Forum: Commission on Sustainable Development

Issue: Combating growing antimicrobial resistance due to climate change.

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Introduction

In an era where our planet faces unprecedented challenges, from rising global temperatures to the loss of biodiversity, the convergence of two critical issues demands our immediate attention.Our collective efforts must now focus on combating the growing menace of antimicrobial resistance—a silent crisis exacerbated by the changing climate. Long-term changes in temperature and weather patterns are referred to as climate change. Such fluctuations can be natural, like volcanic eruptions or variations in the sun's activity. But since the 1800s, human activities—primarily the combustion of fossil fuels like coal, oil, and gas—have been the primary cause of climate change.[1]Thousands of scientists and government reviewers agreed in a number of UN assessments that keeping the increase in global temperature to 1.5°C would help humanity avoid the most severe climate impacts and maintain a habitable environment. However, present strategies predict a 2.8°C rise in temperature by the end of the century.[2]Emissions that contribute to climate change are produced all across the world, yet some nations create far more than others.For example, The United States, as the world's second-largest emitter, produced roughly 5.4 gigatons of CO2 in 2019, accounting for approximately 15% of global emissions. In contrast, the European Union, a bloc of 27 countries, emitted about 3.4 gigatons of CO2 in the same year, making up approximately 9% of global emissions. [3]About half of all greenhouse gas emissions worldwide in 2020 were produced by the top seven polluters (China, the United States of America, India, the European Union, Indonesia, the Russian Federation, and Brazil).[4] These stark emission disparities underscore critical need for immediate and unified action as a handful of the world's largest polluters bear a substantial responsibility for the escalating crisis of climate change.

In a world dealing with the pressing issue of climate change, there's another critical problem that often flies under the radar - Antimicrobial Resistance (AMR). As our planet warms and ecosystems are disrupted, AMR is becoming more connected to these challenges. AMR's link to climate change makes it an urgent

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[1] https://www.un.org/en/climatechange/what-is-climate-change
[2] https://press.un.org/en/2016/sgsm18457.doc.htm
[3] https://globalcarbonatlas.org/emissions/carbon-emissions/
[4] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9914631/#:~:text=While%20temperatures%20rise%20as%20a,horizontal%20gene%20transfer%20%5B75%5D.

concern, with far-reaching consequences for both our health and the environment.It's a shadowy menace that, if left unaddressed, could undermine our ability to combat infections and may compound the complexities of a world already grappling with environmental crises. Antimicrobial resistance (AMR) occurs when microorganisms, such as bacteria, viruses, fungi, and parasites, develop resistance to antimicrobial drugs, rendering them ineffective. Antimicrobial organisms are found in food, people, animals as well as the air,water and soil. They can spread from people to people or even from animals to people. [5]According to the WHO, AMR is one of the top 10 global public health threats facing humanity.It threatens progress in achieving Sustainable Development Goals (SDGs), particularly in areas such as good health, clean water, and life on land. Addressing AMR is crucial for ensuring the long-term viability of these goals.[6]This may also occur as a result of improper (excessive) antibiotic usage, poor infection prevention and control techniques, mediocre medications, and inadequate access to clean water and sanitary facilities. AMR causes several negative impacts such as increased health care costs, increased mortality and reduced efficacy of treatments, burdening a nation's economy by putting pressure on the healthcare system.[7] For example,India has witnessed a surge in Antimicrobial Resistance (AMR) driven by factors like rampant over-the-counter antibiotic use, inadequate infection control in healthcare settings, substandard medications, and limited access to clean water and sanitation. This has led to a high incidence of multi-drug-resistant tuberculosis (MDR-TB), widespread antibiotic misuse, and suboptimal treatment practices, exacerbating AMR challenges in the country.[8]

Climate change can exacerbate the problem of AMR by affecting the spread of infectious diseases, altering the ecology of microorganisms, and increasing the use of antimicrobial drugs.This can lead to diseases that are difficult to treat, making it a serious threat to overall public health.[9]For example- Salmonella and Vibrio cholerae have higher levels of resistance as the temperature rises. Additionally, the distribution and survival of microorganisms and vectors, such as ticks and mosquitoes, that spread diseases to people and animals are affected by climate change.When individuals are displaced due to floods or droughts, additional pathogens are exposed to them, which contributes to the spread of disease and limits their access to medical care.Due to the increased need to prevent bacterial illnesses, antibiotic use in agriculture and animal production has increased Moreover, farming practises including deforestation and intensive agriculture can also contribute to the emergence of antimicrobial resistance.[10]

Climate change and antimicrobial resistance are complex issues that require a multi-sectoral and collaborative approach to mitigate their impact on human health.One such approach is the One Health

[5] https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance
[6]https://healthcare-in-europe.com/en/news/amr-climate-change-a-worrying-dual-threat-to-global-health.html
[7] https://www.annualreviews.org/doi/10.1146/annurev-publhealth-040218-043706
[8] https://www.cdc.gov/drugresistance/solutions-initiative/stories/mdrtb-in-india.html
[9] https://www.cdc.gov/drugresistance/actions-to-fight.html
[10] https://www.cdc.gov/drugresistance/actions-to-fight.html

approach, which brings together multiple sectors and stakeholders engaged in human, terrestrial and aquatic animal and plant health, food and feed production and the environment to communicate and work together in the design and implementation of programmes, policies, legislation and research to attain better public health outcomes.[11]

Definition of Key Terms

Antibiotics

Antibiotics are a class of medications used to treat bacterial infections. They work by either killing bacteria (bactericidal) or stopping their growth and reproduction (bacteriostatic). Antibiotics have been crucial in modern medicine, saving countless lives by effectively treating bacterial diseases.[12]
The overuse and misuse of antibiotics in the face of climate-driven health challenges can contribute to the development and spread of antibiotic-resistant bacteria. When antibiotics are used indiscriminately or prescribed when not necessary, bacteria have a higher chance of developing resistance to these drugs. This, in turn, makes it more challenging to treat infections effectively, posing a threat to public health.

Antimicrobial resistance

AMR (Antimicrobial Resistance) refers to the ability of microorganisms, such as bacteria, viruses, fungi, and parasites, to develop resistance to the drugs (antimicrobials) designed to kill or inhibit their growth. This resistance makes previously effective treatments less effective or even useless.
AMR is a natural evolutionary process, but factors like overuse and misuse of antimicrobials in healthcare, agriculture, and the environment have accelerated it. When microorganisms are exposed to antimicrobials, some may survive due to inherent genetic variations or mutations, and they pass these resistant traits to their offspring. This results in the development of resistant strains, making infections harder to treat and increasing the risk of treatment failures. AMR is a global health crisis that threatens our ability to control infectious diseases and underscores the need for responsible antimicrobial use and new treatment strategies.

Biosecurity

Biosecurity refers to measures that are taken to stop the spread or introduction of harmful organisms to

[11] https://edition.cnn.com/2023/02/07/health/superbugs-climate-change-scn/index.html

[12] https://my.clevelandclinic.org/health/treatments/16386-antibiotics

human, animal and plant life. The measures taken are a combination of processes and systems that have been put in place by bioscience laboratories, customs agents and agricultural managers to prevent the use of dangerous pathogens and toxins.[13]In the context of the agenda on combating Antimicrobial Resistance (AMR), biosecurity is crucial. It involves strict protocols for the handling, storage, and distribution of antimicrobial drugs to prevent misuse or overuse, which can accelerate AMR. Effective biosecurity measures also include infection control procedures in healthcare facilities to limit the transmission of resistant infections, ultimately contributing to the containment of AMR.

Carbon footprint

Carbon Footprint is the total amount of greenhouse gases, primarily carbon dioxide (CO2), and other carbon compounds emitted into the atmosphere as a result of human activities, such as energy consumption, transportation, and industrial processes. It is usually measured in units of carbon dioxide equivalents (CO2e) and serves as an indicator of an individual's or organization's impact on climate change.[14] A carbon footprint quantifies the environmental impact of various human actions and helps us understand our contribution to climate change. By assessing and reducing our carbon footprints, we can take steps to mitigate global warming and work towards a more sustainable future. Conservation International emphasizes the importance of measuring and reducing carbon footprints as part of broader efforts to combat climate change and protect the planet's natural ecosystems.

Drug resistance

Drug resistance is the reduction in effectiveness of a medication such as an antimicrobial or an antineoplastic in treating a disease or condition. The term is used in the context of resistance that pathogens or cancers have "acquired", that is, resistance has evolved. Antimicrobial resistance and antineoplastic resistance challenge clinical care and drive research. When an organism is resistant to more than one drug, it is said to be multidrug-resistant.[15]

GHS Index (Global Health Security Index)

The Global Health Security (GHS) Index is an assessment and benchmarking of health security and related capabilities across 195 countries. The 2021 Global Health Security Index assesses countries across 6

[13] https://www.news-medical.net/health/What-is-Biosecurity.aspx
[14] https://www.conservation.org/stories/what-is-a-carbon-footprint
[15] https://en.wikipedia.org/wiki/Drug_resistance

categories, 37 indicators, and 171 questions using publicly available information. The GHS Index benchmarks health security in the context of other factors critical to fighting outbreaks, such as political and security risks, the broader strength of the health system, and country adherence to global norms.It is designed to inform leaders of the foundational elements that are necessary to prepare their countries for future outbreaks and where they should prioritize planning and invest durable funding. By assessing these capacities every 2-3 years, the GHS Index stimulates political will and action to prioritize addressing these gaps.[16]

GLASS (The Global Antimicrobial Resistance and Use Surveillance System)

On 22 October 2015, WHO launched the Global Antimicrobial Resistance and Use Surveillance System (GLASS), the first global collaborative effort to standardize AMR surveillance. It is a global initiative by the World Health Organization (WHO) aimed at addressing the critical issue of Antimicrobial Resistance (AMR). Through GLASS, countries collect data on antibiotic resistance patterns, antibiotic consumption, and the availability of these drugs. This data helps in identifying emerging resistance trends and enables healthcare systems to take informed actions to combat AMR. GLASS promotes data sharing and transparency, fostering international collaboration to address this global health threat effectively.[17]

Health Impact assessment

Health Impact Assessment (HIA) is a systematic process that evaluates the potential health effects of a proposed policy, project, or development. It considers a wide range of factors, including environmental and social impacts. Recommendations are produced for decision-makers and stakeholders, with the aim of maximizing the proposal's positive health effects and minimizing its negative health effects. The approach can be applied in diverse economic sectors and uses quantitative, qualitative and participatory techniques.[18]
It can assess how climate-related policies, like emissions reduction strategies or adaptation measures, might impact public health, including the spread of infectious diseases. By identifying potential health risks and benefits, HIAs help policymakers make informed choices that mitigate harm and promote public health. For example, an HIA might assess how a new transportation infrastructure project could affect air quality and the transmission of respiratory infections.

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[16] https://www.ghsindex.org/about/
[17] https://www.who.int/initiatives/glass#:~:text=GLASS%2DAMC%20provides%20a%20common,the%20respective%20national%20surveillance%20systems.
[18] https://www.who.int/health-topics/health-impact-assessment#tab=tab_1

Health Resources

Health Resources encompass the personnel, facilities, and funding required to provide healthcare services effectively. These resources include doctors, nurses, hospitals, clinics, medications, and financial support.[19]Inadequate health resources can exacerbate the impact of crises, making it vital to allocate resources effectively to address the health consequences of climate change and AMR.

National action plans

National Action Plans are strategic frameworks developed by countries to address specific challenges or objectives. Such plans ensure coordinated efforts, allocation of resources, and a comprehensive response to a problem. Eg- the "National Action Plan on Antimicrobial Resistance (NAP-AMR)" of the United States.

One Health Approach

One Health is a collaborative, multisectoral, and transdisciplinary approach — working at the local, regional, national, and global levels — with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment.[20]

Public health

Public health is the science and art of preventing disease, prolonging life, and promoting health through the organized efforts and informed choices of society, organizations, public and private communities, and individuals.[21]Public health professionals work to mitigate the risks of AMR by promoting climate resilience, responsible antibiotic use, and effective infection prevention measures. For instance, public health campaigns can educate the public on the importance of vaccination to prevent infectious diseases exacerbated by climate change.

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[19] https://www.oecd-ilibrary.org/social-issues-migration-health/health-resources/indicator-group/english_777a9575-en

[20] https://www.cdc.gov/onehealth/basics/index.html#:~:text=One%20Health%20is%20a%20collaborative,plants%2C%20and%20their%20shared%20environment.

[21] https://www.cdc.gov/training/publichealth101/public-health.html

Background Information

Role of climate change in problem of AMR

The same drivers that cause environmental degradation are worsening the antimicrobial resistance problem. The impacts of antimicrobial resistance could destroy our health and food systems.Climate change contributes to antimicrobial resistance (AMR) by altering disease patterns, increasing the prevalence of infectious diseases, and intensifying the use of antibiotics in healthcare and agriculture. [22]

Increasing natural disasters

Deforestation, burning of fossil fuels as well as improper agricultural practices-such as unsustainable disposal of waste water-negatively affect the water cycle causing floods (mainly through rise in temperature which increases air capacity of holding moisture). More problems of overgrazing and extreme rural poverty also exacerbate the disasters. Similar factors also give rise to drought, earthquakes and wildfires.[23]Negative social and economic outcomes of these disasters like overcrowding, poor sanitation and increased pollution, are known to create a rise in infection rates. As a result, the health of victims deteriorates,and more antibiotics are used. The final outcome is increased antimicrobial resistance as increased antibiotics increases selective pressure on pathogens, favoring evolution.

In addition the migration and displacement caused by natural disasters increases the risk of spread of infections, diseases, and antimicrobial resistance because people have an increased risk of exposure to pathogens and a reduced ability to access healthcare. South-Asian and Sub-Saharan developing countries like Somalia, India and Bangladesh, are one of the most vulnerable to pernicious health effects of natural disasters.[24]In sub-Saharan Africa, where infectious diseases are common and health systems are weak, it is estimated that by 2050, up to 4.1 million people may die each year due to drug-resistant infections, according to the WHO.[25]

[22] https://www.annualreviews.org/doi/10.1146/annurev-publhealth-040218-043706

[23] https://www.eird.org/isdr-biblio/PDF/Natural%20disasters%20coping.pdf
[24] https://en.wikipedia.org/wiki/List_of_countries_by_natural_disaster_risk

[25] https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance

Rising Temperatures

Altering microbial ecosystems ,increasing selective pressure on them and increase in use of antibiotics due to spread of infectious disease are also ways in which rising temperatures contribute to AMR.[26]

The variations that drive resistance evolution will actually speed up as our climate becomes more severe, especially as it warms.[27]Elevated temperatures can affect the immune response of both humans and animals, potentially influencing the effectiveness of antibiotics in treating infections. In some cases, higher temperatures may lead to increased disease outbreaks in livestock or aquaculture. This can result in the increased use of antibiotics for disease prevention or treatment, which in turn can contribute to the emergence and spread of antibiotic resistance.Certain diseases may even become more prevalent or expand their geographical range as temperatures warm.[28]Therefore, we can fundamentally reduce the likelihood of the emergence of new resistance by limiting temperature increases and lowering the extremeness of occurrences.The rate of transfer of resistant genes is higher at higher temperatures, thus due to rising climate change, bacteria can acquire and spread AMR more easily.

Changing methods of food production

Climate change could have an effect on the environment and how we produce food. The need to manage bacterial infections increases the use of antibiotics in agriculture and animal production, and farming practices like deforestation and intensive agriculture can contribute to the proliferation of AMR.Changes in temperature, precipitation patterns, and water availability due to climate change can influence the need for and use of antibiotics in agriculture. [29]In some cases, higher temperatures may lead to increased disease outbreaks in livestock or aquaculture. It can also impact the environment in agricultural settings, including soil quality, water availability, and biodiversity. These environmental changes can create conditions that favor the survival and spread of resistant bacteria, potentially leading to increased AMR. Climate-related disturbances, such as extreme weather events, can also

[26] https://www.sciencedirect.com/science/article/pii/S2542519617301419
[27] https://www.godigit.com/guides/natural-disasters/causes-of-flood#:~:text=Deforestation%3A%20Deforestation%20is%20one%20of,a%20river%20during%20heavy%20rainfall.
[28] https://www.cdc.gov/lyme/index.html
[29] https://academic.oup.com/cid

disrupt agricultural systems and increase the vulnerability to AMR. [30]This can result in the increased use of antibiotics for disease prevention or treatment, which in turn can contribute to the further emergence and spread of antibiotic resistance.

Negative socio-economic conditions

Insufficient education and low health literacy levels within disadvantaged communities can lead to a lack of awareness about the appropriate use of antibiotics. This lack of awareness contributes significantly to the development of Antimicrobial Resistance (AMR) as people may misuse or overuse antibiotics.[31]In such settings, overcrowded living conditions and inadequate sanitation infrastructure are common, creating an environment ripe for the transmission of infectious diseases. This, in turn, escalates the demand for antibiotics to treat these infections, further intensifying the selective pressure on bacteria to develop resistance.[32] Additionally, poverty and economic disparities are closely intertwined with limited access to healthcare facilities and weak healthcare systems in many countries. These factors exacerbate the burden of infectious diseases and the reliance on antibiotics for treatment. Educational disparities within these settings can also hinder efforts to raise awareness about AMR and climate change-related health risks.[33] For example, in the Democratic Republic of Congo, particularly in areas affected by conflict and poverty, climate change related challenges in food and healthcare as well as lack of awareness exacerbates health disparities and poses significant risks in the context of both AMR and Climate change.

Effects

"Antimicrobial resistance is putting the gains of the Millennium Development Goals at risk and endangers the achievement of the Sustainable Development Goals," states a report published by the Pan American Health Organization and the World Health Organization.

Health

The most serious threat of AMR is its impact on global health. The World Health Organization identifies AMR as one of the top 10 major public health crises as the discovery of effective antimicrobial drugs does not keep pace with the increasing antimicrobial resistance rates in bacteria.[34]AMR increases the

[30] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8590523/
[31] https://academic.oup.com/ci
[32] https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(18)30160-6/fulltext
[33] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0223638
[34] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8590523/

risk of treatment failures, leading to prolonged illness, disability and death.It can also affect the efficacy of medical procedures such as organ transplant,chemotherapy, and surgeries.Antimicrobial resistance in mycobacterium tuberculosis, malaria parasites, viruses, and HIV is becoming a reality that could increase human suffering[35]Hospital-acquired infections affect most fragile patients in intensive care units; oncology and neonatology, which often result in high mortality.[36] AMR infections also affect the treatment colony-acquired infections. For example, Escherichia coli urinary tract infections, and respiratory infections by Streptococcus pneumoniae or Haemophilus influenzae may not respond to antibiotics commonly used and require the use of more complex and expensive treatments. Everyone is at risk of antibiotic-resistant infections, but those at the greatest risk for antibiotic-resistant infections are young children, cancer patients, and people over the age of 60. According to recent estimates, in 2019,1.27 million deaths were directly attributed to drug-resistant infections globally.[37] By 2050, up to 10 million deaths could occur annually. In the U.S. alone, it causes more than 2 million infections and 23,000 deaths per year.[38]

Economy

AMR causes economic problems mainly by the need for more healthcare and loss of productivity.[39]The first cause of this is that AMR infections increase the use of expensive second-line drugs due to the need for more specialized medicines. They also require longer hospital stays and more intensive care.[40] Not only does this increase the cost of treatment, it also reduces economic growth by affecting individuals and businesses. According to a World Bank and UNEP assessment from 2020, AMR might cause an additional 28.3 million people to live in extreme poverty in low- and middle-income countries by the year 2030.

If unchecked, AMR could shave US$ 3.4 trillion off GDP annually(a 3.5% reduction in global GDP). [41] The World Bank estimates that if AMR continues to be unchecked, it could cause a

[35] https://www.unep.org/explore-topics/chemicals-waste/what-we-do/emerging-issues/antimicrobial-resistance-global-threat
[36] https://www.paho.org/en/topics/antimicrobial-resistance
[37]https://www.ox.ac.uk/news/2022-01-20-estimated-12-million-people-died-2019-antibiotic-resistant-bacterial-infections#:~:text=Deaths%20caused%20by%20and%20associated,4.95%20million%20deaths%2C%20in%202019.
[38] https://www.cdc.gov/drugresistance/solutions-initiative/stories/ar-global-threat.html#:~:text=In%20the%20U.S.%20alone%2C%20it,all%20regions%20of%20the%20world.
[39] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6929930/#:~:text=The%20CDC%20estimated%20that%20the,billion%20for%20loss%20of%20productivity.
[40] https://www.paho.org/en/topics/antimicrobial-resistance
[41] https://www.unep.org/explore-topics/chemicals-waste/what-we-do/emerging-issues/antimicrobial-resistance-global-threat

financial setback as large as the global financial crisis of 2008. [42]AMR causes the most severe setbacks to low and middle-income countries. This would increase the gap between high and low- income countries by increasing the economic shortfall that developing countries face.

International equality

AMR affects all countries, but the burden is disproportionately higher in low-income and middle-income countries.[43]AMR is thus an equity issue too. The use of antimicrobial drugs varies between regions and countries which is being influenced by the food-animal species, regional production pattern, types of species, lack of polices on the use of antimicrobial drugs, and socio-economic state of population and farmers.

Low- and middle-income countries may have limited access to effective antimicrobial treatments due to a variety of factors, including high costs, weak health systems, and lack of investment in research and development. For example, according to the World Health Organization (WHO), 90% of all malaria deaths occur in sub-Saharan Africa, where resistance to the antimalarial drug artemisinin has been reported. In low-income countries, only 34% of patients with sepsis receive appropriate antimicrobial treatment, compared to 75% in high-income countries.[44] The lack of infrastructure due to poor economy, corruption and low preparedness in many low-income and middle-income countries has led to inadequate attention to preventive measures, such as water, sanitation and hygiene, leading to high burden of infectious diseases.[45]

The adverse effect of AMR is mostly felt in the developing world like parts of Asia and Africa because of the poor surveillance system that exists for antimicrobial drugs in these countries.[46] budgetary constraints limit the prioritization for surveillance of AMR.

Disparities related to antibiotic resistance are also made worse by structural inequities and socioeconomic factors such as household income, type of housing (crowding, persons

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[42] https://www.worldbank.org/en/topic/health/publication/drug-resistant-infections-a-threat-to-our-economic-f uture
[43] https://gh.bmj.com/content/4/6/e002104#ref-1
[44] https://documents.worldbank.org/en/publication/documents-reports/documentdetail/323311493396993758/final-report
[45] https://documents.worldbank.org/en/publication/documents-reports/documentdetail/323311493396993758/final-report
[46] https://documents.worldbank.org/en/publication/documents-reports/documentdetail/323311493396993758/final-report

experiencing homelessness), immigration, type of health insurance, access to health care, and education level. Poor educational status and low awareness leave populations with popular myths, cultural practices and belief systems towards the use of medicines, especially antibiotics.For instance, in Kenya, patient expectations were often felt as pressure by healthcare practitioners to prescribe antibiotics.

Geography and the built environment (buildings, neighborhoods, parks, roads) also play a role in health disparities related to antibiotic resistance, leading to higher rates of infection among people experiencing homelessness or people facing housing insecurity, travelers to countries with unsafe water and inadequate sanitation, and people living in certain metropolitan cities.[47]If you look at the informal settlements in South Africa, the slums in India, or the Favelas in Brazil – the constellation is always very similar: high population density in a warm climate. This is a combination that promotes antibiotic resistance.[48]

AMR can have a significant impact on trade, as countries may place restrictions on the import of goods from countries with high levels of AMR. This can affect a range of industries, including food and agriculture, pharmaceuticals, and medical devices. [49]

Food security

AMR could have a significant impact on the food security of low and middle-income countries. [50]Antimicrobial drugs are most commonly used in agriculture to prevent and cure diseases and as a growth promoter for crops and livestock.According to the FAO some farmer's in developing countries very often farmers lack the use of biosecurity measures and make use of drugs like chloramphenicol and tylosin in livestock and crops. They cause health issues like kidney disease anemia in humans due to the consumption of food-animal products harboring the residues of these antimicrobial drugs. This further contributes to food insecurity and food safety as it causes production loss and renders the food unsafe and unhealthy for consumption.[51]The report also notes that there is limited information available on the impact of AMR on plant health, but that the potential consequences are significant.

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[47] https://www.cdc.gov/drugresistance/solutions-initiative/stories/ar-health-equity.html#:~:text=Disparities%20related%20to%20antibiotic%20resistance,health%20care%2C%20and%20education%20level.

[48] https://healthcare-in-europe.com/en/news/amr-climate-change-a-worrying-dual-threat-to-global-health.htm |

[49] https://link.springer.com/chapter/10.1007/978-3-030-27874-8_16

[50] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3756954/

[51] https://sciencemeetsfood.org/amr/

Another way that AMR contributes to food insecurity and food safety is through contamination to the soil and water. When animals become sick, they may be culled to prevent the spread of disease, resulting in the disposal of large quantities of food. Additionally, when food becomes contaminated with drug-resistant bacteria, it may need to be discarded to prevent the spread of infection. These residues negatively contribute to the food system by making food unsafe for consumption due to drug toxicity, allergic reactions, carcinogenicity, and drug sensitization, thereby leading to food insecurity as it brings about food wastage and consumption of unsafe food. [52]

Moreover AMR can cause losses through decreased animal productivity due to increased mortality and morbidity among infected animals.According to a 2017 report by the review on AMR, drug resistant infections could cause global livestock production to decline by Up to 4% by 2050.[35]Thus, in turn leads to food shortages since it becomes difficult and expensive for farmers to prevent and treat diseases in crops and livestock.

The global production of maize, soybeans, wheat, and rice could decline by up to 11% by 2030. Therefore, countries with high rates of infectious disease and limited access to effective antibiotics are at a high vulnerability to suffer from food shortages due to AMR.[53]

Need for global action

The Global Action Plan on Antimicrobial Resistance, endorsed by the World Health Organization (WHO), provides a blueprint for coordinated efforts at national, regional, and global levels, recognizing that national measures alone cannot adequately address the complex challenges at the intersection of AMR and climate change. . As climate-related events like extreme weather, rising temperatures, and altered ecosystems impact disease dynamics, resistant pathogens may spread more widely. AMR is a global challenge that transcends borders. Combating AMR due to climate change necessitates collaboration across multiple sectors, including health, agriculture, environment, and international trade.

Moreover, it aligns with the Sustainable Development Goals (SDGs), particularly Goal 3 (Good Health and Well-being) and Goal 13 (Climate Action). By mitigating AMR's impact on healthcare systems, global action contributes to achieving universal health coverage and ensures resilience

[52] https://www.cdc.gov/foodsafety/challenges/antibiotic-resistance.html
[53] https://www.cureus.com/articles/7900-a-review-o#!/

against climate-induced health challenges.

Major Countries and Organizations Involved

World Health Organization (WHO)

The World Health Organization is working with countries worldwide to develop strategies and programmes to combat AMR. It developed a global action plan on antimicrobial resistance (AMR) in 2015, which provides guidance to countries on the implementation of strategies to combat AMR. It also provides technical support to countries and regions in developing and implementing national action plans for addressing AMR. This includes providing guidance on surveillance systems, infection prevention and control measures, and appropriate use of antimicrobial agents.It promotes research and development and monitors the global situation of AMR and regularly reports on the prevalence of resistant pathogens, the effectiveness of existing antimicrobial agents, and progress in implementing the Global Action Plan. This information helps to guide policy development and resource allocation.The WHO established the Global Antimicrobial Resistance Surveillance System (GLASS), which collects data on antibiotic resistance to inform global policy and action.[54]

Food and Agriculture Organization (FAO)

Because of the presence of antimicrobial resistant microorganisms in our farming systems, they may also be in the food we eat. Antimicrobial-resistant microorganisms can develop in our food chain and move between animals, humans, and the environment. This makes AMR a problem that crosses sectoral boundaries. FAO, itself a multidisciplinary organization, brings into play its expertise in aquatic and terrestrial livestock health and production, crop production, natural resource management and food safety. An important area for FAO's work is to identify and address the critical information gaps on the subject. Moreover, FAO is working closely with key partners such as the World Organisation for Animal Health (OIE), the World Health Organization (WHO) and others in a global response to the threat of AMR.

In May 2018 the Director Generals of FAO WHO and OIE agreed to strengthen their long-standing partnership, with a strong focus on tackling AMR. These three organizations share the responsibilities for coordinating global activities and tackling AMR through a "One Health" approach, which takes into account animals, humans and ecosystems at the same time.[55]

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[54] https://www.who.int/initiatives/glass#:~:text=Global%20Antimicrobial%20Resistance%20and%20Use%20Surveillance%20System%20(GLASS)

[55]https://www.fao.org/antimicrobial-resistance/background/what-is-it/en/#:~:text=An%20important%20area%20for%20FAO's,to%20the%20threat%20of%20AMR.

India

India is referred to as the AMR capital of the world. Due to the high prevalence of communicable diseases, the overburdened public health system, the lack of standardized effective surveillance platforms that track healthcare-associated infections (HAI), the inconsistent infection prevention control (IPC) practices, the low cost and wide availability of antibiotics without prescriptions, and the limited laboratory capacity for etiology-based diagnosis and appropriately targeted treatment, AMR is a particular challenge in India.[56]

China

According to statistics, China is the world's top producer and user of antimicrobial medications for both humans and animals.[57] The highest prevailing AMR in the world is said to be present in China, especially since it contributes heavily to climate change.

Germany

Germany has played a crucial role in trying to stop the spread of AMR. Germany established a national action plan in 2015 called DART 2020 that also conforms with requirements set forth in this regard by the World Health Organisation (WHO). DART 2020's main objective is to stop the occurrence and spread of antimicrobial resistance in Germany.[58]Additionally, Germany is providing technical and financial support to the Indian government's National Action Plan on AMR, and supporting research and development of new antimicrobial agents in India.Germany is also another major contributor to climate change and is taking steps to reduce global warming.

Brazil

Brazil is one of the largest consumers of antibiotics in the world, with rates of consumption that are higher than many European countries. [59]This is partly due to the high burden of infectious diseases in Brazil, but also reflects overuse and misuse of antibiotics in human and animal health. It is making efforts to improve surveillance, including the development of a national AMR surveillance

[56] https://www.cdc.gov/globalhealth/countries/india/anniversary-report/antimicrobial-resistance.html#:~:text=AMR%20is%20a%20particular%20challenge,antibiotics%20without%20prescriptions%2C%20inconsisten t%20infection
[57] https://www.med.uio.no/helsam/english/research/news-and-events/news/2022/india-is-one-of-the-world%E2%80%99s-leading-producers-of-antibiotics.html#:~:text=%E2%80%93%20China%20is%20the%20world's%20leading,ingredients%2C%20used%20to%20make%20antibiotics.
[58] http://resistancecontrol.info/2017/responses-to-antimicrobial-resistance-in-all-policies-the-german-amr-str ategy/
[59] https://www.who.int/publications/i/item/9789241515528

network and the implementation of a national plan for controlling AMR.[60]According to a study published in the Journal of Antimicrobial Chemotherapy, up to 90% of poultry farms in Brazil use antibiotics, often in subtherapeutic doses, which can contribute to the development of resistance.[61]

Thailand

Thailand has been introducing regulatory reforms through national strategic plans of actions.[62] It created a national governance mechanism as a political platform to strengthen multisectoral collaboration under the One Health approach. This mechanism aimed to bring technical issues on antimicrobial resistance into the political arena by establishing a national policy committee on antimicrobial resistance.[63]It has successfully implemented the WHO global antimicrobial resistance surveillance system in 10 hospitals as sentinel sites representing each health region.It has also implemented regulatory reforms to restrict the use of antibiotics as growth promoters in agriculture and to promote the responsible use of antibiotics in human medicine.

United States of America

Emissions by the United States of America is one of the leading causes of climate change. In 2019, the U.S. emitted approximately 5.4 gigatons of carbon dioxide (CO2), accounting for about 15% of global emissions. However, it has also been involved in international climate agreements aimed at reducing emissions, including the Paris Agreement. The United States is also one of the countries which has suffered the most severe impact of AMR. In the United States of America in 2019, there were 41,900 deaths attributable to AMR and 172,900 deaths associated with AMR. The United States of America has the 32nd lowest age-standardized mortality rate per 100,000 population associated with AMR across 204 countries.[64] The U.S. has taken various actions to combat AMR, including implementing the National Action Plan for Combating Antibiotic-Resistant Bacteria (CARB) and supporting research and surveillance efforts.

It has also been involved in international collaborations to promote responsible antibiotic use and surveillance of drug-resistant pathogens.[65]

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[60] https://www.who.int/news/item/18-11-2019-brazil-launches-national-plan-to-tackle-antimicrobial-resistan ce
[61] https://www.worldanimalprotection.org/sites/default/files/int_files/superbugs-supply-chain-brazil.pdf
[62] https://amrthailand.net/English
[63] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8381094/
[64] https://www.healthdata.org/sites/default/files/files/Projects/GRAM/United_States_0.pdf
[65]https://www.csis.org/analysis/us-government-and-antimicrobial-resistance#:~:text=THE%20U.S.%20GOVERNMENT%20AND%20AMR,Medicare%20reimburses%20for%20new%20antibiotics.

African Republic

Africa has the world's highest mortality rate from AMR infections, resulting in over 27 deaths per 100,000.[66](99 per 100,000 in Sub-Saharan Africa). According to the WHO, AMR could kill 4.1 million people across the continent of Africa by 2050. The African Republic could lose upto 5% of its GDP as a result of AMR. [67]

Timeline of Events

Date	Description of event
1950	Shortly after the introduction of the first antibiotic penicillin, E.coli was reported to be able to inactivate it. [68]
Japan[69] 1984	Unexpected identification of genetically transferable resistance in First Tuberculosis superbug is seen. [70]
2000	CRE superbug emerges as a significant threat, with a70% mortality rate.[71]
2010	WHO declares AMR a global health threat [72]
2011	63,000 cases of deaths by TB superbug worldwide [73]
2015	The World Health Organization (WHO) releases a report on the link between higher temperatures and the spread of antimicrobial resistance.[74]
2020	Covid-19 pandemic exacerbates AMR by increased use of antibiotics

[66] https://africacdc.org/news-item/findings-in-amr-surveillance-data-across-africa-to-shape-health-policy-reform/#:~:text=AMR%20stands%20as%20one%20of,over%2027%20deaths%20per%20100%2C000.
[67] https://www.afro.who.int/ResistAMR#:~:text=Other%20causes%20of%20AMR%20include,ONLY%20for%20treating%20viral%20infections.
[68] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5369031/#:~:text=The%20first%20sign%20of%20antibiotic,by%20producing%20penicillinase%20%5B20%5D.
[69] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5369031/#:~:text=The%20first%20sign%20of%20antibiotic,by%20producing%20penicillinase%20%5B20%5D.
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[71] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4217156/
[72] https://www.cdc.gov/drugresistance/about.html
[73] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4388962/
[74] https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance

Relevant UN Treaties and Events

- Global Action Plan on AMR by WHO, May 2015 (WHA67)[75]
- Paris Agreement by United Nation Framework Convention on Climate Change (UNFCCC), 12th december 2015 (1/CP.21)[76]. It recognizes the impacts of climate Change on Health
- The World Health Organization launched GLASS (Global Antimicrobial Resistance Use Surveillance System in, 22nd October, 2015[77] (WHA 68.7)- It collects data on antibiotic resistance to inform global policy and action.
- United Nations General Assembly Political Declaration on Antimicrobial Resistance, 21st September 2016(A/RES/71/3)[78]
- Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change and Health, 2019- It highlighted the potential for climate change to exacerbate the problem of AMR.
- The United Nations Environment Programme (UNEP) Global Environment Outlook 6, 2019 (GEO-6)[79]- highlighted the impact of climate change on the environment and human health, including the link between climate change and AMR.

Possible Solutions

- Reduce the use of antimicrobial drugs: One of the main drivers of AMR is the overuse and misuse of antimicrobial drugs, including antibiotics. Healthcare professionals, policymakers,farmers and individuals can take steps to reduce the unnecessary use of these drugs, such as only prescribing them when necessary, completing the full course of treatment, and avoiding the use of antibiotics in animal feed.
- Improve infection prevention and control measures: Climate change can lead to the

[75] https://www.emro.who.int/health-topics/drug-resistance/global-action-plan.html#:~:text=The%20%22Global%20Action%20Plan%22%20to,25.
[76] https://unfccc.int/process-and-meetings/the-paris-agreement
[77] ttps://www.who.int/initiatives/glass#:~:text=Global%20Antimicrobial%20Resistance%20and%20Use%20Surveillance%20System%20(GLASS)
[78] https://digitallibrary.un.org/record/842813?ln=en
[79] https://www.unep.org/resources/global-environment-outlook-6

spread of infectious diseases through changes in temperature, humidity, and rainfall patterns. By improving infection prevention and control measures, such as hand hygiene, vaccination, and the use of personal protective equipment, we can reduce the need for antimicrobial drugs and prevent the spread of infections.

- Enhance surveillance and monitoring: We need to monitor the spread of AMR and infectious diseases and develop systems for tracking and reporting outbreaks. This can help us identify emerging threats, monitor the effectiveness of interventions, and inform policy decisions.
- Develop new antimicrobial drugs: With the rise of AMR, we need to develop new antimicrobial drugs that are effective against resistant microorganisms. This requires investment in research and development and the development of innovative approaches to drug discovery.
- Address the root causes of climate change: Finally, we need to address the root causes of climate change to prevent its impact on the spread of infectious diseases and the growth of AMR. This includes reducing greenhouse gas emissions, promoting sustainable practices, and improving resilience to the impacts of climate change.

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