratory surveillance and feedback		• A standardized protocol should be developed outlining the number, type, and frequency of clinical samples to be collected, along with specifications for samples required as part of hospital infection control quality indicators. • This protocol will support consistent surveillance, facilitate accurate antimicrobial resistance tracking, and ensure alignment with infection prevention and control (IPC) standards.	The institutional head must actively involve other members of the Antimicrobial Stewardship (AMS) committee in deciding the number, type, and frequency of clinical samples to be collected, as well as determining which samples related to hospital infection control should be sent to a higher center for further analysis and surveillance.	• Information on local antibiogram • Empirical treatment will be more evidence based • May reduce out of pocket expenditure for patients at lower-level hospitals	• Requires resources for regular microbiological testing at lower-level hospitals though they may be linked to nearest tertiary facility • May lead to increased documentation • Hindrance from laboratories of tertiary facilities to provide hand hold support to lower tier hospitals as it will increase their workload.

Intervention – Core Component	Intervention – Supplementary Component	Input	How to do it	Advantages[1]	Possible barriers[2]
Preauthorization		• Presence of preauthorization committee at secondary and tertiary level • Involvement of hospital administration in empowering the teams • SOP on how and where to exercise preauthorization in each hospital	• Hospital administration may request its' AMS committee to form a preauthorization committee • The purpose of formation of this committee will be supporting the doctors to provide best treatment to the patients • Quick response from both the prescribing doctor and preauthorization team is a must to ensure the best treatment outcome • This should be done in case of use of reserve group antibiotics. • Prescribing doctor if justifies its use may continue treatment despite disagreement with view of preauthorization team.	• Use of reserve group antibiotics may be rationalized • It will create the scope to minimize human error • Hospital cost may also reduce • In long run, it will reduce AMR	• Resource intensive process • Hindrance from doctors may lead to failure • Absence of e tools will make its application difficult • Requires clear guidance from hospital administration for its implementation

Chapter 5

Interpreting AMS Monitoring and Evaluation Output Indicators: Toward Strengthened Stewardship Across the Health System

The evaluation matrix provides a structured and operational framework for evaluating the implementation of Antimicrobial Stewardship (AMS) interventions across healthcare institutions at the primary, secondary, and tertiary levels. Organized around defined interventions, corresponding output indicators, and standardized numerator-denominator logic, the framework supports systematic tracking of stewardship performance at the institutional, district, and state levels. It also defines specific data collection processes, enhancing accountability and enabling triangulation across facility- and district-level reporting systems. This section below synthesizes key interpretations across major intervention domains, highlighting implications for implementation fidelity, policy coherence, and system strengthening.

1. Prospective Audit and Feedback :

The framework prioritizes the institutionalization of audit systems through the establishment of district-level AMS committees, with explicit attention to expert representation. Indicators measuring the coverage of audit committees, availability of audit guidelines, timeliness of hospital-level audits, and training activities reflect an effort to embed prospective audit as a routine institutional process. However, the dependency on annual reporting and self-submitted documents may limit the responsiveness and granularity of monitoring.

Policy Implication: The audit-feedback loop must be supported by digital documentation platforms and quarterly reporting to enable real-time course correction and to foster continuous quality improvement.

2. Antimicrobial Timeouts :

The monitoring of antimicrobial timeouts is structured through indicators capturing training coverage among doctors and nursing staff, and the proportion of inpatient prescriptions undergoing timeout review. The inclusion of a 10% sampling threshold offers a feasible auditing mechanism, though it may risk under-detection in low-performing facilities.

Implementation Consideration: To ensure fidelity, antimicrobial timeout protocols should be integrated into clinical workflows with defined roles for nursing staff and AMS committees. Mandatory documentation fields in prescription records preferably digital can standardize compliance.

3. Antimicrobial Consumption Analysis :

Metrics such as Defined Daily Dose (DDD) per 1,000 patient-days, Access-to-Watch (A/W) ratios, and the proportion of antimicrobial consumption across AWaRe categories represent globally recognized indicators for assessing antimicrobial use. These indicators allow for inter-institutional comparison and benchmarking. However, consistent data capture across inpatient and outpatient services remains a challenge in resource-constrained settings.

System Strengthening Need: Integration of pharmacy dispensing, e-prescription, and drug administration records through interoperable digital health systems is essential for ensuring data completeness and accuracy.

4. Formulary Restriction :

The framework includes indicators for tracking the presence of standard operating procedures (SOPs), preauthorization committees, and the extent of restricted antibiotic oversight. Documentation of justifications for restricted antibiotic use is a critical element for promoting transparency and rational prescribing.

Strategic Implication: Preauthorization systems must be supported by clinical decision support tools and mechanisms for rapid approvals during emergencies. Oversight mechanisms should ensure that recommendations by the AMS committee are consistently reviewed and acted upon.

5. Guidelines and Clinical Pathways :

Indicators focused on AST reporting and local antibiogram development at the primary and secondary levels signal a commitment to evidence-based prescribing tailored to local resistance patterns. The differential tracking across tiers enables stratified policy responses and prioritization of diagnostic strengthening.

Key Recommendation: Regular coordination between clinical and microbiology teams, along with investments in diagnostics and reporting infrastructure, are critical to operationalize guideline updates based on local microbiological data.

6. Dose Optimization and Combination Therapy :

The inclusion of indicators assessing clarity of prescription directions and documentation of rationale for combination therapies or changes in treatment underscores the emphasis on prescription quality. These indicators provide insight into both doctor behavior and clinical appropriateness.

Monitoring Need: Routine prescription audits—whether random or targeted—should be institutionalized to track rationality in drug selection, dosage, and justification for complex regimens.

7. De-escalation and Streamlining of Therapy :

Tracking of de-escalation practices and documentation of therapy revisions reflects efforts to optimize treatment duration and reduce unnecessary broad-spectrum antibiotic use. However, implementation relies heavily on doctor initiative and documentation compliance.

Enabler: Nursing staff must be empowered and trained to flag timepoints for review (e.g., 48–72 hours), supported by automated reminders in electronic health records where available.

8. Parenteral-to-Oral Conversion :

Indicators focusing on the frequency and documentation of intravenous-to-oral switch protocols align with best practices in AMS. These promote shorter hospital stays and reduced intravenous antibiotic use when clinically appropriate.

Barrier: In the absence of standardized documentation tools and decision support, this practice may remain under-implemented or inconsistently applied.

9. Laboratory Surveillance and Feedback:

The inclusion of laboratory surveillance indicators—such as generation of local antibiograms in medical colleges and hospitals—reflects the foundational role of diagnostics in stewardship. These outputs are essential for guiding empiric therapy and monitoring local resistance trends.

Critical Gap: Timely data sharing between microbiology departments and clinicians remains a systemic weakness and requires dedicated coordination structures.

10. Information, Education, and Communication (IEC) :

Indicators related to training coverage among in-service doctors and AMS committee members reflect an ongoing effort to institutionalize stewardship knowledge and practices. However, training alone is insufficient unless accompanied by performance monitoring and supportive supervision.

Sustainability Strategy: AMS training must be embedded into continuous medical education (CME) systems, with participation linked to professional development milestones.

Table 8: Output Measures of AMS Interventions: Monitoring and Evaluation Framework

Intervention	Output Indicators	Numerator	Denominator	Process to Measure
Prospective audit & feedback	Percentage of districts having an audit committee	No. of districts having audit committee	Total no. of districts in a state	Evaluation will be conducted by the State AMR cell based on inputs received from districts.
	Percentage of districts having audit committee with identified experts	No. of districts having audit committee with identified experts	Total no. of districts having audit committee	Each district must receive a yearly audit report from every hospital under its jurisdiction.
	Percentage of hospitals in each district in each tier conducted audit in timely manner per year	No. of hospital in each tier conducted audit timely in each district	Total no. of hospitals in each tier in each district	These hospital-level reports will be collated at the district level for comprehensive assessment.
	Percentage of hospitals in each tier having this guideline	No. of hospital in each tier having the audit guideline in each district	Total no. of hospitals in each tier in each district	Each district is required to submit a consolidated yearly report to the State AMR cell.
	No. of audit trainings conducted for each tier in each district per	No. of audit trainings conducted by medical colleges of each district each year	NA	
Antimicrobial Timeouts	Percentage of doctors and nursing staff per institute had training on AMS each year in each district	No. of doctors and nursing staff in each institute per district had training on AMS	Total No. of doctors and nursing staff in each institute per district had training on AMS	Documentation should be carried out at each institute level, then forwarded to the district, and subsequently submitted to the State AMR cell.
	Percentage of IPD prescriptions where antimicrobial timeout has been practiced per institute in each district	No. of IPD prescriptions where antimicrobial timeout has been practiced per institute	Total no. of IPD prescriptions with antibiotic being audited	Prescription audits must be conducted systematically as part of antimicrobial stewardship activities.
	Percentage of IPD prescription monitored for antimicrobial timeout in each institute (cut off should be 10 percent of IPD prescriptions) in district , may be spread throughout the year	No. IPD prescription monitored for antimicrobial timeout in each institute	Total no. of IPD prescriptions with antibiotic being monitored by AMS committee	Members of the AMS committee are responsible for conducting the monitoring work, which will be reported to the head of the institute, who in turn will report to the district authorities and then to the State AMR cell.
Antimicrobial consumption analysis	DDD/1000 patient days for each institute (WHO)*	Total no. of doses of each antibiotic prescribed* dose unit	WHO assigned DDD*duration*no.of patients received antibiotics*100 (WHO)*	
	Proportion of antimicrobial consumption in AWaRe and OTHER group for each institute	No. of antimicrobial consumption in AWaRe and OTHER group for each institute	Total No. of antimicrobial consumption	Prescription audit should be conducted for both outpatient (OPD) and inpatient (IPD) departments to ensure comprehensive monitoring of antimicrobial use across all levels of care.
	Access to Watch ratio for OPD per institute (cut off 1.5) *	Total no of antimicrobials prescribed from access group	Total no of antimicrobials prescribed from Watch group	

[1]* Antimicrobial stewardship programmes, in healthcare facilities in LMIC a practical toolkit, Published by WHO, 2019 https://iris.who.int/bitstream/handle/10665/329404/9789241515481-eng.pdf?sequence=1&isAllowed=y

Intervention	Output Indicators	Numerator	Denominator	Process to Measure
Preauthorization	Percentage of hospitals in each tier having the SOP in each district	No. of hospitals in each tier having the SOP in each district	Total No. of hospitals in each tier having the SOP in each district	Each district is required to receive an annual report from every hospital under its jurisdiction.
	Percentage of hospitals having the preauthorization committee in district	No. of hospitals having the preauthorization committee in district	Total No. of hospitals having the preauthorization committee in district	
	Percentage of IPD prescriptions checked by preauthorization committee per year	No. of IPD prescriptions checked by preauthorization committee per year	Total no. of IPD prescription generated with antibiotics each year in each institute	Members of the AMS committee are responsible for conducting the monitoring work, reporting to the head of the institute, who will then forward the report to the district and subsequently to the State AMR cell.
	Percentage of prescriptions where restricted antibiotic administration was permitted by committee in each institute where justification mentioned in district	No. of prescriptions where restricted antibiotic administration was permitted by committee in each institute where justification mentioned in district	Total No. of IPD prescriptions with antibiotics checked by preauthorization committee per year	
Guidelines and Clinical Pathways	Percentage of clinical samples for whom microbiological report along with AST pattern has been done for primary level hospital to create local antibiogram in each center	No. of clinical specimens sent for c/s from IPD each institute each year	Total no of IPD cases in a year in each institute requiring microbiological investigation	Each hospital is required to capture this data as part of its AMS activities for reporting to the district.
	Percentage of primary hospitals performing this activity	No. of primary hospitals performing this activity in activity	Total no. of primary hospitals in a district	The district must receive a report from each hospital on a yearly basis.
	Percentage of clinical samples for whom microbiological report along with AST pattern has been done for secondary level hospital to create local antibiogram in each center	No. of clinical specimens sent for c/s from IPD each institute each year	Total no of IPD cases in a year in each institute requiring microbiological investigation	Each hospital is required to capture this data as part of its AMS activities for reporting to the district.
	Percentage of secondary hospitals in each district performing this activity	No. of secondary hospitals performing this activity in activity	Total no. of secondary hospitals in a district	The district must receive a report from each hospital on a yearly basis.
Streamlining or de-escalation of therapy	Percentage of IPD prescriptions where de-escalation has been done in each institute in each district	No. of IPD prescriptions with antibiotics where de-escalation has been done in each institute in each district	Total No.of IPD prescriptions with antibiotics in each institute in each district	A prescription audit should be conducted to evaluate the appropriateness, completeness, and rationality of antimicrobial prescriptions as part of AMS activities.

Intervention	Output Indicators	Numerator	Denominator	Process to Measure
Parenteral to oral conversion	Percentage of IPD prescription with documented evidence in each institute in each district	No. of IPD prescription with antibiotic with documented evidence in each institute in each district	Total No. of IPD prescriptions with antibiotics	A prescription audit should be conducted to evaluate the appropriateness, completeness, and rationality of antimicrobial prescriptions as part of AMS activities.
	Percentage of prescriptions mentioning indications for switching antibiotics in each institute in each district	No. of prescriptions with antibiotic mentioning indications for switching antibiotic in each institute in each district	Total no of IPD prescription with antibiotic	A prescription audit should be conducted to evaluate the appropriateness, completeness, and rationality of antimicrobial prescriptions as part of AMS activities.
Laboratory surveillance and feedback	Percentage of primary and secondary level hospitals performing this activity in each district	No. of primary and secondary level hospitals performing this activity in each district	Total No. of primary and secondary level hospitals performing this activity in each district	Each hospital must capture this data as part of its Antimicrobial Stewardship (AMS) activities for regular reporting to the district authorities.
	Percentage of tertiary level hospitals having local antibiogram for empiric therapy	No. of tertiary level hospitals having local antibiogram for empiric therapy	Total no. of tertiary level hospitals in each state	
Information, education and communication (IEC)	Percentage of doctors undergoing training per year per institute per district	No. of doctors undergoing training per year per institute per district	Total No. of doctors undergoing training per year per institute per district	District and state level trainings on Antimicrobial Stewardship (AMS) should be conducted to build capacity and ensure standardized implementation of AMS practices.
	Percentage of AMS committee members undergone training for implementation of intervention in each district	No.of AMS committee with all members trained in each district	Total No.of AMS committee in each district	Each hospital must capture this data as part of its Antimicrobial Stewardship (AMS) activities for regular reporting to the district authorities.

Conclusion

The monitoring matrix provides a comprehensive and tier-responsive architecture for evaluating AMS implementation across the health system. By combining output-level indicators with structured reporting mechanisms, it lays the foundation for both accountability and continuous improvement. However, several cross-cutting challenges such as manual data collection, variable reporting quality, infrastructure gaps, and fragmented oversight need to be addressed to fully operationalize the framework.
To realize its potential, the following must be prioritized:

- Digitization of data capture and real-time dashboard-based reporting;
- Capacity building of AMS committees and hospital leadership;
- Standardization of tools and templates across facilities;
- Integration of stewardship into broader hospital quality and accreditation systems.

With these enablers in place, the framework can serve as a robust mechanism for translating national AMS policy into measurable institutional practice thereby supporting India's larger strategy to combat antimicrobial resistance and strengthen clinical governance.

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Annexure

WHO Access, Watch, Reserve (AWaRe) Classification of Antibiotics for Evaluation and Monitoring of use, 2021

Antibiotic Group	Class	Category
Amikacin	Aminoglycosides	Access
Amoxicillin	Penicillins	Access
Amoxicillin/clavulanic-acid	Beta-lactam/beta-lactamase-inhibitor	Access
Ampicillin	Penicillins	Access
Ampicillin/sulbactam	Beta-lactam/beta-lactamase-inhibitor	Access
Azithromycin	Macrolides	Watch
Azlocillin	Penicillins	Watch
Aztreonam	Monobactams	Reserve
Benzathine-benzylpenicillin	Penicillins	Access
Benzylpenicillin	Penicillins	Access
Carbenicillin	Penicillins	Watch
Carumonam	Monobactams	Reserve
Cefacetrile	First-generation-cephalosporins	Access
Cefaclor	Second-generation-cephalosporins	Watch
Cefadroxil	First-generation-cephalosporins	Access
Cefalexin	First-generation-cephalosporins	Access
Cefepime	Fourth-generation-cephalosporins	Watch
Cefixime	Third-generation-cephalosporins	Watch
Cefodizime	Third-generation-cephalosporins	Watch
Cefoperazone	Third-generation-cephalosporins	Watch
Cefotaxime	Third-generation-cephalosporins	Watch
Cefotetan	Second-generation-cephalosporins	Watch
Cefoxitin	Second-generation-cephalosporins	Watch
Cefpodoxime-proxetil	Third-generation-cephalosporins	Watch
Ceftazidime	Third-generation-cephalosporins	Watch
Ceftazidime/avibactam	Third-generation-cephalosporins	Reserve
Ceftolozane/tazobactam	Fifth-generation cephalosporins	Reserve
Ceftriaxone	Third-generation-cephalosporins	Watch
Cefuroxime	Second-generation-cephalosporins	Watch
Chloramphenicol	Amphenicols	Access
Ciprofloxacin	Fluoroquinolones	Watch
Clarithromycin	Macrolides	Watch
Clindamycin	Lincosamides	Access
Cloxacillin	Penicillins	Access
Colistin_IV	Polymyxins	Reserve

Antibiotic Group	Class	Category
Colistin_oral	Polymyxins	Reserve
Daptomycin	Lipopeptides	Reserve
Dicloxacillin	Penicillins	Access
Doripenem	Carbapenems	Watch
Doxycycline	Tetracyclines	Access
Eravacycline	Tetracyclines	Reserve
Ertapenem	Carbapenems	Watch
Erythromycin	Macrolides	Watch
Faropenem	Penems	Reserve
Flucloxacillin	Penicillins	Access
Flurithromycin	Macrolides	Watch
Fosfomycin_IV	Phosphonics	Reserve
Fosfomycin_oral	Phosphonics	Watch
Furazidin	Nitrofuran derivatives	Access
Fusidic-acid	Steroid antibacterials	Watch
Gatifloxacin	Fluoroquinolones	Watch
Gemifloxacin	Fluoroquinolones	Watch
Gentamicin	Aminoglycosides	Access
Grepafloxacin	Fluoroquinolones	Watch
Imipenem/cilastatin	Carbapenems	Watch
Imipenem/cilastatin/ relebactam	Carbapenems	Reserve
Kanamycin_IV	Aminoglycosides	Watch
Kanamycin_oral	Aminoglycosides	Watch
Levofloxacin	Fluoroquinolones	Watch
Linezolid	Oxazolidinones	Reserve
Lomefloxacin	Fluoroquinolones	Watch
Meropenem	Carbapenems	Watch
Meropenem/vaborbactam	Carbapenems	Reserve
Metronidazole_IV	Imidazoles	Access
Metronidazole_oral	Imidazoles	Access
Mezlocillin	Penicillins	Watch
Minocycline_IV	Tetracyclines	Reserve
Minocycline_oral	Tetracyclines	Watch
Moxifloxacin	Fluoroquinolones	Watch
Nafcillin	Penicillins	Access
Neomycin_IV	Aminoglycosides	Watch
Neomycin_oral	Aminoglycosides	Watch
Netilmicin	Aminoglycosides	Watch
Nifurtoinol	Nitrofuran derivatives	Access

Antibiotic Group	Class	Category
Nitrofurantoin	Nitrofuran-derivatives	Access
Norfloxacin	Fluoroquinolones	Watch
Ofloxacin	Fluoroquinolones	Watch
Ornidazole_IV	Imidazoles	Access
Ornidazole_oral	Imidazoles	Access
Oxacillin	Penicillins	Access
Oxytetracycline	Tetracyclines	Watch
Pefloxacin	Fluoroquinolones	Watch
Phenoxymethylpenicillin	Penicillins	Access
Piperacillin	Penicillins	Watch
Piperacillin/tazobactam	Beta-lactam/ beta-lactamase-inhibitor_anti-pseudomonal	Watch
Polymyxin-B_IV	Polymyxins	Reserve
Polymyxin-B_oral	Polymyxins	Reserve
Procaine-benzylpenicillin	Penicillins	Access
Rifabutin	Rifamycins	Watch
Rifampicin	Rifamycins	Watch
Rifamycin_IV	Rifamycins	Watch
Rifamycin_oral	Rifamycins	Watch
Rifaximin	Rifamycins	Watch
Roxithromycin	Macrolides	Watch
Secnidazole	Imidazoles	Access
Sparfloxacin	Fluoroquinolones	Watch
Spiramycin	Macrolides	Watch
Streptomycin_IV	Aminoglycosides	Watch
Streptomycin_oral	Aminoglycosides	Watch
Sulbactam	Beta-lactamase-inhibitors	Access
Sulbenicillin	Penicillins	Watch
Sulfadiazine	Sulfonamides	Access
Sulfadiazine/tetroxoprim	Sulfonamide-trimethoprim-combinations	Access
Sulfadiazine/trimethoprim	Sulfonamide-trimethoprim-combinations	Access
Sulfadimidine/trimethoprim	Sulfonamide-trimethoprim-combinations	Access
Sulfamethoxazole/ trimethoprim	Sulfonamide-trimethoprim-combinations	Access
Sulfamethoxypyridazine	Sulfonamides	Access
Sultamicillin	Beta-lactam/beta-lactamase-inhibitor	Access
Tazobactam	Beta-lactamase-inhibitors	Watch
Teicoplanin	Glycopeptides	Watch
Telavancin	Glycopeptides	Reserve
Temocillin	Penicillins	Watch
Tetracycline	Tetracyclines	Access

Antibiotic Group	Class	Category
Ticarcillin	Penicillins	Watch
Tigecycline	Glycylcyclines	Reserve
Tinidazole_IV	Imidazoles	Access
Tinidazole_oral	Imidazoles	Access
Tobramycin	Aminoglycosides	Watch
Trimethoprim	Trimethoprim-derivatives	Access
Vancomycin_IV	Glycopeptides	Watch
Vancomycin_oral	Glycopeptides	Watch

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