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A REVIEW ON ADDRESSING ANTIMICROBIAL RESISTANCE: RATIONAL USE AND PRESCRIBING PRACTICES IN FOCUS

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Abstract
The irrational and widespread use of antimicrobial drugs, particularly antibiotics, is a significant contributor to the global health crisis of antimicrobial resistance (AMR), especially in developing nations like India. Antibiotics, though essential in treating bacterial infections, are frequently overprescribed, often for viral illnesses such as colds or flu, leading to ineffective treatment, higher healthcare costs, and increased resistance. Understanding prescribing patterns is crucial for promoting rational use, optimizing patient outcomes, and preventing resistance development. In India, inappropriate antibiotic use is notably high across various sectors, including primary care and dentistry. Vulnerable populations—such as critically ill, pediatric, and geriatric patients—require individualized dosing due to altered pharmacokinetics and increased risks of adverse effects. Non-adherence by patients, driven by inadequate communication and lack of understanding, further exacerbates the issue. National treatment guidelines have been introduced to guide appropriate antibiotic use, yet implementation remains limited. Evaluating prescription practices through drug utilization studies and applying pharmacoeconomic tools like cost-minimization analysis can support rational drug choices and resource allocation. Enhanced diagnostic techniques and improved provider-patient communication are vital strategies to curb resistance. Without immediate and sustained interventions, AMR threatens to compromise modern medicine's ability to treat infections effectively, making it imperative to strengthen antimicrobial prescribing practices globally.

Keywords: Antimicrobial Resistance (AMR), Antibiotic Overprescription, Rational Drug Use, Prescription Practices, Pharmacoeconomic Analysis, Provider-Patient Communication.

Introduction
WHO defines antibiotics as medicine that treat and prevent bacterial infections. Antibiotics are a type of antimicrobial product [1].
Antibiotics help to treat or stop a few types of bacterial infection. They work by meansmicroorganism killing skill and upper skill to stop them spread. But they do no longer workfor everything. Plenty of light-weight bacterial infections get greater upon their individual devoid of theutilization of antibiotics. Antibiotics gained t artwork for viral infections which includecolds and flu, and nearly all coughs. Antibiotics are no longer automatically prescribed for: chest, infections, ear infections in children, sore throats [2].

Uses
- **Treat bacterial infections:** Antibiotics can deal with infections like urinary tract infections (UTIs).
- **Prevent bacterial infections:** Antibiotics can stop probably deadly bacterial diseases. For example, in areas with excessive infant mortality, pre-emptive azithromycin use can expand survival.
- **Relieve symptoms:** Antibiotics can relieve signs of bacterial infections and assist humans get better faster [3].

Importance of prescribing pattern of antibiotics
Understanding the prescribing pattern of antibiotics is necessary due to the fact it helps to limit the unfold of antibiotic resistance and enhance affected person outcomes.

Antibiotic resistance: irrational antibiotic prescribing is a foremost reason of antibiotic resistance, which can lead to longer clinic stays, greater high-priced medicines, and death.

Patient outcomes: An antibiotic stewardship application (ASP) can assist to enhance affected person results with the aid of promotion the fabulous use of antibiotics.

Infection control: Inappropriate antibiotic use can threaten contamination manage and undermine present day medicine [4].

Antibiotic Prescribing Patterns in India The sound knowledge of appropriate use of antibiotics in India is needed as the inappropriate or.Emergent inappropriate antibiotics use has been a major couple of situations, are ideal places to reduce the unreason for P. aeruginosa and S. epidermidis SSI infectionsapcan with all emergent antibiotic orders or remove epidemiological impact of S. aureus SSI in breast surgery.antimicrobial resistance, representing the most important danger for public health) and also by.infections more difficult to treat, possibly leading to increased morbidity and perhaps mortality if nownot addressed well; thus, knowledge and surveillance of prescribing patterns are important forpromoting advertisement on rational use of antibiotics in the country

Antibiotic prescribing in India

High incidence of antibiotic overuse: Studies exhibit a excessive rate of antibiotic prescriptions in India, regularly for stipulations that do no longer require antibiotics like viral infections, main to useless publicity to the tablets and improved resistance development.

Impact on healthcare costs: Inappropriate antibiotic use can lead to elevated healthcare prices due to extended clinic stays and the want for extra expensive, choice antibiotics to deal with resistant infections.

Concerns in unique sectors: Dental practitioners and most important care medical practitioner are frequently recognized as corporations with probably excessive antibiotic prescribing rates, similarly contributing to the problem

Need for recognition and guidelines: Raising focus amongst healthcare carriers and sufferers about the dangers of needless antibiotic use, alongside with enforcing strict prescribing recommendations primarily based on evidence-based practices, is essential to tackle the issue [5].

Background

Infectious diseases are harmful conditions caused by specific agents such as bacteria, viruses, fungi, or protozoa, affecting various body parts with identifiable signs and symptoms. The discovery of bacteria by A.V. Leeuwenhoek in 1675 and Robert Koch's development of Koch's Postulates significantly advanced disease diagnosis by linking specific pathogens to specific diseases. These diseases involve interactions between the host, pathogen, infection, and virulence, and they spread through various transmission routes. The rise of modern microbiology, particularly through the discovery of DNA's role in genetic transmission, has greatly enhanced our understanding and control of infectious diseases. Today, advanced molecular techniques are crucial in detecting and managing these illnesses.

Infectious diseases can be classified based on location, duration, and timing. By location, they are either local, affecting a specific body area, or systemic, spreading throughout the body. By duration, they are acute (rapid onset and spread), chronic (slow-developing and long-lasting), or latent (dormant with occasional outbreaks). By timing, infections are classified as primary, occurring in a healthy individual, or secondary, affecting someone already weakened by a primary infection.

Infectious agents are microscopic organisms responsible for causing diseases. These include:

- **Bacteria:** Prokaryotic cells (0.8–1.5 µm), classified as Gram-positive or Gram-negative. Most are extracellular, though some are intracellular.
- **Viruses:** Tiny (20–30 nm) obligate intracellular organisms with either DNA or RNA genomes, surrounded by a protein capsid.
- **Prions:** Abnormal proteins (PRP) found in neurons, causing brain disorders like Creutzfeldt-Jakob disease.
- **Chlamydiae:** Obligate intracellular microbes that divide like bacteria but cannot synthesize ATP; cause diseases like blindness and infertility.
- **Fungi:** Eukaryotes (2–100 µm) with chitin in their cell walls and ergosterol in membranes, causing superficial or deep infections.
- **Protozoa:** Single-celled eukaryotes (1–50 µm), often affecting developing countries; include malaria and leishmaniasis.
- **Helminths:** Parasitic worms (3 mm–10 m), including roundworms, flatworms, and flukes, with complex life cycles [6].

Microbial Infection Pharmacotherapy and Guidelines

Accurate diagnosis of infectious diseases involves identifying the infection site, understanding the patient's condition (e.g., age, immune status), and isolating the specific pathogen when possible. This is crucial in serious infections like meningitis or endocarditis, especially if treatment is prolonged. Proper specimen collection before starting antibiotics enhances diagnostic accuracy. A detailed exposure history also aids in identifying region-specific infections. While lab tests like cultures and serology are ideal, empirical treatment based on clinical signs is often used, especially in common cases like cellulitis or mild pneumonia. If symptoms persist despite treatment, further investigation is necessary, and non-infectious causes should be considered in the diagnosis.

The timing of antimicrobial therapy depends on the patient's condition. In critically ill patients (e.g., septic shock, febrile neutropenia, or meningitis), treatment should begin immediately after or alongside diagnostic specimen collection. However, in stable cases like subacute endocarditis or vertebral osteomyelitis, therapy should be delayed until proper samples (e.g., blood cultures or biopsy specimens) are collected. Starting antibiotics too early can hinder pathogen detection, making it difficult to confirm the diagnosis and select effective long-term treatment.

Empiric antimicrobial therapy is initiated before microbiology results are available, typically using broad-spectrum antibiotics based on the likely pathogens and clinical presentation. This is essential for critically ill patients to reduce morbidity and mortality. Once the specific pathogen and its antibiotic susceptibility are identified (usually within 24–72 hours), therapy should shift to definitive treatment-a narrower, targeted antibiotic-to reduce side effects, costs, and the risk of antimicrobial resistance. Choosing empiric therapy involves considering infection site, patient history, and local resistance patterns, especially in hospital-acquired infections often caused by drug-resistant organisms like MRSA or Pseudomonas [7].

Antibiotic treatment for Acute Bacterial Rhinosinusitis (ABRS) depends on symptom severity and recent antibiotic use. Patients are classified into two groups: (1) those with mild symptoms and no recent antibiotics, and (2) those with moderate symptoms or recent antibiotic use (within 4–6 weeks). Prior antibiotic exposure increases the risk of resistance, so treatment should be tailored accordingly. The goal of therapy is to eliminate bacteria, relieve symptoms, prevent complications, and avoid chronic disease. Clinicians should reassess treatment if there's no improvement within 72 hours, which is the benchmark for defining treatment failure [8].

Evaluating prescribing pattern of antimicrobial drugs

The rational use of medicines (RUM), as defined by WHO, ensures patients receive appropriate medications tailored to their needs, duration, and cost-effectiveness. RUM minimizes treatment-related side effects, mortality, and costs while optimizing healthcare resources. Despite its importance, prescriptions globally are irrational, especially regarding antibiotics. The CDC reports that outpatient antibiotic prescriptions are inappropriate. In developing countries, irrational antibiotic use is a major concern, driven by factors like patient pressure, self-medication, incomplete treatments, poor diagnostics, and socioeconomic issues. Many antibiotics are prescribed without proper testing, even for illnesses that may resolve without them [9].

Over the past 50 years, antibiotics have significantly improved outcomes for severe infections. However, their effectiveness is now threatened by the spread of resistant organisms, primarily due to inappropriate and irrational use. Antimicrobial resistance (AMR) is strongly linked to antibiotic overuse, particularly in developing countries where data on usage is limited. Drug utilization evaluations (DUE) and prescription pattern monitoring are essential tools to promote rational use. Studies have revealed alarming costs, including $1.1 billion I n the U.S. for unnecessary antibiotic prescriptions and $20 billion spent on treating resistant infections [10].

Antimicrobial agents (AMAs) are essential in treating infectious diseases, especially in critical care settings like ICUs. However, their widespread and often inappropriate use has contributed significantly to the global problem of antimicrobial resistance (AMR). While resistance is a natural response of microbes, factors such as poor adherence to guidelines, incorrect dosing, and overuse accelerate the issue. The lack of new antibiotic development worsens the crisis. In India, which is the largest consumer of AMAs, high resistance levels to key antibiotics like fluoroquinolones, carbapenems, and polymyxins have been reported. This growing resistance, particularly in ICUs, poses a severe public health threat [11].

Antimicrobial drugs utilization and adherence

Several methods and the ICU specific antibiotic restrictions predominantly AMSP andsensitization nearer to rational antimicrobial prescribing want to be followed in letter andspirit. In addition, point-of-care diagnostic techniques should be followed which can provide forquick and dependable detection of infection. These methods may maximize antimicrobial treatmentand decrease the risk of the develop ment of multidrug - resistant bacteria from prolonged pesticid e use and other source.inadequate use of antimicrobial drugs [12].

The most significant contributors to non-adherence are patients, therapies, and medical professionals.There are several reasons why patients could stray from the treatment plan, whether intentional or unintentional.For instance, patients may (i) decide they no longer need to finish their prescriptions, (ii) take drugs in excess or insufficiently, (iii) take drugs at the wrong time, or (iv) stop taking drugs too soon.Complex treatment plans and poor patient-provider communication may further increase the likelihood of non-adherence.One major factor contributing to non-adherence among patients receiving short-term antibiotics was found to be inadequate information and awareness about the medication [13].

Patients frequently cite ignorance, aspects of their illness and related treatments, scepticism about the advantages and effectiveness of recommended treatment plans, and a lack of social support as causes for non-adherence. Patients' comprehension of the data is essential to helping them make healthier choices for themselves.

Improved adherence is strongly associated with improved patient-centered communication.Maximising adherence to prescriptions requires the capacity to gather and apply knowledge, as well as to develop dedication to a treatment plan [14].

Cost implications in antimicrobial drugs use

AMR infections result in severe illnesses, prolonged hospitalisations, increased healthcare costs, pricier second-line drugs, and treatment failures. For instance, it is predicted that antimicrobial resistance is associated with more than just in Europe. Nine billion euros each annum. Furthermore, in accordance with the Centres for Disease Control.

According to the Centres for Disease Control and Prevention (CDC), antimicrobial resistance incurs an additional $20 billion in direct healthcare costs in the United States, equivalent to around $35 billion in annual lost productivity. The persistence of AMR trends will diminish the efficacy of antibiotics; therefore, physicians should utilise last-resort medicine classes such as carbapenems and polymyxins, which are costly, challenging to get in developing countries, and associated with several bad effects [15].

Cost-minimization analysis' is a device utilized in Pharmacoeconomics to examine the expenses for opportunity publications of remedy or treatment plans that have equal medical effectiveness. It includes value calculations to pick out the least high-priced drug or routine or healing modality.

The National Treatment Guidelines for Antimicrobial Use in Infectious Diseases were initially issued in 2016 by the National Centre for Disease Control, MoHFW, India.More recently, the 2nd edition of the guidelines was released. The ICMR published them in 2019. It is anticipated that the regimens suggested in these guidelines will be used to treat bacterial infections in the nation.This provides us with a rare chance to evaluate the price differences based on the usage of branded or generic medications as well as comparing the prices of various bacterial infection treatment regimens. As far as we are aware, A cost-minimization analysis of the antibiotic regimens covered by national treatment guidelines for infectious diseases has not been made public in India [16].

Use of antimicrobials in special population

With the exception of deaths that occur in residential aged care facilities, hospitals now account for more than half of all deaths in several countries.The elderly and very old account for a sizable portion of hospital mortality.For instance, in the United States, in 2010, 75% of inpatients who passed away at a clinic were 65 years of age or older, and 27% had been 85 years of age or older. As suggested by the term "end-of-life pneumonia," infections like pneumonia frequently directly contribute to these patients' mortality.This presents problems for the use of "end-of-life" drugs, which may lessen difficulties but may make antibiotic resistance resolving stress worse.The prevention, detection, and treatment of infections in older patients require the expertise of infectious diseases (ID) specialists who have a passion for this area of medicine. Additionally, ID since this group is especially at risk. Consultants are crucial in encouraging the careful use of antibiotics in this population due to the detrimental consequences of improper antibiotic usage, which include Clostridium difficile infection, adverse medication responses, and antibiotic resistance [17].

The rise of multidrug-resistant and pan-drug-resistant organisms, combined with limited new antibiotic development since the 1970s, has renewed interest in reusing older antibiotics. However, standard dosing often leads to suboptimal exposure in critically ill patients due to unpredictable changes in drug pharmacokinetics (PK) and pharmacodynamics (PD), as well as decreasing bacterial susceptibility. To ensure the effective reuse of old antibiotics, careful dose optimization is essential to prevent underexposure and treatment failure.

Certain populations of affected individuals have particular dosage requirements due to a severe and intricate pathogenesis. These comprise critically ill patients with severe burn injuries or trauma, organ failure, sepsis, septic shock, major surgery, febrile neutropenia, and cystic fibrosis. dysfunctional people who are overweight. Many of these Patients experience inflammation throughout their bodies. Extreme systemic inflammatory response syndrome (SIRS) is common, particularly in people who have had major surgery, serious infections, burns, trauma, pancreatitis, or ischaemia.Numerous inflammatory mediators interact with individual physiology during SIRS, frequently showing up as increased capillary permeability and hyperdynamic effects on the cardiovascular device. A variety of organ-system failures can also result from SIRS, which may alsorequire renal alternate treatment or extracorporeal membrane oxygenation. Surgical drainage may also serve the similar purpose of providing additional pathways for the elimination of drugs and inflammatory fluids. Furthermore, the majority of these patients have changed body water levels associated with either impaired cardiovascular and renal function or substantial fluid resuscitation. The water dynamics of the body are linked to significant changes that impact the PK of several antibiotics. The concentration of antibiotics is eventually diluted as extra water is transferred into the extracellular space, transferring additional molecules. Additionally, increased blood filtration via the kidneys, driven by increased cardiac activity, may result in a higher cost than routine elimination of pills such as antibiotics are examples of solutes. As a result of their obesity, other patients have changed fat/muscle ratios, which may also significantly impact the way that drugs are distributed [18].

Paediatric care encompasses a wide range of fitness services, from preventative healthcare to the diagnosis and treatment of acute and chronic disorders. Twenty to 25 percent of the world's population is made up of children, and they have many acute and chronic this subpopulation may be affected by diseases. Due to their underdeveloped organ characteristics, premature newborns are more likely to experience abrupt toxicity or a poor medical response from less-than-ideal drug dosage regimes. This modifies the population's pharmacokinetics or dose requirements. In developing countries, paediatricians and other clinical professionals who provide healthcare for infants and young people face many obstacles because there are insufficient resources for appropriate medications, high costs, inadequate infrastructure, and a lack of knowledge. available information on paediatric population pharmacokinetics and pharmacodynamics. Infectious diseases make for a significant portion of hospital admissions, particularly in children, and are a major cause of morbidity and mortality in India. Antibiotics as well as various Therefore, antimicrobials are an essential family of medications used in both hospitals and the general public. Antibiotic use in paediatric treatment is now required due to the increasing prevalence development multi-drug-resistant organisms, namely the emergence of bacterial resistance to widely used antibiotics (Newland et al., 2012). Among the drugs that pediatricians administer the most frequently are antibiotics, and their use has become commonplace in the management of paediatric diseases. Typically, they are recommended for children with conditions that they offer no advantages, including respiratory virus diseases like the common cold. According to Resi et al. (2003), the usage of broad-spectrum antibiotics is increasing, which results in their unnecessary cost and encourages the development of antibiotic resistance. Numerous expert societies have released guidelines intended to reduce the worldwide usage of antibiotics by utilizing a variety of management techniques. Prior to the implementation of policies and procedures, comprehensive data regarding the prescription pattern of antibiotics is required. The majority of medications administered for children have no longer been studied in children. [19].

Conclusion

The enormous and often irrational use of antibiotics has contributed significantly to the world disaster of antimicrobial resistance (AMR), specially in developing countries like India. Overprescription, poor diagnostic practices, and affected person non-adherence are primary drivers of this issue. Antibiotics, though essential for treating bacterial infections, are frequently misused for viral illnesses, mainly in pediatric and outpatient care. Evaluating antibiotic prescribing patterns is crucial to promote rational use, reduce resistance, and minimize healthcare costs. Special populations, which include seriously ill, geriatric, and pediatric patients, require cautious dosing due to altered pharmacokinetics and vulnerabilities. National treatment guidelines exist but are underutilized. Enhanced diagnostic tools, and provider-patient conversation can greatly enhance antibiotic adherence and effectiveness. Cost-minimization techniques are necessary for choosing appropriate regimens. Without stringent action, AMR may undermine current medicine. Thus, rational antibiotic use and monitoring need to be prioritized to maintain their efficacy for future generations.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

INFORMED CONSENT AND ETHICAL STATEMENT

Not Applicable

AUTHOR CONTRIBUTION

All Authors Are Contributed Equally

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