Optimizing Antibiotic Use in India: Addressing Challenges and Exploring Opportunities

Sangham Sravana Kumari[1], Gaddam Kranthi Kumar[2], Kummara Shilpa[3], Shaik Nusurath[4]
Thota Deepika Roy[5], Mude Devendra Naik[6]
[1]*Associate Professor, Department of Pharmacy Practice, Annamacharya College of Pharmacy, Andhra Pradesh, India*
[2,3,4,5,6]*Pharm D Intern, Department of Pharmacy Practice, Annamacharya College of Pharmacy, Andhra Pradesh, India*

***Abstract*—Public health is at risk because of antimicrobial resistance (AMR) in India, as it is driven by high levels of antibiotic use, inappropriate prescriptions, and weak enforcement of regulations. This narrative review brings together the latest information from standard AMR guidelines (WHO GAP-AMR, NAP-AMR 2.0, ICMR) and from open-access original research from 2015 to 2026, to assess how AMR has developed in India — the use of antibiotics, the burden of AMR, the main challenges experienced, the existing stewardship practices, and the potential opportunities for improvement at all levels of India's healthcare system.**

The findings are that there is an excessive amount of Watch-category antibiotics being prescribed, that antibiotics are sold without a prescription, and that there are high resistance rates to these same antibiotics, in particular amongst Gram-negative bacteria such as Klebsiella pneumoniae, Escherichia coli, and Acinetobacter baumannii. The findings also show that AMSP programs have produced encouraging outcomes in some of India's large hospitals but are not consistently implemented across all levels of healthcare. Clinical pharmacists are important contributors to the activities of reviewing medications, conducting audits and providing feedback, and working in multiprofessional teams. Additional opportunities include the use of digital surveillance tools, rapid diagnostics, and strengthening the implementation of NAP-AMR 2.0 in a One Health framework.

In summary, in order to improve antibiotic utilization and reduce AMR in India, continued implementation of regulations, inclusion of AMSP in primary healthcare, and collaboration between all stakeholders is necessary.

***Index Terms*—Antimicrobial resistance, Antibiotic prescribing, Antibiotic stewardship, Clinical pharmacists, India, NAP-AMR, One Health, Rapid diagnostics.**

I. INTRODUCTION

A. Background and Significance

The issue of Antimicrobial Resistance (AMR) is becoming more of a concern because it poses a threat to global health security, in the sense that there will be no way of treating common infections or carrying out routine procedures. There has been misuse and overuse of antimicrobials in human health care, in livestock rearing, as well as the production of food products, thereby posing risks to the future sustainability of methods that can be used to counteract and contain the spread of resistant bacteria [1].

The situation in India is even worse. India is one of the top countries using antimicrobials in the world [2]. In the past three decades, the use of antimicrobials has increased very rapidly in India, leading to high incidences of resistance to drugs such as fluoroquinolones, third-generation cephalosporins, carbapenems, and last-resort polymyxin agents, e.g., colistin [3], [4]. The following are some of the reasons behind the prevalence of AMR in India:

- Selling of antimicrobials without prescription [2]
- Patients' self-medication
- Prescribing empirical use of antimicrobials in viral illnesses [3]
- Less availability of diagnostic tests
- Lack of strict regulation
- Inadequate measures for infection prevention and control [3]
- Low awareness among the people

Moreover, the very high disease burden, scattered health-care delivery system — especially in the unregulated private health-care sector — and limited resources available to several public health-care centers have further exacerbated the problem in India compared to other nations [4].

The consequences mentioned above are extremely serious and result in increased mortality and morbidity, longer hospital stays, costlier treatments, inefficiency of life-saving medications, and negative effects on other advances in surgery, cancer treatment, and maternal/child care [1]. The World Health Organization initiated a Global Action Plan on Antimicrobial Resistance (GAP-AMR) as a solution to this problem in 2015. In addition, India created a National Action Plan for Antimicrobial Resistance (NAP-AMR 2017–2021), which supports the GAP-AMR. The NAP-AMR is implemented through a "One Health" approach, which includes humans, animals, and the environment.

B. Scope and Objectives of the Review

The objective of this literature review is to critically examine and further enhance the use of antibiotics, specifically with regard to their usage in the human healthcare setting only. No efforts were made to explore the linkages between antibiotic use in humans and other health-related fields such as agriculture, animals, or the environment, although this is discussed briefly in a later part of the paper. For the purpose of this literature review, the guidelines under WHO GAP-AMR, NAP-AMR India, and ICMR's guidelines for antimicrobial stewardship were taken into consideration, along with original, open-access papers or studies published from 2015 onward — following the launch of GAP-AMR — sourced from PubMed Central or governmental sites [1], [2], [3]. Hence, the scope of this review includes first-, second-, and third-tier healthcare settings, where most antibiotics are consumed annually.

Key objectives are:

1) To synthesize the available literature to illustrate the uses, prescribing practices, and resistance patterns of antibiotics in India [3], [4].
2) To enumerate the barriers that hinder optimal antibiotic use in terms of regulation, behaviour, infrastructure, and diagnostic factors [2], [3].
3) To enumerate areas of potential opportunity and evidence-based solutions that can be applied, such as an Antimicrobial Stewardship Program (AMSP), policy implementation, education, rapid diagnostics, and monitoring systems, while maintaining efficacy and accessibility of antibiotics [1], [3].

The objective of this review is to produce a body of work that synthesizes information from various literature sources to help formulate actionable steps for implementing an antimicrobial stewardship program in India [3].

II. METHODOLOGY OF THE REVIEW

A. Literature Search Strategy

As part of the review protocol, a comprehensive literature search strategy was adopted using the terms "antimicrobial stewardship" OR "antibiotics" OR "antibiotic prescribing" AND "India" OR "AMR" via Boolean operators, covering the period January 2015 to April 2026, across several literature retrieval platforms including PubMed (MEDLINE and PMC), Google Scholar, Scopus, and governmental portals (WHO, ICMR, Ministry of Health & Family Welfare). Sources of grey literature included NAP-AMR, ICMR AMSP, and NAP-AMR treatment guideline documents [5].

B. Inclusion and Exclusion Criteria

Included in the search criteria were English-language, open-access, original research articles, systematic/narrative reviews, and official guidelines relating to antibiotic consumption, prescribing practices, resistance patterns, and stewardship efforts in the context of human healthcare settings in India from 2015 onward. Excluded were articles that are not open access, studies focusing on animals/agriculture without a direct link to humans, case reports, editorials, and studies published prior to 2015 [6].

C. Study Selection Approach

The titles/abstracts of documents related to this review underwent independent screening, after which both reviewers assessed the full text of all documents. Consensus was used to resolve any disagreements between reviewers. Adaptation of PRISMA flow principles guided the development of this review using a narrative synthesis methodology, with emphasis on both obstacles and opportunities for optimizing antibiotic use [5].

III. CURRENT SCENARIO OF ANTIBIOTIC USE IN INDIA

A. Prescribing Patterns and Trends

In India, antibiotic prescribing remains high and often inappropriate. In a meta-analysis of prescribing behaviours in primary care settings conducted through 2025, the overall prescribing rate was estimated at approximately 65% (95% CI: 54–75%). The majority of antibiotics prescribed are "Watch" antibiotics (e.g., fluoroquinolones and cephalosporins), while only 31.6% fall within the "Access" group. Studies in outpatient settings show that 32%–38% of all prescriptions include antibiotics, most commonly for virus-induced respiratory infections (representing 70%–80% of antibiotic prescriptions written for viral respiratory infections). The WHO AWaRe classification shows "Access" group antibiotic use remains below the 60% target for outpatient prescriptions (38%–47% usage); "Watch" group use is estimated at 37%–57%, and use of "Not Recommended" fixed-dose combinations (FDCs) is also commonly reported [7], [8], [9].

B. Community and Hospital Usage

The largest share of consumption comes from the community (retail) sector. Total systemic antibiotic consumption in 2019 was 5,071 million DDD (10.4 DID), of which Watch antibiotics accounted for 54.9% and Access antibiotics for 27%. Hospital settings show greater intensity: point-prevalence surveys indicate that 50–90% of inpatients receive antibiotics, frequently on an empirical basis, with greater use of Watch/Reserve agents in the ICU (e.g., predominance of piperacillin-tazobactam). Surgical prophylaxis and community-acquired infections account for the majority of prescribing [10], [7].

C. Over-the-Counter Access

Despite Schedule H1 requirements, inadequate enforcement still allows many people to buy antibiotics over the counter without a prescription. Studies show that 24%–62% of respondents obtained antibiotics without a prescription, even for conditions such as fever or cough, often based on prior self-medication experience. Online pharmacies further ease access to all AWaRe categories of antibiotics [11], [12].

D. Recent National Data

There was a small decrease in private-sector antibiotic spending after 2016. At the same time, inappropriate usage (Watch/Not Recommended) has increased rapidly in many states. Continued widespread use of azithromycin and broad-spectrum agents after COVID-19 reflects the high burden of infectious disease, fragmented healthcare delivery, and limited diagnostic availability [13], [10].

IV. BURDEN OF ANTIMICROBIAL RESISTANCE IN INDIA

A. Prevalence and Trends

The occurrence of AMR in India is among the highest in the world. According to the Antimicrobial Resistance Research and Surveillance Network (AMRSN) report published by the ICMR in 2024, analysis of 99,027 positive cultures from tertiary-care hospitals identified Gram-negative bacilli as the major causative agents of bloodstream infection, urinary tract infection, cerebrospinal fluid infection, and respiratory tract infection. Resistance to common antibiotics continues to rise; more concerning is carbapenem resistance among K. pneumoniae and A. baumannii, with over 50–91% of isolates resistant. Resistance to third-generation cephalosporins, fluoroquinolones, and piperacillin/tazobactam has also risen steadily. Global Burden of Disease estimates for 2021 attribute about 267,000 deaths worldwide to bacterial AMR (range: 224,000–310,000), with India accounting for an estimated 987,000 deaths due to bacterial infections associated with resistance (range: 855,000–1,120,000) [14], [15].

B. Major Resistant Pathogens

The major organisms driving multidrug-resistant infections in India include:

- E. coli — declining susceptibility and rising resistance to cephalosporins and carbapenems
- K. pneumoniae — resistance rate of 75–80% to piperacillin
- A. baumannii — more than 90% resistance to carbapenems
- P. aeruginosa
- MRSA (methicillin-resistant Staphylococcus aureus)

These organisms are major causes of healthcare-associated infections (HAIs), most notably ventilator-associated pneumonia (VAP) and bloodstream

infection (BSI). In 2019, carbapenem-resistant Gram-negative (CRGN) organisms were associated with more than 340,000 deaths [14], [16].

C. Clinical and Economic Impact

AMR is associated with increased length of hospitalization (4–13 days), higher rates of ICU admission, and increased mortality (up to three times higher for multidrug-resistant infections). The cost of treating resistant infections is substantially higher (US$199 for resistant vs. US$109 for susceptible infections — roughly 40–50% higher incremental cost), with pharmaceutical costs accounting for most of the additional expense. AMR costs the nation billions of dollars in direct healthcare costs, productivity losses, and out-of-pocket expenses, with many patients borrowing money to pay for treatment. Untreated or inadequately treated CRGN infections further worsen this situation [5], [17].

V. KEY CHALLENGES IN ANTIBIOTIC USE

A. Inappropriate Prescribing Practices

Prescribing is largely empiric, with the majority of antibiotic prescriptions relying on broad-spectrum "Watch" agents such as fluoroquinolones and cephalosporins. Recent studies indicate that 50–80% of antibiotic prescriptions for viral upper respiratory infections and diarrheal disease are inappropriate, driven by diagnostic uncertainty, patient pressure, and the lack of effective stewardship systems in the private primary-care sector [6], [18].

B. Self-Medication and Misuse

Self-medication with antibiotics is common, ranging from 19% to 36% across community-based studies, aided by easy pharmacy access. Common reasons for self-medication include:

1) Perceiving the illness to be relatively mild
2) Concern that seeking care would hinder the ability to work or strain finances
3) Having leftover medications from previous prescriptions

Patients frequently discontinue treatment prematurely or complete an incomplete course of therapy [12], [19].

C. Limited Diagnostic Support

Limited access to rapid diagnostics and antimicrobial susceptibility testing (AST) creates dependency on empirical therapy. Many primary and secondary facilities lack microbiology support, leading to excessive use of broad-spectrum agents [18].

D. Regulatory and Policy Gaps

Weak enforcement of Schedule H1 legislation, limited monitoring of private prescribing, and poor implementation of NAP-AMR strategies persist. Many state governments have made little progress in implementing stewardship programs [20].

E. Use in Agriculture and Veterinary Sectors

Indiscriminate use of antibiotics for growth promotion, prophylaxis, and treatment in poultry, dairy, and aquaculture — frequently without veterinary oversight — is a leading contributor to AMR. Weak regulation of feed additives and poor compliance with withdrawal periods further contribute to the environmental spread of resistance [21], [22].

VI. ANTIMICROBIAL STEWARDSHIP IN PRACTICE

A. Implementation Status in India

Antimicrobial Stewardship Programmes (AMSPs) are not uniformly implemented across the country. Most exist only in select tertiary healthcare centres and, to a lesser extent, secondary centres, despite strong policy support from ICMR and NAP-AMR 2.0 (2025–2029). Formal monitoring structures supporting AMSPs remain scarce in most hospitals, though states such as Kerala and hospitals accredited by NABH and JCI have shown improvement. AMSP presence in primary and secondary care remains extremely limited. The National Medical Commission has been tasked with establishing AMSP committees in all medical colleges, but enforcement remains weak [5].

B. Institutional Strategies

Multidisciplinary stewardship teams — including clinicians, microbiologists, pharmacists, and infection-control nurses — are commonly formed under ICMR AMSP guidelines. Most hospitals also develop hospital-specific antibiotic policies and standard treatment guidelines. Common elements include prospective audit with feedback, prior

authorization for restricted antibiotics, de-escalation protocols, and periodic training. In resource-constrained settings, hub-and-spoke models that integrate infection prevention and control (IPC) with AMR activities are emerging as a developing strategy [23].

C. Outcomes from Existing Studies

Existing initiatives show evidence of efficacy, including reductions in antibiotic prescribing (20–32%), improved prescribing appropriateness (20% improvement), reduced use of broad-spectrum/Watch agents, shorter hospital stays, and cost savings of up to 72–82% in selected tertiary-care settings. Other studies report trends toward decreased resistance and lower mortality. However, sustainability remains a challenge due to limited resources [24].

VII. ROLE OF CLINICAL PHARMACISTS

A. Medication Review and Interventions

Prospective Audit and Feedback (PAAF) is a vital role performed by clinical pharmacists. Pharmacists conduct daily medication reviews to evaluate the appropriateness of therapy with respect to indication, dosage, duration, route of administration, and de-escalation. Common interventions include IV-to-oral switches, therapeutic drug monitoring, dose adjustment for renal dysfunction, and discontinuation of unnecessary antibiotics. A recent study at a tertiary-care hospital in India documented 609 pharmacist-led interventions, of which 79.6% were accepted by prescribers, resulting in reduced prescribing of polymyxins (58%), carbapenems (7%), and glycopeptides (10%).

B. Monitoring and Follow-Up

Using Defined Daily Doses (DDD), pharmacists monitor antibiotic use and adherence to hospital antibiotic policy, watch for adverse drug reactions, and ensure therapeutic drug monitoring (TDM) for agents such as vancomycin and aminoglycosides. Pharmacists also follow up on culture reports in real time to enable timely de-escalation and optimize the duration of antibiotic therapy [25].

C. Contribution to Stewardship Programs

Within multidisciplinary AMS teams, clinical pharmacists have become key contributors to education, policy development, and implementation of the AWaRe classification. Research from Kerala and Pune shows prescribing appropriateness improved by up to 80% after AMS interventions, alongside reduced broad-spectrum use, lower drug costs, and improved provider adherence to treatment guidelines. Given the shortage of infectious-disease specialists, clinical pharmacists have become the operational backbone of AMS programs in many resource-limited areas of India [25], [26].

VIII. POLICY FRAMEWORK AND NATIONAL INITIATIVES

A. National Programs and Regulations

India's primary AMR policy is the National Action Plan on AMR Phase 2 (2025–2029), launched by the Union Minister of Health and Family Welfare on 18 November 2025. Its main aims are to strengthen a One Health approach through collaboration across 20+ government ministries, and to establish clear timeframes, budget allocations, and monitoring/evaluation mechanisms, while implementing Antimicrobial Stewardship (AMS) strategies. These strategies include:

1) Indian Council of Medical Research (ICMR) AMS guidelines (revised 2018)
2) National guidelines on treatment of infections (2025) using antimicrobials
3) Regulatory framework and requirements for Schedule H1 medications (antimicrobials)
4) Use of a blue label on medications that meet the AMS definition, to facilitate appropriate prescribing and dispensing

The National Centre for Disease Control (NCDC) leads AMR surveillance through the Antimicrobial Resistance Surveillance Network (AMRSN), and the National Medical Commission (NMC) requires AMS Committees in every medical college [27].

B. Implementation Challenges

Policy success has been constrained by fragmented implementation, arising from both systemic barriers (e.g., poor regulatory enforcement, particularly in the private sector) and operational barriers (e.g., inadequate resources, trained personnel, inter-agency coordination, laboratory capacity, and low public awareness). Only a limited number of states, such as Kerala and Gujarat, have made significant progress in

establishing functional state AMR cells and monitoring systems [28].

C. Impact Assessment

NAP-AMR 1.0 (2017–2021) enhanced surveillance but had minimal impact on antibiotic-use reduction and resistance trends, largely due to poor implementation. NAP-AMR 2.0 aims to address these shortcomings through improved accountability; early results suggest improved ownership and legislation, though clinical outcomes remain to be seen [29].

IX. EMERGING OPPORTUNITIES

A. Digital Health and Surveillance Systems

Digital technologies are playing a transformative role in AMR surveillance and stewardship. NAP-AMR 2.0 stresses the importance of integrated digital platforms, electronic medical records with clinical decision-support, and AI-based surveillance. The India AMR Innovation Hub (IAIH) highlights the benefits of digital antibiograms, laboratory hub-and-spoke networks, and nationwide data-sharing systems to detect outbreaks earlier and support evidence-based prescribing. Mobile applications and e-monitoring of prescriptions can further help curb misuse [30].

B. Rapid Diagnostics

Tests that distinguish bacterial from viral infections and provide rapid AST can help avoid unnecessary empirical treatment with broad-spectrum antibiotics at the point of care. Promising low-cost innovations include CRISPR-based assays, microfluidics, lateral-flow devices (LFDs), and syndromic PCR platforms suited to the Indian context. Scaling up affordable rapid diagnostic kits is a key strategy under NAP-AMR 2.0 and the IAIH [31].

C. Strengthening Healthcare Delivery

Opportunities exist in layered laboratory systems, pharmacist-driven stewardship in district hospitals, hub-and-spoke systems linking tertiary centres to primary healthcare, and integration of AMS into standard infection-control programs. Building capacity through training, public-private collaboration, and platforms such as Ayushman Bharat can improve diagnostic availability, guideline compliance, and balanced antibiotic utilization across urban and rural settings [23].

X. FUTURE DIRECTIONS

A. Policy and System-Level Improvements

NAP-AMR 2.0 (2025–2029) needs to be strengthened with binding timelines, dedicated budgets, and performance indicators. Priorities include national-level enforcement of Schedule H1, mandatory prescription audits, blue-strip labelling of antibiotics, and greater involvement of the private sector [27], [30].

B. Integration into Primary Healthcare

Simplified AMS should be integrated within Ayushman Bharat and primary/secondary care clinics through hub-and-spoke systems, point-of-care testing, and pharmacist/nurse-driven interventions. Locally relevant empirical treatment protocols, prescription-review systems, and training programs for community health workers should be developed, with emphasis on minimizing empirical broad-spectrum antibiotic use for common infections [23].

C. Strengthening Multidisciplinary Approaches

Holistic stewardship involving clinicians, microbiologists, clinical pharmacists, nurses, and infection-control professionals should be fostered. Initiatives such as multidisciplinary education, SASPI-type expert consensus, and collaborative approaches (prospective audit and feedback, diagnostic stewardship) should be expanded, supported by digital tools for information sharing and behaviour change [32].

XI. CONCLUSION

Antimicrobial resistance has become one of the biggest threats to public health in India, risking the reversal of decades of progress in treating infectious disease. This review highlights the rampant misuse of antibiotics, unacceptably high resistance among Gram-negative pathogens, and the diverse obstacles that prevent optimal antibiotic use.

Policies such as the National Action Plan for Containment and Management of AMR (NAP-AMR) 2.0 and ICMR guidelines for antibiotic stewardship provide a strong policy foundation for India to address AMR, but their application has been hindered by limited resources, weak enforcement, and uneven healthcare delivery. Encouragingly, targeted AMSPs

— particularly those led by clinical pharmacists — have achieved reduced antibiotic use and more appropriate prescribing in tertiary hospitals.

India needs to adopt digital technology in primary healthcare and expand diagnostic testing. Stronger enforcement of regulations and increased public awareness will be important going forward. India must also build genuine One Health cooperation to address antimicrobial resistance and preserve the efficacy of antibiotics

ABBREVIATIONS

Abbreviation	Full Form
AMR	Antimicrobial Resistance
AMRSN	Antimicrobial Resistance Research and Surveillance Network
AMSP	Antimicrobial Stewardship Programme
AST	Antimicrobial Susceptibility Testing
AWaRe	Access, Watch, Reserve (WHO classification)
BSI	Bloodstream Infection
CRGN	Carbapenem-Resistant Gram-Negative
DDD	Defined Daily Dose
DID	Defined Daily Doses per 1000 inhabitants per day
FDCs	Fixed-Dose Combinations
GAP-AMR	Global Action Plan on Antimicrobial Resistance
HAIs	Healthcare-Associated Infections
IAIH	India AMR Innovation Hub
ICMR	Indian Council of Medical Research
JCI	Joint Commission International
NABH	National Accreditation Board for Hospitals & Healthcare Providers
NAP-AMR	National Action Plan on Antimicrobial Resistance
NCDC	National Centre for Disease Control
OTC	Over-the-Counter
PAAF	Prospective Audit and Feedback
POC	Point-of-Care
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SASPI	Society for Antimicrobial Stewardship Practices in India
TDM	Therapeutic Drug Monitoring
VAP	Ventilator-Associated Pneumonia
WHO	World Health Organization

XII. AUTHOR CONTRIBUTIONS

All authors contributed to the conception, literature review, drafting, and critical revision of the manuscript. All authors approved the final version.

DECLARATION ON COMPETING INTERESTS

The authors declare no conflicts of interest.

DECLARATION OF ARTIFICIAL INTELLIGENCE (AI) IN SCIENTIFIC WRITING

AI tools were used only for grammar correction and illustrative image generation. All scientific content, analysis, and conclusions were prepared by the authors.

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