One Health Approach: Combating Antimicrobial Resistance and Zoonotic Diseases in a Connected World

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ABSTRACT

The complex interaction among humans, animals, and the environment significantly influences the emergence and transmission of infectious diseases. Zoonotic diseases, originating from animals and transmissible to humans, pose substantial global health risks. This chapter delves into the multifaceted nature of zoonotic infections, emphasizing their prevalence, impact on public health, and ties to antimicrobial resistance (AMR). Approximately 61% of human pathogens have zoonotic origins, highlighting the critical need for a comprehensive 'One Health' approach. Zoonoses not only cause significant illness and mortality, with approximately 2.7 million deaths annually and a staggering 2.4 billion cases of illness, but also impact livestock workers in low- and middle-income countries disproportionately. These diseases create a cascading effect, influencing both human health and animal productivity. The interconnectivity between humans, animals, and ecosystems serves as a breeding ground for opportunistic infections and the proliferation of drug-resistant pathogens. Antibiotic misuse in both human and animal settings exacerbate the development of antimicrobial resistance, which presents a growing global concern. The persistence of antibiotics in the environment further amplifies this issue, contributing to the proliferation of antibiotic-resistant bacteria (ARBs). The spread of ARBs, facilitated by various factors including animal husbandry practices, agricultural activities, and environmental contamination, amplifies the challenge of managing infectious diseases. Addressing the intricate relationship between zoonotic infections, antimicrobial resistance, and environmental impact necessitates a holistic 'One Health' approach. Collaboration across disciplines, encompassing veterinarians, ecologists, epidemiologists, and healthcare professionals, is crucial for effective surveillance, prevention, and control strategies. Integrated efforts involving rigorous surveillance systems, technological advancements, and public awareness campaigns are imperative to combat the spread of zoonotic diseases and antimicrobial resistance.

Keywords: Zoonotic diseases, Antimicrobial resistance, One Health approach, Environmental impact, Interdisciplinary collaboration, Public health

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1. INTRODUCTION

An important factor in the formation and spread of several infectious diseases is the interaction between people, animals, and the environment (Rahman et al., 2020). Animals are the primary vector of transmission for most infectious diseases that affect people. The "Asia Pacific Strategy for Emerging Diseases: 2010" paper states that over 60% of new human illnesses are caused by these viruses, most of which have their origins in wildlife species (Organization, 2011). There have been recent findings linking animal-based diets to human diseases with animal origins (Slingenbergh, 2013).

The word "zoonoses" comes from the Greek words "zoon" (animal) and "nosos" (disease). The World Health Organization (WHO) defines zoonosis as any illness or infection that can spread naturally from vertebrate animals to humans or from humans to animals (Organization, 2022). The origin of about 61% of human pathogens is zoonotic (Taylor et al., 2001).

Zoonoses is a direct risk that poses a major harm to human health and has the potential to be lethal. An estimated 2.7 million people die and 2.4 billion cases of illness are caused by the 13 most frequent zoonoses worldwide each year, with an emphasis on the impoverished livestock workers in low- and middle-income nations (Fig. 1) (Grace et al., 2012). The majority of these ailments have an impact on animal health and reduce cattle output (Grace et al., 2012).

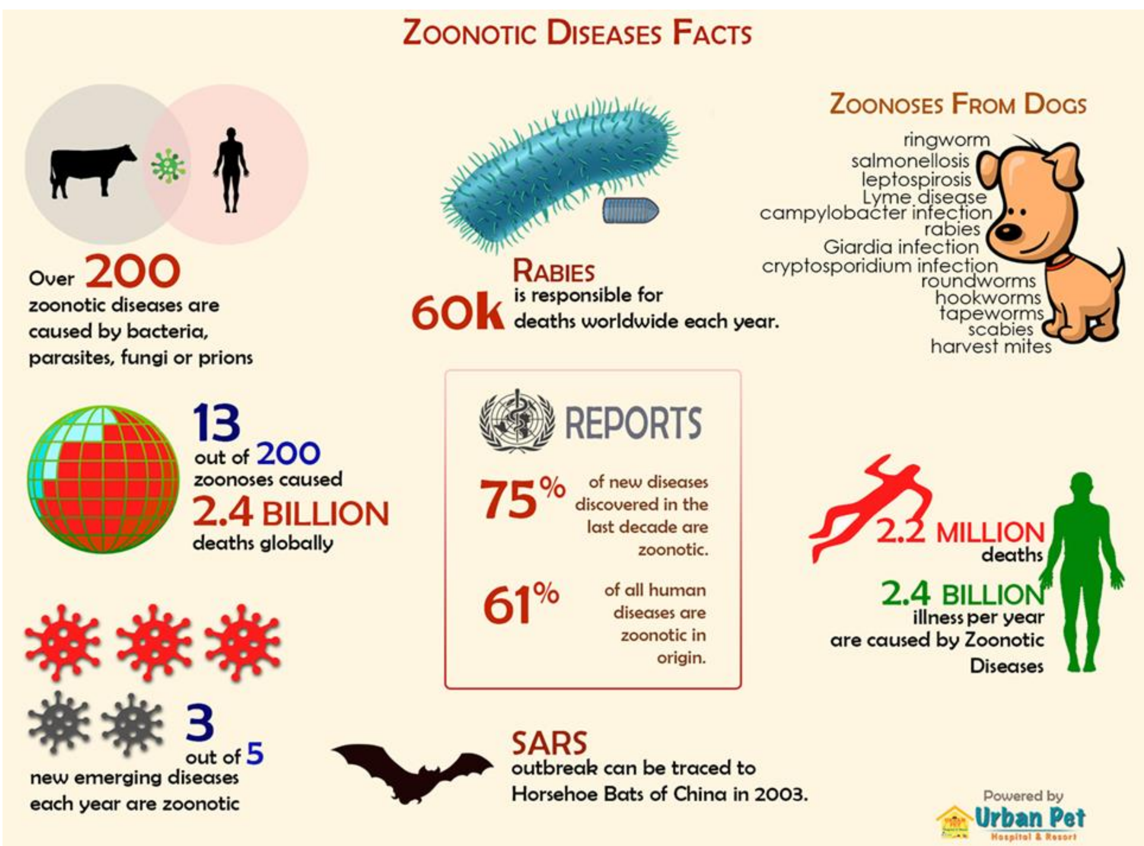

Fig. 1: Zoonotic diseases facts.

In recent years, managing human health has presented new difficulties. A major global problem is the introduction of new opportunistic infections and medication resistance in existing diseases. The majority of developing illnesses have penetrated virtually every ecosystem and crossed transboundaries. According to the emerging hypothesis, the development of disease patterns takes into account how pathogenic determinants breed in ecosystems using any potential biological hosts that may be present. Animals are the most typical biological hosts for the propagation of pathogens with resistance. Animal guts are made up of a variety of microbial communities that work together to benefit their host (Purohit, 2018).

The introduction of a drug-resistant pathogen modifies the community structure by dispersing the resistant gene to other pathogens in the gut. Human health is at risk from opportunistic infections that spread from animals to people through direct contact (zoonoses) or vectors. The ''one health'' approach is now taking into account a situation where humans and animals are interconnected through ecosystems (Purohit, 2018).

Zoonoses, or the transmission of illnesses from animals to humans, are a serious global problem. The zoonotic infections may ultimately result in new epidemic diseases, irregular disease outbreaks, or an odd curiosity specific to the area. All factors influencing the emergence of novel zoonotic illnesses are managed under the "one health" philosophy. One health strategy connects the environment, animals, and people. One health approach is required to address the rise in antibiotic resistance in the human population brought on by zoonotic diseases. For efficient investigations, the one health approach to zoonoses management uses interdisciplinary teams comprised of doctors, ecologists, entomologists, epidemiologists, and ornithologists (Zakaria, 2020).

The discovery of antibiotics in the early 1900s has revolutionized human health and saved millions of lives. Antibiotics are complex chemicals that stop microorganisms from growing in a number of different ways, such as changing cell membranes, blocking the formation of cell walls, inhibiting the synthesis of nucleic acids and proteins, and creating a competitive environment. To avoid infectious infections, antibiotics are used in livestock and animal husbandry to boost the output of dairy products and meat. On a broad scale, it is also employed for enhancing the weight and growth of animals. Even though antibiotics are helpful, their unchecked use and environmental spread constitute a serious worry (Parmar et al., 2018).

The majority of antibiotics used by people and other animals do not completely break down in the body, releasing unmetabolized forms into the environment (Kalia, 2015). They leave the body and enter a different environment where they pass through sewage sludge, animal waste, and municipal wastewater. The development of ARBs is under selection pressure due to the increasing concentration of antibiotics in various settings, which changes the sensitivity of the bacterial population and increases antibiotic resistance in the local microbiome (Parmar et al., 2017).

Antibiotic resistance genes (ARGs) are becoming more prevalent due to environmental antibiotics altering the genetic makeup of bacteria. The frequency of ARBs in the environment is increased by the spread of ARGs to other microbial communities via related mobile genetic elements (MGEs) such as plasmids, transposons, and genomic islands. These ARBs grow into potent zoonotic pathogens that can seriously infect people worldwide (Parmar et al., 2017).

The use of antibiotics in veterinary care and on animals used for food production is encouraging the formation of ARBs in both normal bacterial flora and zoonotic pathogens. A critical issue for modern medicine is the link between AMR and animal and human illness. Even though there is a lot of research being done on zoonotic infections, there is still a lack of adequate management, regulation, and human usage of antimicrobial agents (Thakur & Gray, 2019).

Additionally, the use of antibiotics in manure for agricultural purposes spreads the antibiotics throughout several ecological niches, including the soil and water. Antimicrobial spread from the soil to water sources and subsequent ecological niches. Antimicrobial resistance (AMR) in the environment is the leading health concern, according to the World Bank's most recent One Health approach framework ((Berthe et al., 2018)). Environment, aquaculture, and wildlife are the focus of one AMR prevention strategy (Thakur & Gray, 2019).

2. THE ONE HEALTH APPROACH

AMR can be fatal, yet there are effective, adaptable remedies that are still hidden. Due to its multidimensional, linked, and diverse ecological properties, understanding the AMR pattern is difficult. The right usage of antimicrobial products in diverse areas must be decided upon by individuals and society as a whole to control widespread resistance. The complex AMR scenario necessitates a multi-sectoral approach to supervision. Teams from the veterinary, environmental, and healthcare fields as well as stakeholders should be involved in this strategy. An approach known as "One Health" encourages interdisciplinary collaboration between academics and decision-makers who work at the local, state, federal, and global levels (Fig. 2) (Binot et al., 2015).

Fig. 2: One Health Policy

This strategy aims to improve environmental, animal, and human health outcomes. The ''one health'' strategy places a high priority on the spread of AMR-associated pandemic diseases.

Through the development of appropriate usage guidelines, the transmission of effective risk messages, and an appreciation of the AMR problem, this approach brings together a wide range of sectors with active players in the field. Another issue that requires a more thorough explanation is the spread of AMR. This problem is related to the migration of bacteria between human hosts, animals (both domestic and wild), and the environments in which each of these groups of bacteria can proliferate (Binot et al., 2015).
Understanding how AMR spreads through the air, water, and soil is essential because the environment serves as a reservoir for resistant microorganisms and ARGs as well as a conduit for the disease's transmission between host animal and human populations. AMR can be managed within a single health approach by implementing several factors, such as (1) standards and restrictions for the critical usage of different kinds of antibiotics used for animal and human health, and (2). (3) Well-established and cutting-edge approaches using cutting-edge technologies for assessing AMR, encompassing herd management and animal husbandry (4) Successful communication techniques to raise customer knowledge of the dangers of AMR transmission from the food industry and other nonhuman sources (Binot et al., 2015).
Everyone is impacted by the issue of understanding zoonoses-mediated AMR, including the scientific community, food animal producers, medical professionals, patients, and consumers. "One Health" suggests several strategies to stop the transboundary and zoonotic spread of AMR to maintain the efficient use of antibiotics in the treatment of both humans and animals.

3. ZOONOTIC PATHOGENS AS AMR CARRIER

In the past, chronic illnesses, antibiotic resistance, and environmental pollution have all put human and animal health in jeopardy, increasing death and morbidity rates (Kalia et al., 2014).
The incidence and dissemination of zoonoses, epizootics, and epidemics have brought attention to the elevated risk to global health and the significance of comprehending the transfer of infectious agents from animals to humans. The majority of infectious diseases are thought to have zoonotic origins and are considered serious health issues A zoonotic disease, also known as a zoonosis, is defined by the World Health Organization (WHO) as "any disease or infection that is naturally transmitted between vertebrate animals and humans". An infectious agent that causes disease could be a virus, fungus, bacteria, parasite, or prions. Approximately 200 zoonoses are known to exist in the globe today; some are restricted to a certain region, while others are said to have a global distribution (Kalia et al., 2014). Transmission methods for zoonotic pathogens include ingestion, inhalation, and other methods that contaminate mucosal membranes.
Furthermore, zoonotic diseases can be transmitted by eating foods containing animal tissue, such as raw meat, unpasteurized milk, dairy products, shellfish, and contaminated vegetables. Anthrax, animal influenza, bovine tuberculosis (BTB), brucellosis, hemorrhagic colitis, zoonotic diphtheria, rabies, and Q fever are other well-known zoonotic illnesses (Kalia et al., 2014).
Numerous factors, including biological, genetic, social, ecological, political, physical, and environmental ones, interact to cause the incidence of zoonotic diseases. More than sixty percent of human infectious diseases are caused by zoonotic pathogens. The most common zoonotic infections among them are ARBs, which are frequently present in the environment. The host immune system and antimicrobial medications exert considerable selection pressure on the bacteria and shorten their growth time. These interactions with pathogen-host species that act as a reservoir of infection have caused these communities to undergo major evolutionary modifications that impact human health. Few antibiotics are effective against Staphylococcus species., Proteus mirabilis, Pseudomonas aeruginosa, and Klebsiella pneumonia (Hathroubi et al., 2018).
According to one health strategy, the development of ARBs and the rising use of antibiotics in agriculture and aquaculture are related. Through the transmission of zoonotic diseases, the ARBs intrude into the human gut and disrupt the gut's natural diversity. When humans contract zoonotic infections with ARGs,

the resistance genes are transferred to the human gut microbiome, which modifies the equilibrium of the gut environment. Human excretion of ARGs or ARBs finds its way into the environment through soil or municipal wastewater. After being dispersed by soil or wastewater, ARBs damage animal health and enter the food chain, perpetuating the cycle of ARB transmission (Hathroubi et al., 2018).

4. GLOBAL CHALLENGES AND FUTURE DIRECTIONS

The soil microbial community is negatively impacted by the ongoing release of antibiotics into the environment through animal feces, manure, urine, and sewage sludge.
Antibiotics are given to animals to treat illnesses, but often the antibiotics do not break down in the bodies of the animals, and a sizeable amount of the unmetabolized antibiotics end up in either the soil or urban effluent. The body excretes 60, 50–90, and 75–80% of the dosages of erythromycin, tetracycline, and lincomycin, respectively, according to numerous reports. Tetracyclines are the next most commonly found compound in manure, after fluoroquinolones, sulphonamides, and macrolides. The overabundance of antibiotics in soil eventually alters the susceptibility of the microbial population to antibiotics by promoting the growth of ARBs (Kapley et al., 2016).
The use of antibiotics in soil environments helps bacteria change their genetic makeup and spread ARGs among themselves. Autochthonous soil bacteria become resistant to ARGs as a result of the spread of ARGs, which also makes them a source of ARGs in the environment (Kapley et al., 2016).
In addition to changing genetic, structural, and functional diversity, antibiotics in the soil also have an impact on microbial activity, enzyme activity, the nitrogen cycle, and carbon mineralization. The human body absorbs ARBs from the soil and water environment, where they multiply in the stomach and change how susceptible people are to antibiotics. The development of novel enzymes and genes that confer bacterial resistance has also been linked to the presence of antibiotics in soil, according to research (Kapley et al., 2016).

5. SURVEILLANCE AND EARLY WARNING SYSTEMS

For the protection of public health and global health, it is essential to monitor zoonotic illnesses (diseases that can be spread from animals to people) and antimicrobial resistance (AMR). To efficiently identify, track, and respond to these risks, a variety of technologies and strategies are used. The following are some crucial tools and techniques for tracking AMR and zoonotic diseases:

5.1. GENOMIC SEQUENCING

The rapid sequencing of pathogen genomes made possible by next-generation sequencing (NGS) can be used to find zoonotic pathogens and monitor their evolution. Metagenomics is useful for surveillance since it can identify a variety of infections and AMR genes in a single sample.

5.2. POLYMERASE CHAIN REACTION (PCR) IN REAL-TIME

In clinical samples, PCR can rapidly and precisely identify particular infections or AMR genes, assisting with early diagnosis and tracking.

5.3. GISP: GEOGRAPHIC INFORMATION SYSTEMS

To aid in surveillance and response planning, the spatial distribution of zoonotic illnesses and AMR hotspots are mapped using GIS technology.

5.4. TECHNOLOGIES FOR MOBILE AND WEARABLE HEALTH

Mobile apps and wearable technology can monitor people's health and gather information on disease symptoms and potential exposure, helping early warning systems.

5.5. TELEHEALTH AND TELEMEDICINE

Telemedicine makes it possible to monitor and confer with patients from a distance, lowering the danger of disease transmission and enhancing access to medical care.

5.6. TECHNOLOGIES FOR MONITORING ANIMALS

Animal populations are tracked using tracking and monitoring tools (such as GPS collars and RFID tags) to assist in finding potential disease reservoirs.

5.7. MODELING OF THE EPIDEMIOLOGY

Public health decision-making is aided by the use of mathematical models and machine learning algorithms to predict the development of zoonotic illnesses and AMR.

5.8. LABORATORY TRUCKS

To quickly test for zoonotic infections and AMR, portable laboratories with diagnostic equipment such as PCR machines can be deployed to remote locations.

5.9. AI ANALYTICS WITH BIG DATA

Large amounts of data from many sources, including social media, news articles, and clinical records, can be analyzed with the aid of big data analysis and artificial intelligence to find disease outbreaks and novel AMR patterns.

5.10. ONE HEALTH ARRANGEMENTS

The interdependence of human, animal, and environmental health is emphasized by the one health movement. This strategy encourages cooperation across many industries and academic fields to monitor zoonotic diseases and AMR thoroughly.

5.11. OBSERVATIONAL NETWORKS

Regional, national, and international surveillance networks and reporting systems enable information sharing and early warning of zoonotic disease outbreaks and AMR trends.

5.12. TECHNIQUES FOR MOLECULAR TYPING

AMR-causing pathogens can be tracked down using two methods: multi-locus sequence typing (MLST) and pulsed-field gel electrophoresis (PFGE), which both identify the source of the pathogens and their routes of transmission.

5.13. SEROLOGICAL EXAMINATIONS

Retrospective diagnosis and seroprevalence investigations are made easier by the ability of serological testing to identify antibodies to certain diseases.

5.14. BIOSENSORS

Pathogens or AMR indicators can be found in many samples using biosensors, which are frequently based on antibody-antigen interactions or molecular recognition. To assure the early detection and prompt reaction to growing threats to human and animal health, effective monitoring of zoonotic illnesses and AMR necessitates a multi-pronged approach that incorporates these technologies, as well as worldwide collaboration and data sharing.

6. THE IMPORTANCE OF RESEARCH AND COMMUNICATION

One kind of wildlife interaction with discernible potential drawbacks is wildlife-associated zoonotic illness (Vaske et al., 2009; Wobeser, 2013). However, despite worries that public support for animal research may decline due to misperceptions about zoonotic disease risks, nothing has been done to better understand these beliefs and potential consequences for the One Health Initiative (Brook & McLachlan, 2006; Stronen et al., 2007). Trends and predicted trajectories for zoonotic illness in North America, where infectious disease outbreaks occur more frequently than ever in contemporary times, show the necessity for such research (Jones et al., 2008). Even after accounting for enhanced monitoring and reporting efforts, an analysis of 335 distinct illness occurrences in the global human population from the 1940s to the 1990s showed that the frequency of new zoonoses originating in wildlife rose every ten years (Jones et al., 2008).

The primary drivers of rising disease incidence and prevalence include an increasing human population, global migration of people and animals, and the encroachment of agricultural and urban development on wildlife habitat (Vaske et al., 2009; Wobeser, 2013). Since these trends are likely to continue, it becomes sense to incorporate animal health as a keystone of the One Health concept.

Public support for healthy wildlife populations can be increased by health communications if they convey the idea that safeguarding the health of wildlife also protects human health and wellbeing. People may distance themselves from wildlife by simply becoming more aware of the diseases that are linked to it (e.g., spending less time outdoors where wildlife may be encountered or lessening their support for wildlife protection). Health specialists should better anticipate public reaction to one health message by understanding how and why individuals create their beliefs about diseases related to wildlife. Will people choose to eradicate the diseased species exclusively, or will they accept the notion that shielding wildlife from illness may also shield humans from zoonotic illnesses? A better way to address this question would be to examine the drawbacks of One Health messaging.

7. EXISTING AND NEEDED RESEARCH ON PERCEPTIONS OF ZOONOSES AND WILDLIFE HEALTH

Public worry about zoonoses has hardly been explored by research. Vaske et al. (2009) conducted a recent meta-analysis of human dimensions research on wildlife diseases, which highlights the paucity of studies on most diseases associated with wildlife as well as the incompleteness of these studies' assessments of the variety of possible consequences of these diseases (Vaske et al., 2009).

Rather, risk perception analysis for zoonoses has mostly concentrated on the kinds and intensities of anxiety associated with specific diseases within specific populations (e.g., rabies concerns among recreational cave divers and speleological societies, or chronic wasting disease concerns among Midwesterner hunters).

Each study adds something to the body of knowledge, but they only begin to explain how or why different animal diseases have different risk estimations. We concur with the 2009 recommendation made by Vaske and colleagues for a thorough approach to research on the human aspects of animal-related illnesses (Vaske et al., 2009).

Information regarding risk perceptions and disease development is scarce for most diseases. Given the wide variations in wildlife-associated diseases and the environments in which they arise, it is critical to determine the factors influencing risk perceptions of various diseases in various contexts. For communicators to create effective One Health messages, information on how cultural and other elements, such as social responses, affect risk perceptions of various diseases as well as the same disease across settings would be beneficial. Some researchers have looked at how a wildlife-associated disease's traits affect people's perceptions of danger, although this area of study also requires more development (Peterson et al., 2006).

Perception of current risk Retrospective studies on zoonoses describe how specific groups saw a disease outbreak. It doesn't reveal how a population with a particular set of traits could react to a future outbreak. Further study is needed on a component of risk analysis that can forecast reasonably both the degrees and types of worry about a risk related to wildlife.

Research on zoonoses has concentrated on a variety of issues, such as how they affect the local economy in addition to how they affect the health of people, domestic animals, and wildlife. While some studies have looked at a variety of potential issues, the majority have only looked at those that have to do with human health. Other studies have asked respondents merely "how concerned" they are about a particular disease without disclosing the specifics of their worries (Dorn & Mertig, 2005; Figuié & Fournier, 2008; Peltz et al., 2007).

The narrow focus of the study makes it difficult to comprehend how zoonotic disease is perceived from a One Health standpoint. The fundamental tenet of one health is that people may be concerned about a disease for non-public health reasons (e.g., aesthetic concerns or the health of the ecosystem). Health risk communicators will not be able to determine whether a message has negative side effects if they do not have a comprehensive understanding of people's anxieties.

Although some studies suggest factors that may influence public concern, empirical research does not identify the specific cultural, social, and health characteristics that influence perceived hazards and for whom these characteristics are relevant. Similarly, studies have not demonstrated the relative importance of zoonoses versus other potentially hazardous wildlife interactions. Given the epidemiology and modes of transmission of certain diseases, it is not surprising that a large number of people are ignorant of the risks connected to specific illnesses. The danger is also questionable because human zoonoses like Lyme disease are difficult to detect. While it's unclear if increased ambiguity makes people worry more about zoonoses than other wildlife issues, risk perception theory indicates that people may feel more "dread" when faced with these kinds of threats (Slovic & Peters, 2006).

8. CONCLUSION

The globe is seriously concerned about the growing environmental degradation, which is why it is getting more attention now. Inappropriate use of antibiotics in the cattle industry causes the gut microbiome to become resistant, serving as a bioreactor for the growth of pathogens and raising the likelihood that novel

ARGs will emerge and spread throughout the environment. By moving down the food chain, it disturbs the biogeochemical cycle like how the unmetabolized antibiotic excretes itself into the environment. The growth of resistant bacteria and the suppression of native microorganisms have an impact on the microbial population, enzyme activity, nitrogen cycle, and carbon absorption. Future work plans should concentrate on antibiotic persistence, accumulation, bioaugmentation, biostimulation, and biotransformation since these factors increase the chance of ARBs breeding through HGT events.

As you concentrate on these strategies, it's important to consider how biotic and abiotic degradation processes interact. The "one health approach" should be used to regulate and research the developing resistance trend through ARBs monitoring systems in order to permit a quick public health response. This is because antibiotic resistance thrives in the intestines of animals. It's also critical to develop multi-agency coordinated solutions that will improve coordination, spread information, and raise awareness of the appropriate use of antibiotics in agriculture, animal husbandry, and aquaculture. The results of these actions will boost the environmental efficacy of both novel and existing antibiotics while also controlling human and animal diseases. Additionally, there will be a decrease in the transmission of zoonotic diseases that cause life-threatening, incurable infections in people.

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