International Journal on Science and Technology (IJSAT)
E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

"Awareness is the way to resistance": Role of pharmacist in combating antibiotic resistance of public health

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Abstract:

Antibiotic resistance is one of the most serious public health problems of our time, severely threatening the effectiveness of modern medical treatment. Irrational and excessive use of antibiotics, incomplete treatment courses, and the tendency towards self-medication have been identified as major causes of increasing antibiotic resistance. This is a review-based study that analyzes antibiotic resistance, the role of awareness, and the contribution of pharmacists from a public health perspective.

This study, through a review of existing scientific literature, World Health Organization guidelines, and various policies, highlights the causes, effects, and preventive strategies of antibiotic resistance. The research shows that lack of awareness, the use of antibiotics without prescriptions, and misconceptions among patients play a significant role in the spread of antibiotic resistance.
In this context, pharmacists can play a crucial role, particularly through rational antibiotic dispensing, patient counseling, antimicrobial stewardship programs, and public awareness campaigns. The active participation of pharmacists at the community and hospital levels can help reduce the misuse of antibiotics.

This review concludes that antibiotic resistance is a multifaceted public health problem, and addressing it requires increased awareness, empowering pharmacists, and strengthening policies for the rational use of antibiotics.

Key Words: Antibiotic Resistance; Antimicrobial Resistance (AMR); Public Health; Awareness; Role of Pharmacists; Rational Antibiotic Use; Antimicrobial Stewardship

1. Introduction:

1.1 Antibiotics are a type of medication used to treat infections caused by bacteria (bacterial infections). Since the discovery of penicillin by Alexander Fleming in 1928, antibiotics have revolutionized modern medicine. Diseases that were previously considered fatal, such as pneumonia, tuberculosis, and sepsis, have become treatable with the use of antibiotics (Fleming, 1929). Antibiotics have cured infections and made complex medical procedures like surgery, cancer treatment, organ transplants, and neonatal care

safer. That is why antibiotics are called the "pillar of modern medicine" (Laxminarayan, 2013). Unfortunately, the overuse and misuse of antibiotics are lowering their effectiveness.

1.2 Antimicrobial resistance (AMR) is a condition where microbes like bacteria develop resistance against antibiotics, rendering those antibiotics ineffective. Resistance does not mean that the human body develops resistance, but rather that the bacteria themselves change (Ventola, 2015).

When bacteria are repeatedly exposed to antibiotics, especially when used incorrectly, develop survival strategies. These resistant bacteria can then spread to other people, creating a major public health threat.

1.3 Antibiotic Resistance: A Global Public Health Crisis

Currently, antibiotic resistance is recognized as a global public health problem. According to the World Health Organization (WHO), AMR is one of the top ten public health threats to humanity. The timeline depicting the development of antibiotics and the identification of their respective resistant strains is depicted in Fig 1.

According to the WHO report, millions of people suffer from resistant infections every year, and if appropriate measures are not taken in the future, the number of deaths due to AMR could surpass even cancer by 2050 (Price, 2016). In developing countries like India, OTC antibiotic availability, self-medication and lack of awareness are increasing the spread of AMR (Kotwani, 2011).

1.4 The Antibiotic Resistance Situation in India

India is one of the world's largest consumers of antibiotics. Due to its large population, high infection rates, and easy availability of antibiotics, misuse is prevalent here. In many cases, antibiotics can be purchased without a prescription, which is a major cause of increasing resistance (Kakkar, 2017).

According to a report by the Indian Council of Medical Research (ICMR), the number of multidrug-resistant organisms (MDROs) such as E. coli, Klebsiella pneumoniae, and Staphylococcus aureus is increasing at an alarming rate in India (ICMR, 2023).

In this situation, simply discovering new antibiotics is not enough; rather, using existing antibiotics correctly is the most effective solution.

1.5 The Relationship Between Awareness and Antibiotic Resistance

Awareness refers to accurate knowledge, attitudes, and practices regarding antibiotics. A lack of awareness leads to indiscriminate use of antibiotics for viral infection, not completing the full course of antibiotics, reuse old prescriptions and other practices which contribute to the developing antibiotic resistance (Dyar, 2017). Studies have shown that increasing public awareness can significantly reduce antibiotic misuse and slow down the rate of resistance (Huttner, 2010).

1.6 Importance of Awareness from a Public Health Perspective

Public health is primarily based on prevention. Antibiotic resistance is a preventable problem if people are given the right information at the right time. Through awareness self-medication can be reduced, treatment adherence can be increased and the spread of resistant bacteria at the community level can be prevented. The WHO's Global Action Plan on AMR mentions awareness and education as the first strategic objective.

1.7 Pharmacists: An important part of Public Health

Pharmacists are the most accessible healthcare professionals. Community pharmacies are often the patient's first point of contact. For this reason, pharmacists can play a crucial role in creating awareness about antibiotics (F Sakeena, 2018). Pharmacists can promote the rational use of antibiotics, prevent the misuse of over-the-counter (OTC) medications, provide patient counselling, conduct community awareness programs

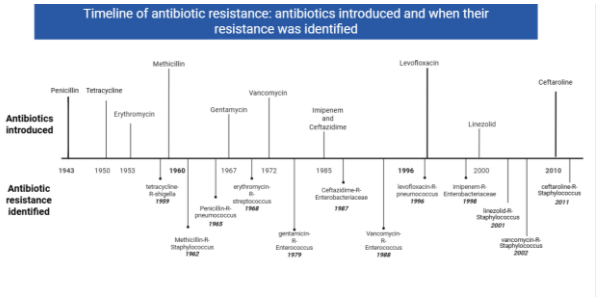

Fig 1: The timeline for the development of antibiotics and the identification of their respective resistant strains

Concept of Awareness in Antibiotic Use and Its Role in Preventing Antibiotic Resistance:

2.1 Awareness:

Health awareness refers to people's accurate knowledge, positive attitude, and appropriate behavior or practice regarding a health-related issue. Awareness is extremely important in the case of antibiotic use because antibiotics are not ordinary medicines; their misuse can directly lead to antibiotic resistance.

Antibiotic awareness means understanding the dosage and duration, when antibiotics should be used, knowing about rational use of antibiotics.

2.2 Lack of Awareness and Irrational Use of Antibiotics

Lack of awareness is one of the most important reasons for the increase in antibiotic resistance. Many people believe that antibiotics can cure all types of infections, which is scientifically incorrect. Antibiotics do not work against viral infections such as the common cold, flu, and COVID-19, yet due to a lack of awareness, people still use antibiotics for these conditions.

These types of irrational practices include taking antibiotics without a doctor's prescription, reusing old prescriptions, taking someone else's antibiotics, stopping the course midway if symptoms improve, which eventually leads to the development of resistant strains.

2.3 Self-Medication and Lack of Awareness

Self-medication is a major driving force behind antibiotic resistance, especially in developing countries. Because antibiotics are easily available from community pharmacies, many people start taking medication on their own without consulting a doctor.

The reasons behind self-medication include avoiding doctor consultation, attempting to save time and money, misconceptions about antibiotics. Studies have shown that where public awareness is low, the rate of self-medication is higher, and antibiotic resistance increases rapidly in those areas (Ocan, 2015).

2.4 Incomplete Antibiotic Course and Resistance

Another major cause of antibiotic resistance is an incomplete course of treatment. Many patients stop taking antibiotics after a few days when their symptoms subside. This does not destroy all the bacteria; instead, some strong bacteria survive, which subsequently become resistant (Spellberg, 2008).

With awareness, the patient can understand that even if the symptoms disappear, the bacteria have not been completely destroyed. Completing the course of treatment is extremely important. Incomplete treatment can lead to more serious infections in the future.

2.5 Awareness, Behavior Change, and Antibiotic Resistance

Awareness is not merely about increasing knowledge, but also about bringing about behavioral change. According to health behavior theory, when people become aware of the harmful aspects of a certain action, they try to avoid that action.

Increased antibiotic awareness leads to reduced antibiotic misuse, increased patient compliance, and ensured rational drug use. Several studies have demonstrated that educational and awareness interventions significantly reduce inappropriate antibiotic use at the community level (Huttner, 2010).

2.6 Community Level Awareness and Public Health Impact

Community level awareness is extremely important in preventing antibiotic resistance. When an individual uses antibiotics incorrectly, it not only harms them personally, but also allows resistant bacteria to spread in the community. From a public health perspective awareness leads to rational use, reduced development of antibiotic resistance and effective treatment. (Dyar, 2015).

2.7 WHO Perspective on Awareness

The World Health Organization (WHO) has given the highest priority to awareness and education in preventing antibiotic resistance. The first objective of WHO's Global Action Plan on Antimicrobial Resistance is: “To improve awareness and understanding of antimicrobial resistance through effective communication, education and training”. This clearly indicates that controlling antibiotic resistance is not possible without awareness.

3.Antibiotic Resistance: Development and Mechanisms

3.1 Antibiotic resistance is not a sudden event; it is a gradual evolutionary process. When bacteria are repeatedly exposed to antibiotics—especially incorrectly or incompletely—they develop various mechanisms to survive. This process is called antibiotic resistance development (Davies, 2010). Antibiotics primarily stop the growth of bacteria or kill them. But not all bacteria are the same. Some bacteria are naturally strong or become resistant over time through genetic changes (Munita, 2016). The mechanisms of antibiotic resistance are shown in Fig 2.

3.2 Evolutionary Basis of Antibiotic Resistance

Antibiotic resistance is essentially a process of natural selection. When antibiotic pressure (selective pressure) is applied to a bacterial population sensitive bacteria die, but resistant bacteria survive. The surviving bacteria multiply rapidly. As a result, the entire bacterial population gradually becomes resistant. Irrational antibiotic use by humans plays a major role in this evolutionary mechanism (Blair, 2015).

3.3 Genetic Mechanisms of Antibiotic Resistance

Two main types of genetic mechanisms are primarily responsible for the development of AR:

3.3.1 Mutation (Genetic Change)

Mutation is a sudden change in bacterial DNA. Sometimes, this mutation results in the production of a protein that alters the target of the antibiotic. As a result, the antibiotic can no longer function as before.

Examples include Rifampicin resistance in Mycobacterium tuberculosis, Fluoroquinolone resistance due to DNA gyrase mutation. Mutation-mediated resistance usually develops gradually, but once established, it can be permanent (Zhang, 2009).

3.3.2 Horizontal Gene Transfer (HGT)

Horizontal gene transfer is a process in which one bacterium acquires resistance genes from another bacterium. This is the most dangerous way for antibiotic resistance to spread. HGT can occur in three ways: conjugation through plasmids, transformation by uptake of DNA from the environment and transduction through bacteriophages. Through this process, multidrug resistance (MDR) spreads very rapidly (Von Wintersdorff, 2016).

3.4 Biochemical Mechanisms of Antibiotic Resistance

Resistance is expressed not only at the genetic level but also at the biochemical level. The main mechanisms are discussed below:

3.4.1 Enzymatic Inactivation of Antibiotics

Many bacteria produce enzymes which is break down the chemical structure of antibiotics. As a result, the antibiotic becomes inactive. Example is β-lactamase enzyme, which breaks down penicillin and cephalosporin. Currently, extended-spectrum β-lactamases and carbapenemases have become a major problem worldwide (Bush, 2016).

3.4.2 Modification of Antibiotic Target Sites

Some bacteria modify the antibiotic's target site. As a result, the antibiotic cannot recognize its target. For example MRSA (Methicillin-resistant Staphylococcus aureus) and altered penicillin-binding proteins (PBPs). This type of resistance makes treatment extremely difficult (Chambers, 2009).

3.4.3 Reduced Permeability of Bacterial Cell Wall

Gram-negative bacteria have an outer membrane, which hinders the entry of antibiotics. If the number or structure of porin proteins is altered, the antibiotic cannot enter the cell. This mechanism is usually associated with multidrug resistance (Delcour, 2009).

3.4.4 Efflux Pump Mechanism

An efflux pump is a transport system that expels antibiotics from inside the bacterial cell, even after they have entered. The characteristics of this mechanism are that it works against multiple antibiotics, creating low-level resistance. It can cause combination therapy to fail. Efflux pump-mediated resistance is currently a major area of research (Li, 2009).

3.5 Development of Multidrug Resistance (MDR)

When a bacterium becomes resistant to multiple antibiotics, it is called a multidrug-resistant organism (MDRO). MDR usually develops due to multiple resistance genes and a combination of different mechanisms Examples include MDR E. coli and Carbapenem-resistant Klebsiella pneumonia. This type of infection is extremely dangerous for public health (GBD 2021 Antimicrobial Resistance Collaborators, 2024).

3.6 Role of Irrational Antibiotic Use in Resistance Development

The lack of awareness and irrational antibiotic are directly linked to resistance development. Specifically, sub-therapeutic dose, incomplete course, unnecessary antibiotic use. These practices give bacteria the opportunity to develop resistance (Laxminarayan, 2013).

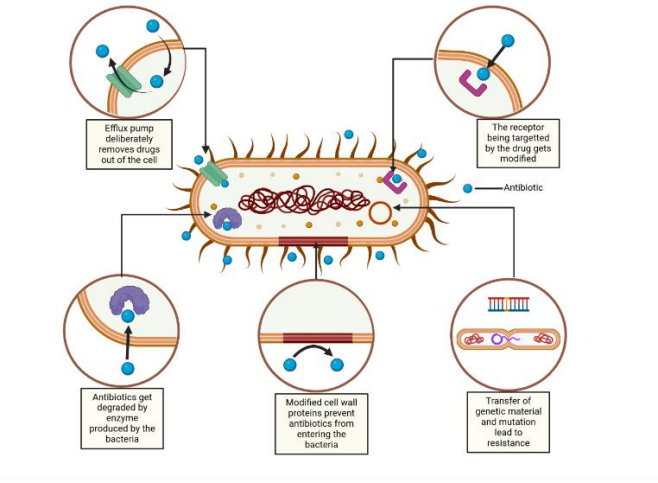

Fig 2: The mechanisms of antibiotic resistance

4. Antibiotic Resistance as a Major Public Health Threat

4.1 Introduction

Antibiotic resistance is currently not just a clinical problem, but a serious public health crisis. Resistant bacteria can spread from person to person, from hospitals to the community, and even from country to country. For this reason, antibiotic resistance has a long-term and widespread impact on public health (Prestinaci, 2015).

From a public health perspective, antibiotic resistance means increased infection rates, treatment of complications and additional burden on the healthcare system.

4.2 Impact on Morbidity and Mortality

Antibiotic resistance increases the severity of infections. In case of a resistant infection the illness becomes prolonged, the risk of complications increases and mortality rate increases. The mortality ranges of Antimicrobial resistance in various parts of the world were compared from the year 1990 and 2021 and the data has been given in Table 1. According to WHO data, millions of people suffer from antimicrobial-resistant infections every year, and a large proportion of them die. Especially resistant forms of sepsis, pneumonia, tuberculosis, urinary tract infections are extremely dangerous for public health (Zhen, 2021).

4.3 Increased Healthcare Cost and Economic Burden

Antibiotic resistance creates a significant economic burden on the healthcare system. Treating resistant infections requires expensive second-line or last-resort drugs, longer hospital stays, increased diagnostic tests. Studies have shown that the healthcare costs due to antibiotic-resistant infections are significantly higher than those for ordinary infections (Cassini, 2019). This economic burden is even more severe in developing countries, as it places additional pressure on limited resources.

4.4 Burden on Healthcare System

Antibiotic resistance reduces the effectiveness of the healthcare system. In hospitals and healthcare centers ICU bed occupancy increases, workload for the healthcare workers increases and infection control becomes difficult. Resistant organisms spread rapidly in the hospital environment and increase healthcare-associated infections (HAIs), which is a major threat to public health.

4.5 Impact on Medical Procedures and Modern Medicine

Many successes of modern medicine depend on antibiotics. With increasing antibiotic resistance, surgery becomes riskier, organ transplantation becomes more difficult, and cancer chemotherapy becomes unsafe among other things. According to the WHO and CDC, antibiotic resistance is undermining the very foundation of modern medicine (Holmes, 2016).

4.6 Community-Level Spread of Resistant Bacteria

Antibiotic resistance is not limited to hospitals; it spreads rapidly at the community level. Poor sanitation, overcrowding, and lack of awareness play a significant role in the spread of resistant bacteria. Community-acquired resistant infections are particularly concerning for public health because they are difficult to control and spread rapidly.

4.7 Global and National Perspective

The Deaths attributable and associated with antimicrobial resistance, by detailed age group, for 1990 and 2021 is shown in Fig 3. Antibiotic resistance is a global problem that requires international cooperation for its solution. The WHO's Global Action Plan on AMR has set five strategic objectives for controlling antibiotic resistance. In countries like India, a National Action Plan on AMR (NAP-AMR) has been developed, but its successful implementation requires awareness, regulation, and the involvement of healthcare professionals (Ranjalkar, 2019).

4.8 Public Health Importance of Prevention

The main goal of public health is prevention. Antibiotic resistance can be prevented if rational antibiotic use is ensured, awareness is increased and infection prevention and control are strengthened. A prevention-based approach is considered the most cost-effective strategy for combating antibiotic resistance (Lee, 2013).

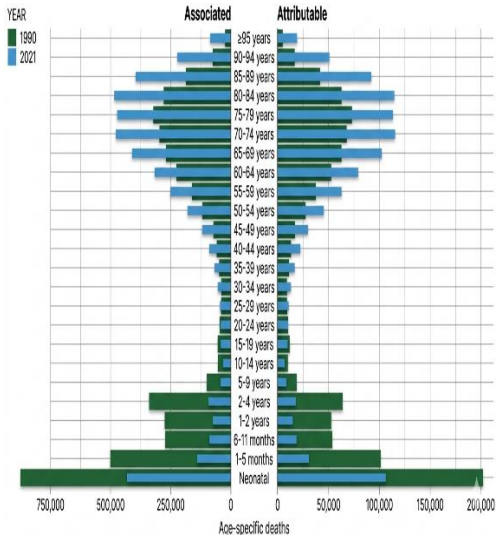

Fig 3: Antimicrobial resistance related deaths (associated and attributable), by age group, for 1990 and 2021

Region / Sub-Region	**Mortality Rate Range (1990)**	**Mortality Rate Range (2021)**	**Notable Trend**
North America	3 to <9	3 to <9	Stability in low mortality
Western Europe	<3 to <6	<3 to <6	Continued low mortality
Eastern Europe & Balkans	12 to 21	15 to 24	Slight increase/stagnation
Sub-Saharan Africa	≥30	18 to ≥30	Significant, though uneven, reduction
North Africa	15 to 24	9 to 15	Marked improvement
Middle East / Persian Gulf	6 to 12	<3 to 9	Sharp decline in mortality
South Asia (e.g., India)	24 to 30	12 to 18	Significant reduction
East Asia (e.g., China)	9 to 12	12 to 15	Slight relative increase
Southeast Asia	9 to 21	6 to 15	General reduction
South America	6 to ≥30	6 to 18	Notable improvement in Andean region

Oceania (Australia/NZ)	<3 to 6	3 to 9	Minimal fluctuation

Table 1: Global Mortality Rate due to AMR compared for 1990 and 2021 by Region

5. Role of Pharmacists in Combating Antibiotic Resistance in Public Health

5.1 Combating antibiotic resistance requires the collective role of all healthcare professionals, not just doctors or the government. Pharmacists are in a crucial position in this regard, as they are among the most accessible and trusted professionals in the health system. Community pharmacies often serve as the first point of contact for patients. For this reason, creating awareness and ensuring rational antibiotic use through pharmacists is a highly effective strategy for public health (Królak-Ulińska, 2025).

5.2 Pharmacists as Accessible Healthcare Professionals

Pharmacists are healthcare professionals whom people can easily access—without an appointment. Especially in developing countries, many people go directly to the pharmacy for minor illnesses. This position gives pharmacists a unique opportunity to combat antibiotic resistance.

Pharmacists can provide patient counselling explaining when antibiotics are needed, preventing spread of misinformations about antibiotic use and helping patients make informed decisions. This accessibility makes pharmacists extremely important in creating public health awareness (Kotwani, 2021).

5.3 Role of Community Pharmacists

Community pharmacists play a frontline role in preventing antibiotic resistance.

5.3.1 Rational Dispensing of Antibiotics

One of the main responsibilities of community pharmacists is to ensure the rational dispensing of antibiotics. Selling antibiotics without a prescription is a major cause of antibiotic misuse. If pharmacists strictly adhere to the prescription-only antibiotic policy, resistance can be significantly reduced at the community level.

5.3.2 Patient Counselling and Education

Patient counselling is one of the most powerful tools for pharmacists. Through counselling, pharmacists can explain to the patient the importance of completion of the full course of treatment, maintaining the correct dose and timing is crucial and the dangers of sharing antibiotics with others. Studies have shown that pharmacist-led counselling significantly increases patient compliance and reduces misuse (Farhana, 2025).

5.3.3 Prevention of Self-Medication

Self-medication is one of the main causes of increased antibiotic resistance. If community pharmacists discourage self-medication and refer patients to a doctor, the rate of resistance can be significantly reduced (Mohammed, 2021).

5.4 Role of Hospital Pharmacists

Hospital pharmacists play a more structured role in preventing antibiotic resistance.

5.4.1 Antibiotic Stewardship Programs (ASP)

Hospital pharmacists are an integral part of antibiotic stewardship programs. Through ASPs appropriate antibiotic selection, correct dose and duration and de-escalation of therapy can be ensured. Evidence shows that pharmacist-involved ASPs reduce both antibiotic misuse and resistance in hospitals (Schuts, 2016).

5.4.2 Monitoring and Audit of Antibiotic Use

Hospital pharmacists can audit antibiotic prescriptions and identify irrational prescribing. By providing feedback, prescribers can be encouraged towards rational antibiotic use (Davey, 2017).

5.5 Pharmacists and Public Awareness Programs

Pharmacists can play a crucial role in conducting public awareness programs. These types of activities include observing World Antimicrobial Awareness Week, Community seminars, Awareness sessions in schools and colleges, Distribution of leaflets and posters. According to the WHO, pharmacist-led awareness initiatives are highly effective in reducing antibiotic misuse at the community level.

5.6 Role of Pharmacists in Infection Prevention and Control

Infection prevention is a crucial aspect of preventing antibiotic resistance. Pharmacists can promote hand hygiene, provide advice on the proper use of disinfectants and increase vaccination awareness. When infection rates decrease, antibiotic use naturally decreases, which helps prevent resistance (Allegranzi, 2016).

5.7 Challenges Faced by Pharmacists

Although the role of pharmacists is extremely important, they face various challenges patient pressure for antibiotics, commercial interests, and lack of time for counselling, weaknesses in regulatory enforcement among other challenges. Policy support and training are needed to overcome these challenges.

5.8 Pharmacists as a Bridge Between Policy and Community

Pharmacists can act as a bridge between policymakers and the general public. The role of pharmacists is undeniable in communicating government guidelines, AMR policies, and stewardship principles to the general public.

6. Awareness Strategies to Combat Antibiotic Resistance

6.1 Awareness is the most powerful and long-term way to combat antibiotic resistance. No matter how many new antibiotics are discovered, if people do not use them correctly, the resistance problem will not be solved. For this reason, the WHO and other international health organizations have identified awareness creation as a core strategy in combating antibiotic resistance.

6.2 Importance of Awareness in Antibiotic Resistance

Due to a lack of awareness, ordinary people harbor many misconceptions, such as antibiotics are needed for all fevers, antibiotics work quickly and there is no problem even if the full course is not completed. These misconceptions are the main reasons for antibiotic misuse. Increasing awareness makes people conscious of rational antibiotic use and they themselves begin to avoid misuse (Mittal, 2023).

6.3 Community-Based Awareness Programs

Community-based awareness is highly effective in reducing antibiotic resistance.

6.3.1 Public Campaigns and Health Education

To create awareness at the community level through health camps, local seminars, street plays and community meetings. These types of activities help to explain the risks of antibiotic resistance to people in simple language (Huttner, 2010).

6.4 School and College-Level Education

School and college students are the responsible antibiotic users of the future. If education about antibiotic resistance is provided at an early age, long-term behavioral change is possible. Basic concepts such as difference between bacterial and viral infection, importance of completing the antibiotic course and dangers of misuse should be included in the curriculum as they play a crucial role in preventing antibiotic resistance.

6.5 Awareness Through Healthcare Professionals

Doctors, nurses, and pharmacists are key agents in spreading awareness about antibiotic resistance. Pharmacists, in particular, can create awareness through patient counselling, leaflet distribution, one-to-one education. Healthcare professional-led awareness programs are more credible and effective than general public campaigns (Afifi, 2025).

6.6 World Antimicrobial Awareness Week (WAAW)

The WHO observes World Antimicrobial Awareness Week (18–24 November) every year to raise global awareness about antibiotic resistance. The main target groups of this campaign are general public, healthcare workers, policy makers. Such global initiatives inspire awareness activities at the national and local levels.

6.7 Awareness Through Policy and Regulation

Awareness is created not only through education but also through policy and regulation. For example prescription-only antibiotic policy, warning labels on antibiotic packaging, public notices in pharmacies. These types of measures compel people to use antibiotics responsibly (Van Katwyk, 2017).

6.8 Challenges in Awareness Implementation

There are some challenges in implementing awareness strategies such low literacy level, cultural beliefs, misinformation and limited resources. To overcome these challenges, locally adapted, culturally sensitive awareness programs are needed (Tangcharoensathien, 2021).

6.9 Future Directions for Awareness Strategies

Future awareness strategies should be technology-based (apps, SMS alerts), pharmacist-led, community-focused, policy-supported. An integrated awareness approach is considered the most sustainable solution in combating antibiotic resistance (Mathew, 2019).

7. Conclusion

Antibiotic resistance is one of the most serious public health challenges in the world today. Although the discovery of antibiotics revolutionized modern medicine, their irrational and excessive use is gradually rendering these crucial drugs ineffective. This thesis has discussed in detail the causes of antibiotic resistance, its public health impact, the role of awareness, and the significant contributions of pharmacists.

The review-based analysis makes it clear that antibiotic resistance is not merely a clinical problem; it is a multidimensional public health crisis. Resistant infections increase morbidity and mortality, raise healthcare costs, and place immense pressure on the health system. Furthermore, modern medical procedures such as surgery, chemotherapy, and organ transplantation are also put at risk.

This research specifically highlights that awareness is a powerful tool to combat antibiotic resistance. Until people become aware of the proper use of antibiotics, it will not be possible to control the resistance problem.

7.2 Role of Pharmacists: Key Findings

A crucial aspect of this thesis is the analysis of the role of pharmacists in preventing antibiotic resistance. Pharmacists act as an important bridge between the community and the healthcare system. According to the key findings community pharmacists can reduce antibiotic misuse through rational dispensing and patient counselling. Hospital pharmacists play a vital role in implementing antibiotic stewardship programs. Pharmacist-led awareness programs are capable of bringing about long-term behavioral change in public health. For this reason, pharmacists can be considered frontline warriors in combating antibiotic resistance.

7.3 Public Health Implications

A public health approach is crucial in combating antibiotic resistance. Individual-level interventions are not sufficient; coordinated efforts are needed at the community, healthcare system, and policy levels. This review demonstrates that awareness-based interventions are cost-effective, prevention-focused strategies are sustainable and pharmacist involvement improves outcomes. Significant progress in controlling antibiotic resistance is possible if public health policies more actively include pharmacists.

7.4 Limitations of the Study

This thesis is entirely based on a literature review. Primary data collection, such as surveys or experimental studies, was not included. Consequently, there is a lack of field-level real-time data. However, despite this limitation, the current thesis provides a comprehensive understanding of antibiotic resistance based on existing evidence and global guidelines.

7.5 Future Prospects

The future of combating antibiotic resistance depends on an integrated and multidisciplinary approach. The important aspects for future prospects include expansion of pharmacist-led antimicrobial stewardship, digital awareness tools like mobile apps and telepharmacy), stronger regulatory enforcement on antibiotic sales, inclusion of AMR education in academic curriculum, continuous professional training for pharmacists. If these initiatives are implemented, long-term and sustainable solutions to prevent antibiotic resistance will be possible.

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