Perspective

Antimicrobial Resistance: From Discovery to Dilemma

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It all began with one drug called "PENICILLIN." Discovered by Alexander Fleming in the year 1928, this "wonder drug" proved to be a boon to the soldiers in World War II when bacterial wounds, once considered fatal, were easily treated and numerous lives were saved. However, the problem of antimicrobial resistance (AMR) could be foreseen by Fleming himself. In his Noble lecture in 1945, he stated, "*The time may come when penicillin can be bought by anyone in the shops. Then there is the danger that the ignorant man may easily underdose himself and by exposing his microbes to non-lethal quantities of the drug make them resistant*." Even several decades ago, he highlighted the potential danger that can arise due to the misuse of antibiotics and ultimately pose a threat to public health.[1]

The emergence of AMR has created a buzz in the world, becoming one of the global health problems and surpassing national boundaries as well as ethnicity. As early as the 1940s, antibiotic resistance came into the picture due to the widespread use of penicillin. *Staphylococcus aureus*, an organism that is commonly implicated in the causation of many diseases, became resistant to penicillin due to the production of the enzyme, penicillinase. With the passage of time, although more antibiotics were discovered such as tetracycline, macrolides, and fluoroquinolones, resistance mechanisms continued to evolve rapidly.[2]

Access this article online	
Website: themmj.in	Quick Response Code
DOI: 10.15713/ins.mmj.104	

The emergence of methicillin-resistant *Staphylococcus aureus* in the 1960s, vancomycin-resistant Enterococcus in the 1980s, and multidrug-resistant tuberculosis in the 1990s highlighted the growing crisis. Some other resistances that emerged later were extensively drug-resistant tuberculosis and pan-drug-resistant *Acinetobacter* and *Pseudomonas* in the 2000s. The coffin to the nail was the discovery of the New Delhi metallo-beta-lactamase-1 gene in the year 2008 which rendered bacteria resistant to even last-resort antibiotics, such as carbapenems. Inspite of the emergence of several of these AMRs, the discovery of newer antibiotics slowed down and bacterial infections which were once easily treatable became a "threat."[2]

However, what are the factors responsible for the emergence of AMR? Let's delve somewhat deep into its etiology. One of the prime factor is the overuse and misuse of antibiotics in healthcare. I'm sure, most of the medical doctors would have observed antibiotics being prescribed for viral infections against which they are ineffective. Another observation seen in our country is the availability of antibiotics as over-the-counter drugs, where patients self-medicate with the wrong medicines, a practice due to a lack of antibiotic stewardship and stringent rules for the prescription of drugs.[3] Inappropriate use of antibiotics create selective pressure in a population of bacteria resulting in the thriving of the resistant bacterial strains.[4] These then spread in the environment and genes coding for resistance get transferred to other unrelated bacteria. The irrational use of antimicrobials, without a proper diagnosis, and not following antimicrobial susceptibility reports are some other points to be mentioned.[5,6]

In present days, the use of antimicrobials is no longer limited to humans alone. It has been used extensively in animal and agriculture sectors, particularly for growth promotion and disease prevention. Other

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contributing factors include inadequate sanitary conditions, inappropriate waste disposal methods, and poor infection control practices in hospitals.[7,8] These resistant strains are no longer limited by borders but get spread across different nations due to increased connectivity, making AMR a global rather than localized issue.[9]

At this point, the next question arises "Why is AMR so important in today's world?" The answer lies in numerous adverse consequences directly linked to it such as an increase in mortality and morbidity rates as infections become difficult to treat and prolong the duration of diseases. The World Health Organization (WHO) estimates that by 2050, AMR could cause 10 million deaths annually.[10,11] The economic burden on the healthcare system is also amplified due to increased costs from longer hospital stays, expensive treatments, and the need for more intensive care of the patients.[12-14] The cumulative financial impact is projected to reach $100 trillion globally by mid-century. In addition, various life-saving interventions such as organ transplant, cancer chemotherapy, and major surgeries become risky due to the non-availability of appropriate antibiotics as a result of resistant strains.[5]

Who can forget the COVID-19 pandemic? Besides the grave situation it put the world in, we saw an increase in AMR when secondary bacterial infections in such patients exhibited resistance to critical antibiotics such as carbapenems and colistin. There was a surge in infections caused by multidrug-resistant organisms which brought into light the urgent need to strengthen infection control practices and propagate the judicious use of antibiotics.[5,8,15,16]

So now the question arises- How to combat this widespread AMR which is taking the shape of a pandemic? Various organizations and institutes have increased their efforts to prioritize awareness, surveillance, and research in this field, one of them being the WHO. It emphasizes the need for sustainable investment in new medicines, diagnostics, and infection control measures. Another strategy is the One Health approach, which integrates human, animal, and environmental health and recognizes the interconnectedness of these domains in addressing AMR and is only possible through collaborative initiatives between healthcare providers, veterinarians, and environmental scientists.[10,11,17]

Antimicrobial stewardship programs (AMSPs) play the most vital role in rationalizing the use of antimicrobials in healthcare settings. These aim to optimize the use of antibiotics through evidence-based guidelines, education, and monitoring.[18] These AMSPS are a multidisciplinary approach that ensure the use of a right drug, for the right patient at the right time with the right dose, route, and frequency, for the right duration, thus minimizing the risk of resistance. Another initiative taken by the WHO is the global campaign "World Antibiotic Awareness Week" held annually which aims in educating communities about the dangers of misuse and emphasize the importance of completing prescribed courses and avoiding antibiotics for viral infections.[5,11,19]

One of the fundamental aspects to combat AMR is the promotion of antimicrobial awareness to bring behavioral change in the community. Education and training of healthcare professionals regarding prescribing responsibly is an important step. The AWaRe Classification, developed by the WHO has categorized antibiotics into three groups – Access, Watch, and Reserve.[20] This promotes responsible use, combats AMR, and preserves the effectiveness of these drugs. It not only aids antibiotic stewardship, policy-making, and surveillance but also ensures effective treatments and reduces resistance globally. This education should be extended to the community level as well where topics such as hygiene, vaccination, and the risks of self-medication can be highlighted and counter various misconceptions about antibiotics.

I would like to conclude with these words: "Antimicrobial resistance represents a silent pandemic that demands immediate and sustained action." As healthcare professionals, it is our responsibility to reduce the impact of AMR by spreading awareness, promoting stewardship, and investing in innovation, for the ultimate aim of preserving the efficacy of antimicrobials for future generations. This challenge requires a collective effort, transcending borders and disciplines, to ensure that the silent pandemic of AMR does not overshadow the victories of modern medicine.

REFERENCES

1. Available from: https://www.nobelprize.org/uploads/2018/06/fleming-lecture.pdf [Last accessed on 2024 Dec 10].
2. Ventola CL. The antibiotic resistance crisis: Part 1: Causes and threats. P T 2015;40:277-83.
3. Sachdev C, Anjankar A, Agrawal J. Self-medication with antibiotics: An element increasing resistance. Cureus 2022;14:e30844.
4. Salam MA, Al-Amin MY, Salam MT, Pawar JS, AkhterN, Rabaan AA, *et al*. Antimicrobial resistance: A growing serious threat for global public health. Healthcare (Basel)

2023;11:1946.
5. Huttner A, Harbarth S, Carlet J, Cosgrove S, Goossens H, Holmes A, *et al*. Antimicrobial resistance: A global view from the 2013 world healthcare-associated infections forum. Antimicrob Resist Infect Control 2013;2:31.
6. The Review on Antimicrobial Resistance. Antimicrobial Resistance: Tackling a Crisis for the Health and Wealth of Nations. London: Wellcome Trust; 2014.
7. World Health Organization. Global Action Plan on Antimicrobial Resistance. Geneva: World Health Organization; 2015.
8. Centers for Disease Control and Prevention. Antibiotic Resistance Threats in the United States, 2019. Atlanta: Centers for Disease Control and Prevention; 2019.
9. Laxminarayan R, Duse A, Wattal C, Zaidi AK, Wertheim HF, Sumpradit N, *et al*. Antibiotic resistance-the need for global solutions. Lancet Infect Dis 2013;13:1057-98.
10. O'Neill J. Tackling Drug-resistant Infections Globally: Final Report and Recommendations. London: Review on Antimicrobial Resistance; 2016.
11. Walsh TR, Toleman MA, Poirel L, Nordmann P. Metallo-beta-lactamases: The quiet before the storm? Clin Microbiol Rev 2005;18:306-25.
12. Murray CJ, Ikuta KS, Sharara F, Swetschinski L, Aguilar GR, Gray A, *et al*. Global burden of bacterial antimicrobial resistance in 2019: A systematic analysis. Lancet 2022;399:629-55.
13. Poudel AN, Zhu S, Cooper N, Little P, Tarrant C, Hickman M, *et al*. The economic burden of antibiotic resistance: A systematic review and meta-analysis. PLoS One 2023;18:e0285170.
14. Ramdas N, Meyer JC, Schellack N, Godman B, Turawa E, Campbell SM. Knowledge, attitudes, motivations, expectations, and systemic factors regarding antimicrobial use amongst community members seeking care at the primary healthcare level: A scoping review. Antibiotics (Basel) 2025;14:78.
15. Rezwan F, Fatima T, Ali F, Nadeem M, Salahuddin N. Frequency and patterns of multidrug-resistant organisms among ventilated patients during the coronavirus disease-19 pandemic. J Coll Physicians Surg Pak 2025;35:100-5.
16. Vulcanescu DD, Bagiu IC, Avram CR, Oprisoni LA, Tanasescu S, Sorescu T, *et al*. Bacterial infections, trends, and resistance patterns in the time of the COVID-19 pandemic in Romania-A systematic review. Antibiotics (Basel) 2024;13:1219.
17. Oliveira M, Antunes W, Mota S, Madureira-Carvalho Á, Dinis-Oliveira RJ, Dias da Silva D. An overview of the recent advances in antimicrobial resistance. Microorganisms 2024;12:1920.
18. Lewnard JA, Charani E, Gleason A, Hsu LY, Khan WA, Karkey A, *et al*. Burden of bacterial antimicrobial resistance in low-income and middle-income countries avertible by existing interventions: An evidence review and modelling analysis. Lancet 2024;403:2439-54.
19. Available from: https://www.who.int/campaigns/world-amr-awareness-week [Last accessed on 2024 Dec 21].
20. Sharland M, Zanichelli V, Ombajo LA, Bazira J, Cappello B, Chitatanga R, *et al*. The WHO essential medicines list aware book: From a list to a quality improvement system. Clin Microbiol Infect 2022;28:1533-5.

How to cite: Sahai S. Antimicrobial Resistance: From Discovery to Dilemma. MIMER Med J 2024;8(2):29-31.

Source of Support: Nil. **Conflicts of Interest:** None declared.