# Unseen Threats: Exploring the World of Antimicrobial Resistance

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Healthcare providers worldwide rely on inadequate and outdated drugs to treat patients, inadvertently fueling a global crisis. Microbes capitalize on every opportunity to infiltrate humans, animals, the environment, and healthcare systems. For the longest time, antimicrobials, including antibiotics, antivirals, antifungals, and antiparasitics were the only thing keeping these pests at bay. Since their discovery, antimicrobials have been instrumental in reducing mortality rates, allowing us to overcome once-deadly diseases and becoming the cornerstone of modern medicine. This scientific miracle served as the foundation on which nations built healthcare systems, and it grew to play a role in nearly every public health intervention. Immunizations, surgeries, cancer treatments, and more would lose all reliability in a world without these drugs. More recently, an overwhelming number of germs breached humanity's only line of defense, leaving the world vulnerable to the silent threat of antimicrobial resistance (AMR). According to the Centers for Disease Control and Prevention (CDC), at least 2.8 million people in the United States develop an antibiotic-resistant infection yearly, and more than 35,000 people die. Although the yearly deaths are decreasing, the opportunities AMR has to spread keep it a threat to human well-being.

AMR is not when humans become resistant to antimicrobials. Instead, microbes slowly develop resistance to drugs designed to kill them. Bacteria evolve utilizing horizontal gene transfer, a unique characteristic that allows genes to be shared across multiple organisms, yielding an exponentially increasing rate of resistance that grows stronger with an increasing number of infections. Eventually, any treatment will lose effectiveness, permitting the germ's growth and amplifying the disease effects. AMR poses a significant challenge to public health,

threatens to exacerbate medical expenses, and overwhelms healthcare systems with endless outlets and opportunities to spread.

When standard antibiotics are no longer effective, healthcare providers may need to resort to alternative treatments, such as more potent or combination therapies, which can prolong hospitalization periods. Resistant strains diminish healthcare resources and expose patients to the risk of further complications and hospital-acquired infections. The need for more intensive and specialized treatments, extended hospital stays, and additional diagnostic tests to identify resistant strains can all contribute to higher expenses. Further, patients and doctors may be susceptible to healthcare-associated infections during extended stays, surgeries, or other medical procedures. When measures are not in place to prevent and control diseases, hospitals morph into a breeding ground for the transmission and amplification of AMR. Without secure hospitals to trap outbreaks, treat patients, and protect health providers, the physical threat branches out into the lives of innocent bystanders.

The economic burden extends beyond individual patient costs. It overextends healthcare systems, insurance providers, and society. The average price of a prescription after discounts for a generic drug fell from $57 in 2009 to $50 in 2018 for the Medicaid Part D program and from $63 to $48 in the Medicaid program, whereas name-brand drug prices rose from $149 to $353 in Medicare Part D and from $147 to $218 in Medicaid (Prescription Drugs: Spending, Use, and Prices, 2022). The shift in price creates an uneven divide between the number of people using each type, heavily favoring broad-spectrum generic drugs, which share several similarities in functions and treatment methods. With this new trend, bacteria find themselves in a more advantageous environment to spread. Once resistance to one drug develops, there is a higher

likelihood for a similar cure to lose effectiveness. Overusing broad-spectrum antibiotics when narrow-spectrum options would suffice promotes the emergence of resistant bacteria.

Prescribing antibiotics for viral infections risks harming a patient without any positive impact. Antibiotics are ineffective against viruses, so when an individual takes the prescription without a bacterial infection, the drug will likely still operate on whatever good bacteria is in the body. In the presence of a harmful species, the means justify the end by killing both the good and the bad. Bacteria have a high rate of evolution due to horizontal gene transfer and their natural tendency to grow in colonies. They are constantly adapting and effortlessly developing mechanisms to survive the effects of antibiotics, especially when exposed to them unnecessarily or for prolonged periods. Alexander Flemming, credited as the father of antibiotics and the creator of penicillin, observed that although his new medicine is nonpoisonous and patients should not worry about an overdose, there is a danger of an underdose. Flemming explains

"It is not difficult to make microbes resistant to penicillin in the laboratory by exposing them to concentrations not sufficient to kill them, and the same thing has occasionally happened in the body" (A warning from Flemming, 2018). However, widespread negligence of the dangers of antibiotics fueled non-compliance with prescribed regimens and self-medication without professional guidance. When antibiotics were relatively new, patients misused them against viruses, and doctors underdosed them against bacteria, exposing microbes to enough drugs to develop resistance strains that survive and proliferate to this day.

The interconnectedness of the modern world means that AMR knows no borders. From hospitals that care for patients to the costs of prescriptions to the farms that put food into stores, the effects of AMR touch critical aspects of life that the world cannot lose. Resistant bacteria can spread swiftly across countries and continents through international travel, trade, and migration.

AMR poses a common challenge to healthcare systems worldwide, directly threatening the United Nations' Sustainable Development Goal (SDG) for Good Health and Wellbeing, as well as having a multitude of implications that hinder SDGs "across human health, animal health, plant production, food safety and the environmental sectors" (Antimicrobial resistance and the United Nations Sustainable Development Cooperation Framework: guidance for United Nations country teams, 2021). The UN's extensive reach and concern warrant bacterial infections as a global concern, and the efficacy of antibiotics is vital for the successful treatment of patients across all countries. Farmers, for instance, use antibiotics immensely in agriculture, hoping to promote growth and prevent diseases in livestock. Yet, the routine and unnecessary use of antibiotics in healthy animals contributes to the development of AMR. Antibiotics do not serve as a preventative measure and, when administered unnecessarily, kill helpful bacteria. Farmers waste money on a maladaptive practice, put animals and crops at risk, and reduce overall productivity. Fortunately, on June 12, 2023, the FDA facilitated a movement that yielded a shift toward a safer and more controlled practice for medicating livestock. "FDA is pleased to share that all affected animal drug sponsors opted to either voluntarily change the approved marketing status of certain medically important antimicrobial drugs for animals from over-the-counter (OTC) to prescription (Rx) or to voluntarily withdraw approval of their affected OTC animal drug applications" (FDA Center for Veterinary Medicine, 2023). With agriculture providing bacteria an efficient medium to spread, this recent feat exemplifies one of many procedures underway in the battle against AMR seeking a ban on OTC medication. While some encourage rational drug use, increased collaboration, infection control, and antimicrobial surveillance, they all share the broader goal of combating resistance.

The rise of antimicrobial resistance is one of the greatest threats to global health and sustainability. In a Lancet study conducted by over 150 researchers, "there were an estimated 4.95 million deaths associated with bacterial AMR in 2019, including 1.27 million deaths attributable to bacterial AMR" (Murry et al., 2022). Compared to all underlying causes of death that year, bacterial AMR was among the top leading causes of death globally, ranking higher than HIV and malaria. Although the researchers conducted their study in 2019, this report contains the most comprehensible and accurate estimates of antibiotic resistance. The Review on Antimicrobial Resistance, chaired by Jim O'Neill, predicts that in 2050, "10 million more people would be expected to die every year than would be the case if resistance was kept to today's level". World leaders must initiate combined efforts to fight antimicrobial resistance to evade O'Neill's estimation of a worst-case scenario. "Without urgent action, we are heading for a post-antibiotic era, in which common infections and minor injuries can once again kill." (WHO, 2020). To secure a future where people feel safe going to the doctor's office, professionals should reflect on how AMR escalated to its current magnitude. Knowing what has and has not worked in the past will aid in beginning the war against antimicrobial resistance.

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