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Vaccines and resistance: A preventive approach.

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Introduction

Antimicrobial resistance (AMR) is one of the most formidable challenges facing global health today. As pathogens evolve to evade the drugs designed to eliminate them, the effectiveness of antibiotics, antivirals, and antifungals is steadily eroding. While much of the focus has been on developing new treatments, a powerful yet underutilized strategy lies in prevention—specifically, through vaccines. Vaccination not only protects individuals from infectious diseases but also plays a critical role in curbing the emergence and spread of resistant organisms. By preventing infections caused by resistant pathogens, vaccines reduce the burden of disease and the need for antimicrobial treatment. Vaccines lower overall antimicrobial use, thereby reducing the selection pressure that drives resistance in both target and non-target organisms [1, 2].

This preventive approach is gaining recognition among global health authorities. The World Health Organization (WHO) estimates that existing and new vaccines could prevent up to 515,000 AMR-associated deaths annually, save $30 billion in hospital costs, and reduce antibiotic use by 2.5 billion doses. By stopping infections before they occur, vaccines eliminate the need for antibiotics. For example, pneumococcal and influenza vaccines have been shown to reduce antibiotic prescriptions significantly. Vaccinated individuals are less likely to spread pathogens, including resistant strains. This herd immunity effect protects vulnerable populations and slows the spread of resistance genes [3, 4].

Antibiotics often affect non-target bacteria, promoting resistance in commensal organisms. Vaccines reduce antibiotic use, thereby minimizing this unintended consequence. Some vaccines are specifically designed to combat resistant strains, such as the RTS, S malaria vaccine and the PCV13 pneumococcal vaccine, which have shown promise in reducing resistant infections. Recent studies underscore the impact of vaccines on AMR: A 2025 Wellcome Trust report found that rotavirus and pneumococcal vaccines reduced the prevalence of resistant gut bacteria in children across Malawi, Ghana, and Zambia [5, 6].

In Guatemala, vaccination was linked to lower carriage of extended-spectrum cephalosporin-resistant *Enterobacterales*. A simulation study in the U.S. showed that increasing influenza vaccination rates reduced flu cases among both vaccinated and unvaccinated individuals, indirectly lowering antibiotic use. Malaria vaccines like RTS,S and R21/Matrix-M have demonstrated efficacy in reducing infections, which in turn lowers the use of antimalarial drugs and the risk of resistance. Despite their promise, vaccines face several challenges in the context of AMR: Vaccination can alter microbial populations, sometimes leading to the emergence of non-vaccine strains. Resistant genes can still spread among bacteria, even in vaccinated populations. Vaccine uptake and prescribing practices vary widely, affecting outcomes [7, 8].

More empirical data is needed, especially from low- and middle-income countries, to validate models and guide policy. Including resistance metrics in clinical studies can provide valuable insights. Harmonized protocols for measuring AMR in vaccine studies would enable better comparisons and meta-analyses. Robust monitoring systems are essential to track vaccine impact on resistance, especially in underserved regions. Vaccine hesitancy remains a significant obstacle. Misinformation, mistrust, and political rhetoric have undermined public confidence in vaccines,

particularly during the COVID-19 pandemic8. Addressing these concerns through transparent communication, inclusive research, and community engagement is vital to ensure widespread vaccine adoption [9, 10].

Conclusion

The WHO's 2024 study identified 17 priority pathogens for vaccine development, many of which pose significant AMR risks, including *Klebsiella pneumoniae*, *Group A Streptococcus*, and *Staphylococcus aureus*. Vaccines are a cornerstone of public health—and a powerful weapon against antimicrobial resistance. By preventing infections, reducing antibiotic use, and curbing the spread of resistant pathogens, vaccines offer a sustainable and cost-effective solution to a growing crisis. To unlock their full potential, we must invest in research, strengthen surveillance, and build public trust. In the battle against resistance, prevention is not just better than cure—it may be our best hope.

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