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ANTIBIOTIC MISUSE: A DRIVING FORCE BEHIND THE GLOBAL RISE OF ANTIMICROBIAL RESISTANCE

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Abstract. Antimicrobial resistance (AMR) is one of the world's most pressing public health challenges. The 2014 Global Burden of Disease study estimated that 1.27 million deaths were caused by bacterial AMR that year and that bacterial AMR contributed to an additional 4.95 million deaths. In 2019, the World Health Organization (WHO) listed AMR among the top 10 threats to global public health. Misuse and overuse of antimicrobial agents in both human and animal health and agricultural settings is the primary factor for increasing rates of drug resistance. In addition to the impact on human life, AMR increases the cost of health care and the global economy. The World Bank has estimated that, by 2030, AMR could result in an additional $1 trillion in global health care costs, and between $1 trillion and $3.4 trillion in annual losses to the global economy by 2050. Mitigating strategies are vital to combat this situation. One way to do this is to educate the public about the impact of inappropriate antimicrobial use, for example, the difference between bacterial and viral infections, through information campaigns. Stringent regulations must be instituted to control the over-the-counter sale and dispensing of antibiotics. It is important to educate the public about the rationale for the complete dose of antibiotics prescribed and to explain that antibiotics are prescribed based on culture and sensitivity of the pathogen concerned, and if required, other clinical findings. Further, infection prevention and control practices, as well as research and development of novel antimicrobials, must be implemented to combat pathogenic resistance. If these strategies are to be successfully implemented, collaboration and commitment of various agencies, healthcare workers and the public, is vital to maintain the efficacy of available antibiotics and to avoid a scenario whereby infections become untreatable.

Keywords: Antibiotic, Resistance, Antibiotic Misuse

Introduction

Antibiotic definition and background of antibiotic discovery

An antibiotic is a selective chemical agent that is usually produced by a microbial organism (such as bacteria or fungi) or derived from them, and is used in medicine to treat bacterial infections. It acts either by killing bacteria (bactericidal effect) or inhibiting their growth (bacteriostatic effect) through targeting specific bacterial functions or structures that are absent or different in human cells — such as the bacterial cell wall, protein synthesis, or nucleic acid synthesis.

Utilizing microorganisms to treat infections is an ancient idea. However, the modern age of antibiotic treatment began in 1928 when Alexander Fleming identified penicillin [1]. Before Fleming's discovery, knowledge of microorganisms and infections, for example the Egyptians' use of moldy bread, had little impact on the treatment of infectious diseases. The development of new classes of antibiotics during the "Golden Era" of post World War II antibiotic discovery, changed infectious disease treatment and continued to build upon Fleming's early discoveries [2].

Classification of antibiotics

Antibiotics can be classified in several ways, depending on different criteria such as mechanism of action, antibacterial spectrum, or source of production.

1. According to Mechanism of Action:

A. Inhibitors of Cell Wall Synthesis:

They prevent the formation of the bacterial cell wall, leading to bacterial death. Examples: Penicillin Cephalosporins Vancomycin

B. Inhibitors of Protein Synthesis:

They bind to bacterial ribosomes and prevent the formation of proteins essential for bacterial growth.

Examples:

Tetracyclines Macrolides

Chloramphenicol [3].

C. Inhibitors of Nucleic Acid Synthesis:

They interfere with the synthesis of DNA or RNA in bacterial cells. Examples: Fluoroquinolones Rifampicin

D. Inhibitors of Folic Acid Synthesis:

They disrupt the formation of folic acid, which is essential for bacterial growth. Examples: Sulfonamides Trimethoprim

E. Disruptors of Cell Membrane:

They alter the permeability of the bacterial cell membrane, leading to cell death. Examples: Polymyxins [4].

2. According to Spectrum of Activity:

Broad-spectrum:

Effective against multiple types of bacteria (Gram-positive and Gram-negative). Examples: Tetracycline, Ampicillin.

Narrow-spectrum:

Effective against a specific type of bacteria only.

Example: Penicillin G (only against Gram-positive bacteria) [3].

3. According to Source of Production:

Natural: Produced by microorganisms such as bacteria or fungi. Example: Penicillin from Penicillium fungus.

Semisynthetic: Chemically modified to improve activity or resistance to degradation.

Example: Amoxicillin.

Synthetic: Completely produced in laboratories.

Examples: Sulfonamides and Fluoroquinolone [4].

Conception of Antimicrobial Resistance (AMR)

Antimicrobial resistance (AMR) is the ability of microorganisms such as bacteria, viruses, fungi, and parasites to change over time and become unresponsive to antimicrobial drugs . This ability includes developing advanced defense mechanisms such as producing drug-degrading enzymes, modifying drug-binding sites, or enhancing the cell's capacity to expel the drug, making standard treatments less effective or completely ineffective [5].

As a result, infections persist and spread more easily, leading to increased illness, severe complications, and death. AMR is accelerated by inappropriate and excessive use of antimicrobial drugs in humans, animals, and agricultural settings, which enhances the microbes' capacity to survive, adapt, and develop these resistance defenses [6, 7].

The Relationship Between Antibiotic Misuse and Bacterial Resistance

When antibiotics are used excessively or unnecessarily (e.g., taking them without a prescription, using them for viral infections, or stopping treatment early), bacteria gain the opportunity to develop protective mechanisms against the drug (e.g., genetic mutations, production of drug-degrading enzymes, changes in cell wall structure). Consequently, antibiotics gradually become less effective or even ineffective [8].

Over prescription of antibiotics (especially without performing culture and sensitivity tests) means that partially resistant bacteria have the "opportunity to survive and spread" within the patient or community, increasing the number of resistant strains, [9].

Therefore, the misuse of antibiotics by any of the stakeholders (pharmacies, patients, health care providers) accelerates the spread of multidrug resistant bacterial infections, and eventually renders previously treatable infections as "hard to treat" and eventually "untreatable" infections [9].

Prudent use of antibiotics along with adherence to prescription, dose and duration are critical to control spread of bacterial infections and to ensure that antibiotics retain their effectiveness [6]. Likewise, prescription without performing sensitivity tests is counterproductive.

Concept of Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC).

Resistance to antibiotics is a result of several reasons including the facts that some bacterial growth is not completely inhibited by antibiotics, and some are not completely killed by the action of antibiotics, and some acquire the ability to circumvent the action of antibiotics [10].

MIC is the least concentration of an antibiotic that prevents visible growth of bacterial, and MBC is the least concentration of antibiotic that kills 99.9% of the bacterial load. Antibiotic misuse such as incomplete or sub-therapeutic dosing enhances bacterial survival at sub MIC or MBC, and speeds up resistance to antibiotics [11]. Therefore, understanding the above concepts is of public health importance to control the misuse of antibiotics [12].

Methods

The purpose of this study is to examine the effect of misuse of antibiotics in details and to provide an academic review of published literature. This is a theoretical and descriptive research study, and did not include collection of primary data, or experimental work.

Data Collection Methods

This study used published research work, and did not involve experimental or clinical work.

Google Scholar ScienceDirect

World Health Organization (WHO) reports.

Results and Discussion

Current literature reviews demonstrate that the misuse of antibiotics is no longer merely a transient medical issue; it has transformed into a "key catalyst" toward an era where minor infections could become fatal due to the absence of effective drugs. Analysis of Economic and Human Impact

The analysis reveals a terrifying gap between the speed of bacterial evolution and the deceleration of pharmaceutical innovation. While the "Golden Age" of antibiotics was rich with discoveries, today we face a direct threat manifested in: Direct Mortality: Antimicrobial Resistance (AMR) was directly responsible for 1.27 million deaths in 2014, contributing to a total of approximately 4.95 million deaths globally ,This was consistent with what Murray and other had stated in 2022 [13].

Economic Attrition: The damage extends beyond lives to figures and consistent with what World bank had stated in 2020.

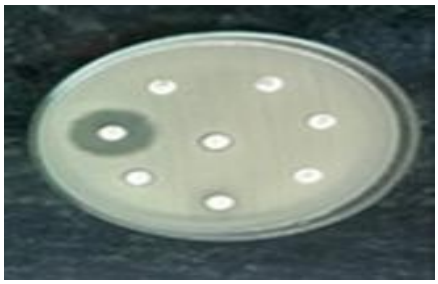
The Correlation Between Misuse and Resistance Development

The analysis clarifies that improper practices grant bacteria a "golden opportunity" to survive and mutate:

Sub-therapeutic Dosing: Using doses below the Minimum Inhibitory Concentration (MIC) or Minimum Bactericidal Concentration (MBC) allows bacteria to survive and develop defense mechanisms, such as producing drug-degrading enzymes or altering binding sites.

Unjustified Use: Prescribing antibiotics for viral infections (e.g., influenza) or dispensing them without a prescription accelerates the emergence of multidrug-resistant (MDR) strains, this was consistent with what Haque and other 2020 had stated [14]. Antimicrobial resistance: a global multifaceted phenomenon. Pathogens and Global Health, give the Importance of Laboratory Testing By analyzing the mechanisms of action (such as cell wall inhibitors or protein synthesis inhibitors), it is evident that the random selection of antibiotics without identifying the bacterial type (Gram-positive vs. Gram-negative) diminishes treatment efficacy. The study emphasizes that relying on Culture and Sensitivity testing is the only way to ensure the use of "narrow-spectrum" antibiotics rather than unnecessarily wasting "broad-spectrum" options.

Figure (1) illustrates the inhibition zones resulting from the effect of antibiotic on the culture medium. We observe the presence of an inhibition zone around one antibiotic tablet, indicating the bacteria's sensitivity to it, while the other antibiotic tablets appear without inhibition zones, indicating the bacteria's resistance to all these antibiotics.



Ramanath *et al* . [15].

The Gap in Community Awareness and Regulation, the analysis identifies three primary pillars contributing to the escalation of the crisis:

The Patient: Failing to complete the full treatment course once symptoms improve, the Healthcare Provider: Over-prescribing without adhering to World Health organization protocols, regulatory: The absence of strict laws prohibiting Over-the-Counter (OTC) dispensing of antibiotics, the transition from the "Golden Age" of antibiotics to an era of "untreatable infections" is not so much a biological inevitability as it is a result of flawed human behaviors. The solution requires international cooperation to strengthen Antimicrobial Stewardship programs and develop new drugs targeting resistant organisms.

Conclusions and Recommendations

Conclusions

This paper outlines how misuse of antibiotics is one of the largest challenges in public health. The indiscriminate and unregulated use of antibiotics can lead to rapid evolution of bacterial strains that become resistant to antibiotic therapy. Ultimately, this can lead to once treatable infections becoming unus treatable. The reviewed literature has cited numerous factors for this issue. These include, but are not limited to, public unawareness, self-medication, and poor observance to medical guidelines.

The report outlines several actions to reduce antibiotic misuse, including enforcement of regulations to limit misuse, strengthening of stewardship programs, and promoting awareness. In order to successful limit antibiotic misuse, all sectors of the community and legislature should work to limit misuse and preserve the impact of antibiotic therapy.

Recommendations

1. Enhance public awareness about the dangers of antibiotic misuse by
   Public health campaigns should be implemented to educate communities about the risks associated with taking antibiotics without a medical prescription.
2. Emphasis should be placed on distinguishing between bacterial and viral infections, and clarifying why antibiotics are ineffective against viral illnesses such as influenza
3. Provide continuous training for healthcare professionals on antibiotic based on international standards (e.g., WHO, CDC) to ensure proper prescribing practices.
4. Antibiotic therapy should be guided by culture and sensitivity test results whenever possible.
5. Educate patients dangers of stopping treatment prematurely, even when symptoms improve. Incomplete treatment promotes the survival of resistant bacteria.
6. Improving infection control procedures within hospitals by Enhancing hygiene, sterilization, and implementing patient isolation policies when necessary to reducing hospital-acquired infections (HAIs) that lead to increased antibiotic use.
7. Integrate antibiotic awareness into school and university programs educational.
8. Collaborations with international research centers can accelerate the development of drugs targeting multidrug-resistant organisms.

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