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Review Article

Antibiotic Use and Resistance: Mechanisms, Trends, And Preventive Strategies

Preethi V.*, Poovarsan S., Monika P.

Department of Pharmacy Practice, School of Pharmaceutical Sciences, Vels Institute of Science Technology and Advanced studies – Pallavaram, Chennai.

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ABSTRACT

The term 'antibiotics' which means "against life". Antibiotic-resistant bacteria have emerged as a result of inappropriate and excessive use of antibiotics, rendering treatment ineffective and increasing morbidity and mortality rates. prevalence and patterns of Self-medication is a significant public health concern worldwide, with its prevalence varying widely across the globe, ranging from as low as 11.7% to as high as 92%. From 2000 to 2015, high-income countries' use of antibiotics to treat infections stayed constant, however throughout this time, poor nations saw dramatic increases in antibiotic consumption. Between 2016 and 2023, antibiotic consumption in reported countries rose by 16.3%, from 29.5 billion to 34.3 billion defined daily doses (DDDs), with a corresponding 10.6% increase in the daily consumption rate, from 13.7 to 15.2 DDDs per 1,000 people. prevention of antibiotic resisance The influenza and S. pneumonia vaccines are essential for preventing infections and types of the disease that are resistant to antibiotics. The vaccine targets seven serotypes of S. pneumonia that are extremely resistant to medications and frequently cause infections. Immunization against these serotypes lowers the frequency of infections and resistant strains, which lessens the selection pressure that causes antibiotic resistance.

INTRODUCTION

The 1928 discovery of antibiotics by Sir Alexander Fleming transformed contemporary medicine, but the subsequent abuse and overuse of these drugs led to antimicrobial resistance, which currently threatens world health [1]. Antibiotic resistance began when Abraham and Chain discovered penicillinase, a substance that renders penicillin inactive. Antibiotic abuse reduces their effectiveness and promotes the emergence of resistance. The effectiveness of antibiotics can be

***Corresponding Author:** Preethi V.
Address: Department of Pharmacy Practice, School of Pharmaceutical Sciences, Vels Institute of Science Technology and Advanced studies – Pallavaram, Chennai.
Email ✉: preethiv870@gmail.com
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undermined by improper use, which can produce resistance in bacteria, result in adverse effects, and pose health risks. The therapy may not be what the patient needs, the right dosage, or it may not be required at all. The use of antibiotics responsibly will be essential to ensuring that life-saving medications continue to work and lowering the danger of antibiotic resistance, as bacterial resistance to antibiotic treatments is a serious threat to society [2]. Antimicrobial resistance (AMR) is a remarkable and pervasive global public health issue that threatens our ability to successfully treat and prevent infectious illnesses [3].To stop the spread of antibiotic resistance, medications must be prescribed carefully. This detail selecting the appropriate antibiotic, taking it as needed, and knowing how long to take it for. Overuse and misuse of antibiotics contribute to the development of resistance. Patients must precisely follow their treatment plan, and healthcare professionals must use antibiotics sparingly. evaluating the necessity of antibiotics. Infections and diseases brought on by vaccination and proper hygiene can also be decreased with radio control methods. Adhering to these easy, basic strategies will help stop the spread of antibiotic resistance. In order to keep antibiotics effective for future generations, we must utilize them properly. Antibiotics are essential for treating bacterial infections and stopping the spread of infectious diseases. However, because of their overuse and abuse, antibiotic resistance has become a rising public health concern. Thousands of individuals die from overusing antibiotics because they mistakenly think they can cure viral illnesses. Negligent practices, such as pressing physicians to write prescriptions for antibiotics, also encourage abuse. Antibiotic illiteracy exacerbates this issue, particularly with regard to what antibiotics are, when and how to use them, and their possible side effects [4]. Interventions that promote ethical use of antibiotics through education are a vital weapon in the fight against antibiotic resistance. The high prescription rate of antibiotics, the decrease in the number of antibiotics prescribed, and the creation of educational initiatives on the appropriate and sensible use of antibiotics are also among the primary responsibilities of healthcare professionals. in the proper medical facilities [4]. Reasons to exercise caution when using antibiotics to ensure their continued effectiveness and to stop the emergence of resistant microorganisms. Negative effects of abuse include decreased treatment effectiveness, higher medical expenses, and the emergence of antibiotic resistance. Longer hospital stays, worse patient care, and increased death rates can result from this. Additionally, the rise of antibiotic resistance increases the strain on health systems and complicates the treatment of illnesses. Humans must use antibiotics wisely in order to mitigate the risks posed by antimicrobial resistance [5]. The effectiveness of common medicines used to treat medically relevant bacterial infections is being jeopardized by antibiotic resistance, which has emerged as a global concern. According to the 2022 Global Antimicrobial Resistance and Use Surveillance System (GLASS) report, "GLASS provides countries with a standardized way to collect, analyze, and share data on antibiotic resistance." The research reveals worrying rates of resistance to common bacterial infections. It ensures data quality and representativeness by monitoring national surveillance systems. Some WHO regions offer technical support and facilitate GLASS enrollment through established surveillance networks." Notably, the analysis shows that across 76 nations, the median resistance rates for methicillin-resistant Staphylococcus aureus and third-generation cephalosporin-resistant E. coli were 35% and 42%, respectively. Given that Staphylococcus aureus and E. coli are prevalent sources of illnesses globally, these findings are very alarming. The information in the paper

emphasizes how urgently coordinated international efforts are needed to address antibiotic resistance, encourage responsible antibiotic use, and create novel antimicrobial treatments in order to lessen this escalating threat to public health (WHO). One of the top priorities in the WHO (World Health Organization) global action plan is the need to further reduce the spread of AMR by raising knowledge and comprehension of antibiotics and AMR through efficient training, education, and communication [6]. A serious worry is the rise in multidrug-resistant bacterial strains, which raise the incidence of chronic illnesses, treatment costs, and healthcare consumption. There could be fatal consequences from this, and cooperation is desperately needed. These increasing death rates demonstrate how urgently strategies to combat antibiotic resistance are needed [7].Although there are rules in place, 81.25% of the rural population in Sindh, India, reported using antibiotics for self-medication. This suggests that the public needs more education on how to use over-the-counter antibiotics properly [9]. Self-medication has significant health risks and is frequently encouraged by friends, neighbors, family, pharmacies, or advertisements. The problem with self-medication is that it increases pathogen resistance, which in turn causes antibiotic resistance to rise and treatment to fail against harmful microorganisms. Serious health hazards could result from this, such as prolonged discomfort, negative reactions, and even potentially fatal complications. The worldwide spread of antibiotic resistance is also influenced by the careless use of antibiotics without a prescription. Increasing knowledge among medical professionals to support judicious drug use, strengthening prescription regulations, and educating the public about the use of antibiotics are the answers.

Educating patient and prescribing responsibly. The way antibiotics are given has evolved significantly throughout the years, despite the fact that they have been used to treat illnesses. Multidrug-resistant illnesses have alarmingly increased as a result, and a number of studies have demonstrated a substantial correlation between consumption and bacterial resistance. Over time, bacteria adapt and change in response to repeated administration of the same antibiotics, making the drugs less and less effective. And the results are fatal: more deaths, prolonged illness, and more medical expenses. People frequently use antibiotics as self-treatment for a variety of conditions, such as bronchitis, influenza, congestion, bladder pain, and oral infections. This is frequently accomplished with the aid of unconventional methods of acquiring antibiotics. The issue can get worse if neighborhood pharmacies give out antibiotics without valid prescriptions. People attempt to utilize "old" antibiotics from an outdated prescription, unaware of their efficacy and the risky immunity they are developing against them. Friends, family, or online resources, like online pharmacies, may give these antibiotics without the required medical supervision. It highlights the need of following medical advice and using antibiotics ethically because abuse of them can result in unpleasant side effects, antibiotic resistance, and other health problems [11].

The Evolution of Antibiotics: A Historical Perspective:

Rudolph Emmerich and Oscar Low, two German scientists, discovered pyocyanase, the first antibiotic, in the late 1800s. Originally used to treat cholera and typhus, it is derived from Pseudomonas aeruginosa. Antimicrobial agents that are safer and more effective were made possible by this revolutionary discovery.

Antimicrobial therapy was transformed in 1909 when Paul Ehrlich introduced Salvarsan. Treponema pallidum, the bacterium that causes syphilis, was the focus of this arsenic-based medication, which effectively treated the illness. Ehrlich's finding, which showed promise for targeted therapy, was a major turning point in the battle against infectious illnesses. Salvarsan's creation inspired researchers and saved numerous lives by opening the door for later antimicrobial drugs. Ehrlich's groundbreaking research has changed the field of infectious illness therapy and improved patient outcomes for a long time. Modern medicine is still influenced by his legacy [12]. The 1928 discovery of penicillin by Alexander Fleming transformed the treatment of bacterial infections and saved many lives. One essential component of therapeutic treatment is still penicillin. The antibiotic qualities of Penicillium sp. were initially identified by Ernest Duchesne in 1897, but his work was overlooked until Fleming's discovery. Protonsil, the first sulphonamide, was developed by Bayer's team in 1932, and Gerhard Domagk demonstrated its effectiveness against serious bacterial infections, opening the door for further advancements in antimicrobial technology[13]. In 1946, the first antibiotic that physicians could prescribe was penicillin, which was made from the fungus Penicilium. World War II research sped up its development. Tetracycline and streptomycin appeared by the late 1940s and early 1950s, establishing antimicrobial chemotherapy in clinical practice. Bacillus tuberculosis was one of the many harmful bacteria that these medicines successfully targeted. This revolutionized patient care and saved many lives, marking a major turning point in the treatment of bacterial infectionsThe advent of these antibiotics gave patients hope and transformed the medical industry [14]. They researched medications in the 1970s, and then pollutants, analgesics, and antibiotics in the following decades. The Nobel Prize was awarded to Sir Alexander Fleming in 1945 for his discoveries of penicillin and lysozyme, which he made in 1922 [15].

Prevalence And Patterns of Self-Medication:

With an incidence ranging from 11.7% to 92%, self-medication (SM) misuse is a worldwide public health concern [16]. In India, self-medication is a major contributing factor to antibiotic resistance. Under this approach, overuse of antibiotics may hasten the emergence of antibiotic-resistant microorganisms. Major health concerns, such as adverse drug combinations, allergic reactions to certain prescriptions, and ineffective treatment, are associated with using prescription medications without a prescription. Treatment overuse or delays may result in needless suffering and health decline. In order to address this issue and encourage the prudent use of pharmaceuticals while lowering the hazards associated with self-medication, it is crucial to strengthen public awareness campaigns, educational initiatives, and stronger laws [17]. In underdeveloped nations like India, where over-the-counter (OTC) drugs are easily accessible, self-medication is widespread. However, their unchecked usage can result in abuse and misuse, even though they have a long history of being safe and effective. Over-the-counter drug sales are facilitated by lax enforcement and laws. To summarize, this approach may result in serious outcomes like treatment failure, unpleasant reactions, and the development of drug resistance, all of which could endanger public health [18]. Due to the availability of the majority of OTC (over-the-counter) medications in developing nations like India, self-medication has grown widespread.When used as prescribed by a physician, these medications are safe and effective; but, they can be abused if not utilized

properly. Drugs are sold over-the-counter, and regulations are strictly enforced. There is less self-medication. Long-term public health may be at risk due to the negative consequences of this approach, which include side effects, treatment failures, and an increase in antibiotic resistance [19]. The development of antibiotic resistance, adverse responses, and the postponement of appropriate medical care are among the dangers associated with self-medication. It also provides access to over-the-counter medications and deters people from visiting a doctor. It will be necessary to promote safe self-medication, regulate the sale of over-the-counter pharmaceuticals, enhance health systems, and run public awareness programs. In addition to lowering the risks associated with self-medication, this more all-encompassing approach may improve overall health and wellness and encourage safe medical practices. Contact a doctor immediately.

Global Trends In Antibiotics Use

Between 2000 and 2015, there was no discernible shift in the usage of antibiotics to treat sickness in high-income nations. Other research, however, showed that the use of antibiotics in less developed states was increasing quickly [20]. Antibiotic consumption in the reporting countries increased from 13.7 to 15.2 DDDs per 1,000 people, representing a 16.3% increase in proportion and a 10.6% increase in the rate of daily intake, from around 29.5 billion DDDs in 2016 to 34.3 billion DDDs in 2023 [21].Among lower- and middle-income nations, India is among the top users of antibiotics worldwide and saw the largest growth in antibiotic use (103% between 2000 and 2015) [22]. 2017 saw the creation of the Access, Watch, and Reserve (AWARE) Classification by the World Health Organization (WHO). According to this paradigm, antibiotics can be divided into three groups according to their best-use and likelihood of causing antimicrobial resistance (AMR).Antibiotics available under access strategies are thought to carry a low risk of AMR and adequate for the majority of disease cases, whereas Reserve describes drugs for critical conditions and Watch is the group for antibiotics that may increase the potential danger for AMR. While antibiotics that may raise the risk of AMR are designated watch, those necessary for serious infections are designated reserve. Antibiotic stewardship programs and evidence-based antibiotic use are supported by the AWaRe classification. According to the World Health Organization (WHO), at least 60% of all antibiotic prescriptions in each nation should fall under the Access category by 2023 in order to promote responsible antibiotic prescribing and reduce antimicrobial resistance (AMR) [23]. The increase in antibiotic use in India between 2011 and 2019 was startling. Since they are the first antibiotics to be permitted access, they are far less common. Conversely, the usage of antibiotics that are kept back is more susceptible to AMR due to their reserve nature. The fact that reserve medications are typically utilized to treat drug-resistant illnesses indicates that AMR is rising in India. This trend emphasizes how important it is to conduct careful prescribing and improve antibiotic stewardship in order to battle the impending threat of AMR [24]. To address this issue and encourage the prudent use of antibiotics, immediate action is required to guarantee that these life-saving measures continue to be effective [25]. However, monitoring antibiotic use is one way to enhance antibiotic stewardship. By keeping an eye on usage trends, clinicians can also create customized treatments for regional issues. This approach could lead to targeted immunization programs, health care policies and procedures, and educational initiatives. For instance, identifying the nations with the highest antibiotic usage may aid in the creation of regional awareness

campaigns aimed at encouraging healthcare providers to use antibiotics sensibly. This data analysis also identifies the locations where immunization would have the biggest effect on lowering antibiotic use. According to the report, as the yearly expenditure on antimicrobial resistance (AMR) increased, it became more important to address this problem to avoid suffering from pain and death rates that would otherwise have been unthinkable. [26] The severe impacts of AMR on the global economy will have a significant influence.With the global GDP predicted to decline by two to three percent by 2050, AMR poses a threat to the economy that has never been witnessed before. With output predicted to decline by 3% to 8%, the livestock industry is particularly heavily hit. Communities and nations worldwide will suffer greatly if nothing is done, and the cost is an astounding USD 100 trillion. The necessity of concerted international action to eradicate AMR, lessen its detrimental effects on the economy, and perhaps

Mechanisms Of Antibiotics Resistance:

The class of medications known as antibiotics is crucial in the fight against bacterial infections. These drugs function by focusing on particular metabolic pathways that are essential to the development and survival of bacteria. In this post, we'll go over the five main ways that antibiotics function, emphasizing how they differ from one another.

.1.1 Cell-Wall Synthesis Inhibition:

The first line of treatment is to stop cell-wall formation, which is essential for bacterial growth and division Glycopeptides (like vancomycin), cephalosporins, and penicillins are examples of beta-lactam antibiotics that kill bacteria by binding to particular enzymes essential for the formation of their cell walls. An essential part of the bacterial cell wall, the cross-linking of peptididoglycan chains, is prevented by this interaction. Bacterial death is the result of bacterial cell lysis, which is brought on by the bacterial cell wall becoming lighter [28].

1.2 Interference with Cell Membrane Function Cell membrane function, which is necessary to maintain cellular balance, is disrupted by the second. Among the polymyxin antibiotics, colistin alters the composition and functionality of the bacterial cell membrane. Cell death is the result of this disturbance, which results in the permanent loss of vital nutrients and ions.

1.3 Prevention of the Synthesis of Proteins The third strategy is to stop the bacterial cell from synthesizing the proteins it needs to thrive and survive. Some antibiotics, including tetracyclines, aminoglycosides, like streptomycin, and phenicols, like chloramphenicol, react with particular bacterial ribosome locations to prevent messenger RNA translation into protein. Consequently, the bacteria are unable to manufacture vital proteins [29], which ultimately results in their demise.

1.4 Nucleic Acid Synthesis Inhibition Fourth, there's a halt to the production of nucleic acids, which are necessary for transcription and, consequently, bacterial development. A class of quinolones and nucleic acid synthesis inhibitors known as ciprofloxacin and rifamycins inhibits the topoisomerases, which are enzymes involved in DNA transcription and replication. By blocking topoisomerases, critical gene transcription is inhibited, preventing bacterial cell division and causing cell death.

1.5 Action as Antimetabolites The sixth way that antibiotics work is by antimetabolic activity, which prevents the host and bacterial metabolic systems from interacting. Antibiotics like

trimethoprim and sulfamethoxazole prevent bacteria from producing the necessary nutrients, including folic acid, that allow them to proliferate because the mass of the bacterial cell is too large. Therefore, bacteria may die if necessary nutrient production is inhibited [30].

Factors Influencing Self Medication with Antibiotics

1.1 Socio Demographic Factors

The main factors influencing self-medicating behavior are sociodemographic characteristics. Because elderly individuals with chronic illnesses may self-medicate, age is a significant determinant. Numerous health issues that require medicine, such as diabetes, high blood pressure, and arthritis, are common in older adults. Elderly people who receive inadequate counseling may turn to self-medication as a way to cope with their symptoms, which could have negative health effects [31]. In terms of its influence on self-medication, gender is the sociodemographic characteristic that came in second. Reproductive health problems may be self-diagnosed by women more often than by men. With the decline of natural remedies for health issues including menstrual cramps, pregnancy, and menopause, women are turning more and more to over-the-counter pharmaceuticals (vitamins, supplements, and pain relievers). If women are not given access to adequate medical treatment, they may be more likely to abuse prescription pharmaceuticals and other prescriptions, which can be harmful to their health at a time when they are dealing with new health issues. Education level is another element that influences a person's propensity to self-medicate. Due to their lack of knowledge about health issues, those with lower levels of education may be more prone to self-medicate. Lack of knowledge about health and wellness may make it more likely that people may abuse medications or look for unproven remedies, which could result in serious health issues [32]. Lastly, self-medication behavior may also be influenced by one's occupation. Self-medicating for comfort could result from hectic or stressful professions, she explains. Perhaps as a result of the stresses of contemporary life, people are choosing band-aid solutions over the appropriate medical treatment for their illnesses. That can be especially challenging for those who work in time-sensitive, demanding fields like banking, law, or healthcare [33].

1.2 Socioeconomic Factors:

The urge to self-medicate is also greatly influenced by socioeconomic factors. Income is a major social factor. People with lesser earnings might be more likely to self-medicate since they have fewer access points to medical professionals. If the cost of medicine is too high for the impoverished, they may choose to treat themselves or turn to quackery. This probably applies particularly to individuals who are low-income or impoverished. Insurance for health care is another significant socioeconomic element. Self-medication may also be used by people to lower their medical expenses if they have insufficient or no health insurance. It is now nearly impossible for people without health insurance to receive medical care, much less a wellness program; for some, self-medication is their only option. This is particularly true for people whose employment do not provide health insurance and for people who cannot afford private insurance [32].The likelihood that someone will self-medicate may also be influenced by their residence. Rural locations, where many people self-medicate, have limited access to healthcare services. Even hospital access and experts are scarce in urban areas due to the high population density per health professional. Therefore, people can start taking care of

themselves at home to take control of their health [34] .Employment and other socioeconomic factors may also have an impact on self-medicationand health-related data. People from low socioeconomic origins may self-medicate because they have less access to health care, and because they have limited financial resources, they will have a very hard time getting health care [33]

1.3 Health-Seeking Behavior and Health System:

Antibiotic self-medication is a concerning situation that is influenced by a wide range of elements, including systemic variables and health-seeking behavior. While health-seeking behavior refers to the steps people take to avoid, treat, or manage health conditions, the health system encompasses the planning, financing, and delivery of healthcare services.Health-seeking behavior also has a big impact on self-treatment with antibiotics. Individual views, attitudes, and beliefs about health and illness may influence a person's propensity to self-medicate. Antibiotics are seen as a panacea for all ailments by some, while others think they are essential for treating any infection.such misconceptions will inevitably lead to the abuse of antibiotics, which is a major cause of antibiotic resistance [32]. system-related factors can also be potential drivers for self-medication with antibiotics. Moreover, health Antibiotics can be purchased without a prescription in the majority of countries because they are easily accessible over-the-counter. Second, because self-medication is more easy and less expensive than visiting a doctor, and because access to medical experts is severely restricted, people may turn to it. [10] Antibiotic self-medication may also be influenced by aspects of the healthcare system. Antibiotics can be purchased over-the-counter in the UK and many other countries without a prescription. Because medical experts are expensive and hard to obtain, people may think self-medication would be a better option [35] . The relationship between the patient and the therapist is another important consideration. Patients are more prone to self-medicate and abuse antibiotics if medical providers do not spend time educating them. People will be less likely to self-medicate, however, if doctors establish a relationship of trust with their patients and provide them explicit instructions on how to take antibiotics [36].

Prevention Of Antibiotic Resistance:

Vaccines that guard against infection and resistant strains of the disease, like those for influenza and S. pneumoniae. It is intended to target the seven drug-resistant S. pneumoniae serotypes that cause the bulk of infections. By lowering illness and resistant strains, vaccination against these serotypes lessens the selection pressure to create antibiotic resistance. Since vaccination protects against infectious diseases and fights AMR, it is an essential part of infection prevention and control measures. These two benefits highlight how important good vaccination practices are. An strategy that is meticulous is necessary when diagnosing and treating infections. Targeting the suspected pathogen and starting empirical therapy is the initial step. Finally, definitive therapy is administered based on the identified pathogen once the patient has been cultured to determine the precise pathogen. Optimal treatment includes choosing the optimum time, regimen, dose, method, and duration, closely monitoring the patient's reaction, and adjusting the treatment as necessary to provide effective infection control and prevent the development of antibiotic resistance [37]. In order to ensure that antibiotics target actual infections and not contaminants, it is crucial to distinguish between infection and contamination while treating illnesses. This can be accomplished by following the correct antisepsis

procedures while taking blood cultures and avoiding cultivating vascular catheter tips or using temporary vascular catheters to avoid contamination and incorrect diagnosis, which will ultimately help determine the best course of antibiotic treatment. Making the distinction between infection and colonization is essential when treating infections so that medications target the infection site and not colonized areas. To ensure effective treatment and reduce unnecessary antibiotic use, for example, in treating pneumonia, treat the lung infection rather than the tracheal aspirate or endotracheal tube. In treating urinary tract infections, treat the bladder or kidney infection instead of the indwelling catheter or simple bacteriuria; in treating bacteremia, treat the bloodstream infection instead of the catheter tip or hub; and in treating bone infections, treat the bone rather than the skin flora, Follow established guidelines and utilize local data to understand your patient population [34]. Careful measures must be taken in both community and healthcare settings to prevent the spread of illnesses from person to person. Standard infection control measures, such as contact, droplet, and airborne precautions, must be closely adhered to in healthcare institutions, and infection control specialists must be contacted as necessary. In community settings, individuals must take responsibility by staying home when sick, maintaining good hand hygiene, and setting an example for others to follow, thereby reducing the spread of infectious diseases and protecting vulnerable populations [38]. Particularly when it comes to catheter use and disinfection procedures, careful attention to detail is necessary to prevent transmission from the environment. Only when absolutely necessary should catheters be used, and the right kind of catheter should be chosen to reduce the risk of infection. Catheters must be inserted and cared for properly, and they should be taken out as soon as they are no longer required. To further stop the transmission of illnesses from environmental sources, rigorous adherence to disinfection procedures is essential. Optimizing the use of antibiotics requires the implementation of hospital controls, which can be accomplished in a number of ways. Persuasive and instructional methods have little effect, while facilitative techniques such using computer assistance displays when placing an order and asking clinical specialists or pharmacy clinicians for advice can work better. Antibiotics can be categorized as uncontrolled, monitored, or limited; the latter is only available to infectious disease specialists. Power methods like as formulary management, usage monitoring, and drug restriction can also be used [35].

CONCLUSION:

Antibiotics have changed the world of medicine as we know it, bringing relief to countless patients suffering from bacterial infections. But there is a dark side to this miracle drug: The over-and inappropriate use of antibiotics has given rise to antibiotic-resistant bacteria - bacteria that are resistant to the drugs designed to kill them. This resistance acts as a critical global health threat, as it increases treatment failures, healthcare costs, and mortality rates. Knowledge about the way antibiotics work and how bacteria become resistant to them is determinant for designing effective mechanisms to fight against this global problem. Rational antibiotic prescribing, public awareness campaigns, better hygiene, and widespread vaccination, especially against drug-resistant pathogens, are critical. This calls for global, concerted action from health professionals, policymakers and the public, to preserve the effectiveness of antibiotics for those who come after us.

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