# ANTIMICROBIAL RESISTANCE'S IMPACT ON THE HEALTHCARE SYSTEM: THE ERA OF ANTIBIOTIC ABUSE

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**ABSTRACT**
Nearly a century after the first discovery of antibiotics, the rampant misuse of antibiotics has increased the rate of antimicrobial resistance (AMR) exponentially. This misuse has impacted modern healthcare systems around the world with the rise of drug-resistant infections. While bacterial species have had the ability to resist antibiotics before humans utilized antibiotics for treatment, AMR has increased with overuse of antibiotics to treat bacterial infections (Larsson, 2021). This paper explores the rise of AMR as the consequence of the overuse of antibiotics and the halt in production of new pharmaceuticals. These obstacles drive the increase of AMR, and consequently, the rise of deadly antibiotic-resistant infections such as *Staphylococcus aureus* in modern healthcare systems. In addressing this rise of deadly infection, the international health community has mobilized in fighting AMR through investment in research and development of new antibiotics. The world's reliance on antibiotics is emerging as one of the largest global health threats of the twenty-first century, with impacts felt around the globe.

**WHAT IS ANTIBIOTIC RESISTANCE (AMR)?**

First discovered by Sir Alexander Fleming, antimicrobials were recognized to pose great risks to the public after Fleming warned of the potential for misuse and resistance as early as 1945, "...public will demand [the drug and] ... then will begin an era... of abuses." (Ventola, 2019). Antibiotic resistance is a subset of Antimicrobial resistance (AMR) which occurs when microbes such as viruses, bacteria, fungi, or parasites are no longer affected by the use of antimicrobials, or medicines utilized to prevent and treat infectious diseases in humans, animals, and plants (World Health Organization, 2023).

Figure 1: Synthetic production of penicillin by Professor Alexander Fleming, who first discovered the mould *penicillin notatum,* in his laboratory at St Mary's, Paddington, London (1943) (Imperial War Museums, 2023)

AMR is a natural occurring process in genetic evolution, as bacteria and other microbes evolve over time to resist treatment and compete with other bacteria for resources. In fact, every natural, synthetic, and semi-synthetic antibiotic has been met with resistance from the pathogens they target, signifying the natural need in microbials for resistance (Larsson, 2021). However, AMR rates are being driven forward through the overuse of antibiotics in treating infections and the underproduction of new antibiotics. Data on antibiotic prescriptions reflect the healthcare's heavy reliance on those drugs. In the U.S., for example, the IMS Health Midas database estimated that 22 standard units (e.g., pills, capsules, or doses) of antibiotics were prescribed per person in the 2010 (Ventola, 2019). This study discloses the dependency that healthcare systems have for antibiotic treatments, which has led to an increased rate in AMR through evolution of microbes. Furthermore, of the sheer amount of antibiotics prescribed, studies have shown that many of these antibiotics were incorrectly prescribed. In fact, it has been estimated that thirty to sixty percent of antibiotics prescribed in intensive care units have been found to be unnecessary, inappropriate, or suboptimal to patient recovery. In such cases, incorrect prescription of antibiotics exposes patients to potential complications of antibiotic therapy, and an increased hospital stay (Ventola, 2019). This overuse and misuse of antibiotics have significantly increased AMR rates throughout the world by driving forward genetic evolution of microbes.

While misuse and overuse of antibiotics are significant contributing factors to AMR in hospital or clinical settings, drug production and research in pharmaceutical settings is another contributing factor. A standstill in production of new antibiotics in the pharmaceutical industry has risen in the past decades, with fifteen of the eighteen major pharmaceutical companies abandoning the production of new antibiotics. This arose out of fear of profitability of antibiotics, as antibiotics are for short-term infections, compared to chronic conditions such as diabetes, asthma, or psychiatric disorders (Golkar, 2013). Furthermore, antibiotics are generally less expensive, with new antibiotic courses costing an average of one thousand to three thousand dollars, compared to drugs such as chemotherapy drugs that cost upwards of tens of thousands of dollars (Ventola, 2019). Challenges in production also come from stringent guidelines set by the US Food and Drug Administration in trials for new antibiotic production (Golkar, 2013). After the FDA (the US Food and Drug Administration) approved the drug Telithromycin, it was found to cause hepatotoxicity. Public outcry erupted, prompting the FDA to tighten drug trial purity standards, including antibiotic trials. This resulted in changes in the design of antibiotic trials. For instance, trials were forced to increase their sample sizes to rule out the placebo effect in results. Although later FDA

analysis suggested that smaller sample sizes were sufficient, the requirement is kept, causing unnecessary increase in trial costs and burden on research companies (Shlaes, 2013). Combined with the disadvantages set forth by profitability of chronic illness drugs, many pharmaceutical companies have abandoned production of new antibiotics, increasing resistance of drugs already in circulation.

## IMPACT OF AMR IN COMMON INFECTIONS

Antibiotics are integral in treating common infections throughout the world and were revolutionary for modern medicine. But what happens when common infections start resisting antibiotics? One major effect is death: in a study done by the CDC, it is approximated that seventy thousand deaths from drug-resistant infections occur in the US per year (Golkar, 2013). In 2021, this number increased to one-hundred and thirty thousand deaths in the US, even with the disease- control measures set by the Covid-19 pandemic (Institute, 2024). Globally, this number was almost five billion deaths in 2019 (World Health Organization, 2023). Furthermore, scientists estimate that during the next twenty-five-year span, an average of 39 billion people are expected to perish from drug-resistant infections globally (Barron,2024). This growing crisis highlights the severe consequences of AMR, leaving patients susceptible to common infections. Because AMR compromises the immune systems of patients fighting common infections, this may force physicians to use last-resort medicine, which could have potentially fatal side effects (Dadgostar, 2019). Methicillin resistance in *Staphylococcus aureus* (MRSA), one of the most well-known AMR cases, has recorded high mortality for several years. When comparing the number of deaths every year by MRSA, a study by the CDC revealed that more Americans are killed every year by MRSA than emphysema, HIV/AIDS, Parkinson's disease, and homicide combined (Golkar, 2013). Globally, AMR infections such as MRSA have been found in every single nation. For example, in 2022, the Global Antimicrobial Resistance and Use Surveillance System (GLASS) reported resistance rates in seventy-six countries for forty-two percent of third generation Cephalosporin-resistant *E. Coli* and thirty-five percent for Methicillin- resistant *Staphylococcus aureus* (World Health Organization, 2023). These studies illustrate the significant effects AMR has on once-common infections and infections still rampant in the international health community.

Figure 2: Colorized scanning electron micrograph of methicillin-resistant *Staphylococcus aureus* (MRSA) bacteria (gold) interacting with a human neutrophil (red). Image captured at NIAID's Rocky Mountain Laboratories (RML) in Hamilton, Montana (NIAID, 2023)

## WHAT IS AMR COSTING HEALTHCARE?

AMR has significant costs for both health systems and national economies overall. It creates a need for more expensive and intensive care, affects productivity of patients or their caregivers through prolonged hospital stays, and affects life-saving procedures. When AMR infections are identified, health care providers may be forced to prescribe last-resort drugs, which are usually more expensive, and as these last-resort drugs become less effective, it becomes more likely the infection will become untreatable. For example, *Klebsiella pneumoniae,* a common intestinal bacterium, has shown enough resistance for the last-resort class of drug called carbapenem to be utilized (World Health Organization, 2023). As more drugs become ineffective in treating AMR infections, increasingly expensive and risky treatments will be implemented.

Consequently, fighting AMR infections has significantly cost healthcare systems and global economies billions of dollars annually. In fact, fighting AMR infections costs the US healthcare system an estimated twenty-one to thirty-four billion dollars per year (Golkar, 2013). Hospital and clinical settings may have to take extra

steps when treating AMR infections which, on average, add an additional fourteen hundred dollars to hospital bills for patients fighting bacterial infections. Excessive costs come from expensive and intensive treatments with prolonged hospital stays and the use of intensive care units (ICUs) to prevent further spread of infection (Dadgostar, 2019). In many cases, physicians must use valuable time and energy to experiment with available drugs for treatment which increases hospital stays and if there is an outbreak in a hospital of AMR infection, an entire wing or hospital could be forced to quarantine.

Along with the direct effects of fighting AMR infection, AMR also affects the ability of healthcare workers to do procedures that involve antibiotics, as the risk of infection is increased in operations such as organ transplantation, hip replacement, C-sections, and chemotherapy (World Health Organization, 2023). In organ transplantation, both the receiver and donator of said organ are exposed to possible infections during surgery, and drug-resistant pathogens increase the risk of death and transplant failure of the organ. Furthermore, chemotherapy weakens the patient's immune system, which exposes the patient to AMR infections. Therefore, physicians will not give antibiotics to chemotherapy patients if AMR is prevalent (Dadgostar, 2019). Many of the treatments affected by AMR infections are vital to the healthcare system, and without protection of these procedures, healthcare systems around the world will and are struggling to provide quality healthcare to its citizens.

## GLOBAL INITIATIVES TO CURB AMR

With the significant effects of AMR already taking hold in modern healthcare systems, multiple global organizations have formed to combat it since the early 2000s. One of these global organizations is the Quadripartite Joint Secretariat on Antimicrobial Resistance, which is a partnership between the following organizations: the World Health Organization, Food and Agriculture Organization of the United Nations, the United Nations Environment Program (UNEP) and the World Organization for Animal Health (WOAH). This cohort focuses on fighting the spread of AMR through the design, communication, implementation, and monitoring of legislation and policies concerning AMR. These focuses are part of the Global Action Plan (GAP) on Antimicrobial Resistance which was adopted by the World Health Assembly in 2015 (World Health Organization, 2023). With this plan, the global health community is united in its goal of attaining positive health and economic outcomes concerning AMR.

## CONCLUSION

With the overuse and misuse of antibiotics in modern healthcare systems, antimicrobial resistance is on the rise around the globe. Due to the misuse of antibiotics and the standstill of production of new antibiotics driving the rise of AMR, common infections such as *Staphylococcus aureus* are becoming harder to treat, mortality rates for infections are increasing, and healthcare expenses are climbing annually with the increase of AMR infections. However, there are multiple global initiatives forming to create positive health and economic outcomes despite the significant effects of AMR rates increasing. Investment in research in new antibiotic production and aiding in efforts to circumvent reliance on antibiotics is imperative if AMR is to decrease. In order to circumvent deadly outcomes for healthcare worldwide, the global health community must revisit their reliance on antibiotics and the unknowns of how to combat this increasingly perilous issue.

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