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(RESEARCH ARTICLE)

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A report on the misuse of antibiotics and developing resistance in microbes: A Threat to Public Health in India.

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Abstract

Background and Objectives: The broad-spectrum antibiotics act against the causative pathogenic bacteria covering a broad range of activity in case of bacterial infections. These are frequently used as a "first-line" treatment of suspected bacterial infection. Antimicrobial resistance (AMR), a natural response of bacteria, is the result of misuse and overuse of antibiotics. Presently the misuse and overuse of broad-spectrum antibiotics in infections and disease treatment are responsible for major health concerns, leading to development of a bacterial response as antibiotic resistance against antibiotics and consequently a less effective response of antibiotics with a slower disease recovery rate in patients is noticed.

Methods: The antibiotics prescription data and assessment views of medical practitioners from Muzaffarnagar, Uttar Pradesh and adjacent region, India, during the study period from April, 2025 to July, 2025 were analyzed to find out the prescription pattern of antibiotics for patients and Antimicrobial Resistance, AMR. The responses of general public were also collected through Google forms and analyzed related to knowledge, attitude and practice (KAP).

Results: The analyzed data determined that 84% patients had no knowledge of prescribed antibiotics and only 16% knew about the antibiotics. The analyzed data related to antibiotic prescription in combination of two or more broad spectrum antibiotics, revealed that 41.2% patients were prescribed one, 23.5% with a combination of two, and 35.3% were prescribed a combination of more than two broad spectrum antibiotics at one time for infection control. Medical practitioners agreed about the misuse and overuse of antibiotics in India leading to evolvement of bacteria against the bactericidal effect of antibiotics leading to hard to treat the bacterial infections.

Interpretation and conclusion: Today, the issue related to attainment of resistance by bacteria against antibiotics is a major global health concern, especially in Indian context, where the level of knowledge and awareness about misuse of antibiotics is not sufficient. The present research study findings conclude that there is an urgent need of prescription regulatory policies related to use and misuse of broad-spectrum antibiotics. A campaign to raise the awareness in public for use and misuse of broad-spectrum antibiotics (BSA), must be carried out for the prevention of development of resistance against antibiotics in bacterial community. The judicial use of broad-spectrum antibiotics, based on diagnostic examination must be recommended for a safer use of BSA in public domain.

Keywords: Antibiotics; Antimicrobial Resistance (AMR); Ciprofloxacin; Cefixime, Infection; Misuse; Salmonella

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1. Introduction

The broad-spectrum antibiotics are used effectively against various bacterial pathogenic agents to treat the bacterial infectious diseases, as these are Gram-positive and Gram-negative bacteria. These antibiotics are generally used when the specific infectious bacterial population is undetected and multiple categories of bacteria are suspected for infection. The broad-spectrum antibiotics act against the causative bacterial populations covering a broad range of activity in case of bacterial infections. These are frequently used as a "first-line" treatment of suspected bacterial infection and connected health condition of a patient. The broad-spectrum antibiotics are preferred in various health complications when quick relief is needed. Humans generally vulnerable to pathogenic microbial communities, which are responsible for various types of health issues by infecting and affecting the biological working mechanism of specific body cells and organs leading to various disorders and diseases. There is the vast majority of bacteria which can infect the humans, when they find favorable route of entry and adaptability of infections, especially in the condition of vulnerability of an individual and bacterial exposure. The bacterial population can grow in living environment with a fast rate by occupying cellular working plan and damaging the host cells. The pathogenic microbial communities can exist in environment and can be transmitted through various modes as air, water, food, soil, vectors and contact etc.

The discovery and practice of antibiotics against the staphylococci bacteria was initiated by Alexander Fleming, a bacteriologist at St. Mary's hospital in London in 1928, when he isolated the active substance penicillin produced by the mold, *Penicillium.*

The penicillin was purified and clinically used as an antibiotic against bacterial infection during the World War II. Howerd Florey and Ernst Chain, along with other researchers at Oxford University, successfully developed a method to isolate and purify penicillin in sufficient quantities for medical use.

The period from the late 1940s to the 1960s the new antibiotics were identified and developed for clinical uses against bacterial infections, which saved the lives of people to greater extent. The antibiotics, literally meaning, inhibiting life forms generally referred the substance acting against the bacteria, the microbes.

The main concern related to the use of antibiotics is their overuse and some bacterial populations have evolved resistance to antibiotics. [1]

Antimicrobial resistance (AMR), a natural response of bacteria, is the result of misuse and overuse of antibiotics. [2] [3]

The World Health Organization, WHO, has classified AMR as a widespread "serious threat" which is happening right now in every part of the world and in all countries, affecting anyone, of any age. Each year nearly 5 million deaths are connected with AMR globally. Global deaths due to AMR were recorded as 1.27 million in year 2019.

India is the largest consumer of antibiotics globally in terms of absolute volume, with a significant portion being used in the private sector. The total anti-infective sold was recorded in India in 2019 was 2807 million packs, with systemic antibiotics making up to 77.1% of that. A government survey revealed that over 38% of in patients are prescribed antibiotics by hospitals and many patients are on more than one antibiotic at one time. The private sector accounts for a significant portion 85-90% of total antibiotics consumption in India.

Antibiotic resistance occurs when bacteria evolve to evade the effect of antibiotics through multiple and different bio-mechanisms. Dissemination of antibiotic resistance genes is an ecological, psychological and public health concern worldwide. Some bacteria can modify their outer structure and receptors under changed biological environment so that antibiotics cannot attach to them. Bacteria can also gain resistance against antibiotic through mutation in their genetic material. A change in genomics of bacteria leads to the production of altered receptor proteins which enable the bacteria to become resistant against a certain antibiotic.

Currently in use, Ciprofloxacin, a widely used antibiotic that has lost its efficacy due to development of resistance in bacteria. Antibiotics are often over prescribed and misused, including being dispensed over- the counter (OTC) without prescription, which contribute to the issue of Antibiotic Resistance, ABR.

A report of Institute of Health Metrics and Evaluation, University of Washington in collaboration of University of Oxford under Global Research on Antimicrobial Resistance says that AMR represents a global challenge in healthcare sector. Globally, the problem of AMR is highly challenging as 4.95 million people died in 2019 from drug-resistant infection. AMR directly caused 1.27 million of those deaths. 1 in 5 of those deaths occurred among children under 5 years of age. In

India in 2019, there were 297,000 deaths attributed to AMR and 1,042,500 deaths associated with AMR. There are five pathogens reported to be aware of in India, which remained responsible for deaths associated with AMR in *Escherichia coli, (*152,700), *Klebsiella pneumoniae* (123,200), *Staphylococcus aureus* (111,400), *Acinetobacter baumannii* (103,500) and *Mycobacterium tuberculosis* (98,600).

The number of AMR deaths in India is higher than deaths from neoplasm, respiratory infections and tuberculosis, enteric infections, diabetes and kidney diseases and maternal and neonatal disorders.

2. Review of Literature

Presently the misuse and overuse of broad-spectrum antibiotics in infection and disease treatment are responsible for major health concerns, leading to development of a bacterial response as antibiotic resistance in bacterial population against antibiotics and consequently a less effective response of antibiotics with a slower disease recovery rate in patients is noticed. The time and cost of disease treatment can be increased in a multi-fold way as extended time of occurrence of infection and disease condition can cause a negative psychological impact leading to irritant behavior and a slower recovery rate in patients.

People generally unaware of the use, misuse or overuse of broad-spectrum antibiotics under a condition of health disorder and disease. They rely on their medical practitioner and in several cases, they consume the antibiotics with self-prescription, without having the knowledge of nature, composition, dose amount, cellular and metabolic effects of used antibiotics. In such cases of self-medication, the adverse impacts along with health challenges can be appeared. The condition can be life threatening in case of children, when the antibiotics are used without the prescription of authorized medical practitioner.

Antimicrobial resistance (AMR) is fast emerging and compelling health issue worldwide in present twenty-first century. The initiation of development and spread of drug-resistant pathogens posed a substantial health threat to humans.

The study related to the factors which contribute to antibiotic misuse among parents of school going children in Dhaka city, Bangladesh concludes that approximately 45% of respondents demonstrated moderate knowledge, 53% had uncertain attitude, and 64% exhibited antibiotic misuse. The study findings

emphasized the importance of targeted education and awareness initiatives to enhance the knowledge and responsible antibiotic use among parents, contributing to global efforts against antibiotic resistance. Factors such as parental age, education level, employment status, income, child's age and family type significantly influenced knowledge, attitude and practice, KAP.[4]

Antimicrobial resistance is considered as a challenging public health problem with long term and unpredictable health, social and economic worldwide. [5,6,7]

AMR has a wide range of effects, including prolonged hospital stay, longer treatment time, financial burden, morbidity and mortality. [8,9,10] The World Health Organization (WHO) reported in 2019 that approximately 700,000 annual deaths globally recorded due to antimicrobial resistance, AMR. It is estimated that by the year 2030, AMR will contribute to a projected ten million deaths worldwide. [11,12]

Antibiotic consumption and AMR data have shown the continuously interrelated increasing trend. The rise in antibiotic consumption contributes to the global spread of antibiotic-resistant bacterial strains and infections. [13,14,15,16]

The burden of AMR is significantly higher and challenging in developing countries due to excessive, irrelevant and nonjudicial use of antibiotics with prescriptions, insufficient knowledge, awareness and education in general public, abandoned full medication course, overuse of antibiotics in animal and fish farming, subpar infection control in healthcare facilities, inadequate hygiene and sanitation practices, unregulated and uncontrolled antibiotic sales and a dearth of new antibiotic development. [17,18,19,20]

The emergence and spread of antibiotic resistance (ABR) have been recognized by WHO as a hotspot among developing countries in Southeast Asia (SEA). According

to a 2018 based report, superbugs and bacteria resistant to multiple drugs were identified in approximately 14% of all infection cases, and approximately 70% of fatalities in intensive care units resulted from infections resistant to multiple drugs. [21]

Once antibiotics are inappropriately and unnecessarily used, patients experience no recovery benefit while their susceptibility to the side effects still exists. Antibiotics act to disrupt the composition of the infectious pathogenic agent, leading to bacterial adaptation or mutation, and in turn, to new strains that are resistant to the antibiotics being used currently for infection control.

The inappropriate and unregulated use of broad-spectrum antibiotics in one patient might develop a resistant strain that spreads to other patients that do not use antibiotics, which make this issue a pressing public health concern. In the year 2015, 30% of the outpatient antibiotics prescribed were unnecessary, with acute respiratory infections holding the highest unnecessary use of antibiotics at 50%. [22]

On analysis of collected data from electronic records of hospitalized patients with positive bacterial culture, during 2016 to 2019, the prediction of ciprofloxacin resistance for *E.coli, Klebsiella pneumoniae, Morganella morganii, Pseudomonas aeruginosa, Proteus mirabilis and Staphyllococcus aureus* in hospitalized patients was assessed. [23]

The bacterial infections have again become a threat because of the rapid emergence of resistant bacteria, leading to a crisis, and has attributed to abuse of antibiotics medication and a lack of new drug development.[24]

The CDC, the Centre for Disease Control and prevention declared in 2013 that the human race is now in the "post-antibiotic era" and in 1014, the World Health Organization, WHO, warned that the antibiotic resistance crisis is becoming dire.[25] MDR bacteria have been declared a substantial threat to US public health and national security by the Infectious Diseases Society of America, IDSA, and the Institute of Medicine, as well as the Federal Interagency Task Force on AMR.[26]

Among gram- positive pathogens, a global pandemic of resistant *S. aureus* and Enterococcus species currently pose the biggest threat. [27][28] Vancomycin-resistant enterococci (VRE) and the growing number of additional pathogens are developing resistance to many common antibiotics.[26] The global spread of drug resistance among common respiratory pathogens, including *Streptococcus pneumoniae* and *Mycobacterium tuberculosis,* is epidemic.[28] Gram-negative pathogens are causing the serious threat as these are becoming resistant nearly to all antibiotic drug options available, creating situations reminiscent of the pre-antibiotic era.[26][27][28] The emergence of MDR (and increasing pan-resistant) gram-negative bacilli has affected practice in every field of medicine.[26]

The most serious gram-negative infections occur in health care systems and are most commonly caused by Enterobacteriaceae (mostly *Klebsiella pneumoniae*), *Pseudomonas aeruginosa,* and *Acinetobacter.*[27][28] MDR gram-negative pathogens are also becoming increasingly prevalent in the community.[28] These include *Escherichia coli* and *Neisseria gonorrhoeae.*[28]

Countries like India, where the standard of education, awareness, knowledge and practice (EAKP) related to misuse and overuse of broad-spectrum antibiotics is not at sufficient level in general public are at a greater risk of AMR. General poor public is unaware of types, use and dose of antibiotics and drugs.

3. Material and Methods

For present investigating study the following methodologies were applied

- The antibiotics prescription data and views of medical practitioners were analyzed on the basis of and questionnaire designed to find out the prescription pattern of antibiotics for patients and antimicrobial resistance, AMR.
- A questionnaire on Google form was designed and circulated to people and people groups to assess the Knowledge, Attitude, Practice (KAP), bacterial infections, diagnosis and use of antibiotics.

To review the published studies especially in reference to Indian scenario.

4. Results and Discussion

On the basis of collected data from respondents 550, the present research **study** revealed that 68.1% respondents did not do a pathogenic diagnostic test, while 31.9% do the diagnostic test. 36.4% were not told about the source of infection by the medical practitioner. 63.6% were told about the source of infection. The 89.69% patients did not know the type of bacterial pathogen and not diagnosed for the type of pathogen. Only 10.31% patients get diagnosed the type of pathogen as 2.6% had *Mycobacterium tuberculosis,* 7.1% had *Salmonella typhi.*

The analyzed data determined that 84% patients had no knowledge of prescribed antibiotics and only 16% knew about the antibiotics. 13.9% patients

were suffering from tuberculosis disease and were prescribed tuberculosis drugs in combination AKT-4, a combination of Ethambutol, Isoniazid, Pyrazinamide and Rifampicin and 2.1% were prescribed Pulmocef, Cefuroxime Axetil, to cure the pneumonia.

In case of infection, the antibiotics prescription is generally advised without pathogen diagnostic test, in a combination of four broad spectrum antibiotics, BSA, as Amoxycillin, Cloxacillin, Ofloxacin and Cefexime. This combination of these four BSA prescription developed lip soring, angular cheilitis, headache, nausea, dizziness, restlessness, excess sweating, sleeplessness, taste loss in observed patient. After a single dose of this combination of four BSA, the prescription was stopped for prevention of further adverse impacts on patient.

The analyzed data related to antibiotic prescription in combination of two or more broad spectrum antibiotics, revealed that 41.2% patients were prescribed one, 23.5% with a combination of two, and 35.3% were prescribed a combination of more than two broad spectrum antibiotics at one time in prescription for infection control. In 19% cases the infection re-occurred. The knowledge regarding the antibiotics in public assessed that 73.3% people had no knowledge of antibiotics. 67.4% people had no any adverse effect of antibiotics, while in 20.9% people admitted that they had the adverse effects of antibiotics. The 11.6% people were not sure in response to the adverse effects.

On the basis of responses from medical practitioner, it was concluded that the antibiotic resistance, ABR, is being developed in bacterial community against broad spectrum antibiotics. The medical practitioners are prescribing a combination of antibiotics to patients at one time in approximately 30 % cases. All the cases are not diagnosed for the presence of specific pathogen. *Salmonella* and aerobic and anaerobic mainly Streptococcal species were diagnosed. Adverse

effects were observed approximately in 50% cases. Generally, the microbial infection was found as re-occurred. The medical practitioners agreed that the ABR is a major health concern in India. They agreed about the misuse and overuse of antibiotics in India and said that antibiotic resistance and infections have become hard to treat due to evolvement of bacteria against the bactericidal effect of antibiotics.

They also responded in a positive way in reference to repetition of bacterial infections due to the development of antibiotic resistance in bacteria. They were agreed that the several bacterial infections have attained the anti-microbial resistance. On the basis of current findings, the regular discovery of new generation antibiotics is the prime need to overcome the bacterial infections.

5. Antimicrobial resistance in India

In its seventh annual report, the Indian Council of Medical Research's (ICMR) Antimicrobial Resistance Surveillance Network (AMRSN) noted a worrying drop in the efficacy of antibiotics used to treat respiratory illnesses, pneumonia, sepsis and diarrhea. In 2023, 99,492 samples from public and private healthcare facilities in India—including intensive care units and outpatient settings—were examined. Escherichia coli (E. Coli), Klebsiella pneumoniae, Pseudomonas aeruginosa, and Staphylococcus aureus were among the samples examined for bacterial resistance. One important discovery was the concerning resistance of E. coli to antibiotics, including ciprofloxacin, levofloxacin, cefotaxime, and ceftazidime, with efficacy frequently falling below 20 percent.

Hospitals and other healthcare institutions are significant producers of antimicrobial waste, either directly through patient secretions or indirectly through the disposal of unwanted medications. This waste provides an environment where bacteria are exposed to antibiotics, potentially supporting the creation and spread of resistant strains in neighboring environments. According to studies, hospital effluents in India contain high concentrations of tinidazole,

lipoamides, and fluoroquinolones, which can cause genotoxic changes and create resistant microorganisms. Although 80-85 percent

of antimicrobial residues may be eliminated by proper wastewater treatment, less than 45 percent of Indian healthcare facilities have the necessary systems, raising worries about the effects of antimicrobial waste on the environment and public health.

As per the current research-based studies in the field of health, the Clostridium difficile, a gram-positive bacterial species known for causing serious diarrheal infections, which produces three types of toxins: enterotoxin A, cytotoxin B and Chloridoids

difficile transferase, is now have a new highly toxic strain, which is resistant to fluoroquinolone antibiotics such as ciprofloxacin and levofloxacin and said to be causing geographically dispersed outbreaks in North America was reported in 2005. [29]

Currently this is in the category of urgent threat with carbapenem- resistant Enterobacteriaceae (CRE) and drug-resistant Neisseria gonorrhoeae

The category of serious threat includes multi-drug resistant Campylobacter , fluconazole-resistant Candida (a fungus), extended spectrum beta-lactamase-producing Enterobacteriaceae (ESBLs), Vancomycin-resistant Enterococci (VRE), multi-drug resistant Pseudomonas aeruginosa, drug resistant non-typhoidal Salmonella, drug- resistant Salmonella typhimurium, drug-resistant Shigella, Methicillin- resistant Staphylococcus aureus,(MRSA), drug resistant Streptococcus pneumoniae, and drug resistant tuberculosis.

There is concerning threats from Vancomycin-resistant Staphylococcus aureus (VRSA), Erythromycin-resistant group A Streptococcus and Clindamycin-resistant group B Streptococcus.

The stories of the spread of 'superbugs' have become familiar in recent years. There is a growing recognition that action must be taken to deal with the alarming rise in bacterial resistance to today's antibiotics and its implications for global public health.[30]

The importance of public awareness and health literacy of lay audiences still needs to be further emphasized as part of global and local action plans. Antimicrobial resistance continues to be a major global public health dilemma of the 21st century.[31]

The present research study findings conclude that there is an urgent need of public awareness, knowledge and prescription regulatory policies related to use and misuse of broad-spectrum antibiotics in Indian context for the prevention from antibiotic resistance and related health challenges.

6. Conclusion

Today, the problem related to evolution of resistant bacteria against presently using antibiotics for infection control is a major global health concern, especially in Indian context, where the level of knowledge and awareness about misuse of antibiotics is not sufficient. Rapidly emerging resistant bacteria threaten the advanced and extraordinary health benefits that have been achieved with antibiotics.[32] The present research study findings conclude that there is an urgent need of prescription regulatory policies related to use and misuse of broad-spectrum antibiotics in Indian context. The self-prescription attitude must be discouraged. A campaign to raise the awareness in public for use and misuse of broad-spectrum antibiotics, BSA, must be carried out for the prevention of development of resistance against antibiotics in bacterial community. The judicial use of broad-spectrum antibiotics, based on diagnostic examination must be recommended for a safer use of BSA in public domain.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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