FORUM: World Health Organization (WHO)

QUESTION OF: Measures to Mitigate Antimicrobial Resistance

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INTRODUCTION

In a day and age where medicine rapidly develops at a rate in which more infections and diseases can be cured and even more lives can be saved, many drugs have paradoxically become ineffective due to improper use. This has resulted in an ongoing issue that revolves around drug-resistant infections and diseases globally known as Antimicrobial Resistance (AMR). More specifically, Antimicrobial Resistance emerges when pathogens such as bacteria, fungi, viruses, and parasites are unresponsive to Antimicrobial Drugs. It is a natural process in which genetic alterations occur in microorganisms from misuse and overuse of Antimicrobial Drugs administered in humans, animals, and plants. As a result, epidemics, accelerated mortality, reduced agricultural productivity and even an economic burden can occur. For instance, the COVID-19 pandemic has had a significant impact on AMR as it retrograded the progress society has

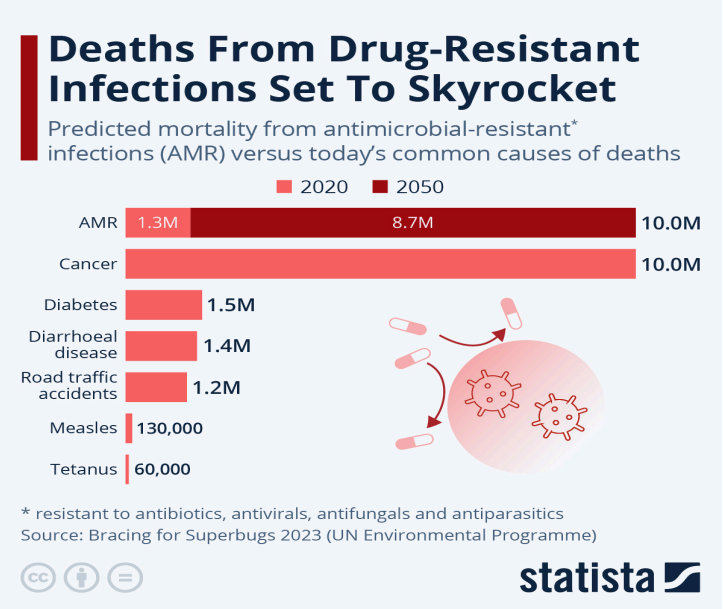

Figure 1 : Predicted mortality from antimicrobial resistance infections in 2050 versus today's common causes of death [1]

[1] "Redirect Notice." *Google.gr*, 2024, www.google.gr/url?sa=i&url=https%3A%2F%2Fwww.statista.com%2Fchart%2F3095%2Fdrug-resistant-infections%2F&psig=AOvVaw2PwAZD_e3SsVhKVQcdx7qN&ust=1724254314849000&source=images&cd=vfe&opi=89978449&ved=0CBUQjhxqFwoTCNCykIryg4gDFQAAAAAdAAAAABA4 . Accessed 20 Aug. 2024.

made combatting this issue. The surveillance and reporting on AMR were interrupted causing a dearth of data during that period making it harder for countries to monitor their progress and comprehend their present state. Antibiotics were also used extensively for secondary bacterial infection treatments in COVID-19 patients such as pneumonia. Naturally, the COVID-19 virus does not respond to any antibiotics, however, due to the public's worry and apprehension about this virus and its complications, antibiotic use has accelerated significantly. Additionally, the resources that were specifically allocated towards monitoring and fighting AMR before the COVID-19 virus, were in 2021 diverted to control the pandemic causing a faulty, ineffectual control of AMR. Since 1928 when the first antimicrobial drug was invented, AMR has become a constant threat to the environment, the economy, food security, animal health, human health, since more than 4.9 million people have died[2] because of it. Therefore, it is of utmost importance for this issue to be combatted. Currently, the United Nations is actively addressing this issue through international collaboration among Member States and Major Organizations involved, such as the UN Environment Programme (UNEP) and the Global Antimicrobial Resistance and Use Surveillance System (GLASS). Also, the UN has endorsed a global action plan and a 2023-2030 Roadmap which are both aimed to tackle and address the issue of AMR. The World Health Organization (WHO) alongside its Member States, has established the Pandemic Treaty Alias the Pandemic Accord which primarily aims to ameliorate international preparedness and response to following pandemics.

Ultimately, this issue intersects with the theme of our conference, namely "Ethos Vs Progress; Reassessing our Values in a Fragile World", as it emphasizes on ethical considerations such as responsible antibiotic stewardship and global equity, ensuring that everyone has equal access to healthcare.

DEFINITION OF KEY TERMS

Antibiotic

Antibiotics are medicines that fight bacterial infections in people and animals. They completely destroy bacteria or hinder their growth process.[3]

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[2] World Health Organization. "Antimicrobial Resistance." *World Health Organization*, WHO, 21 Nov. 2023, www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance. Accessed 31/7/24.
[3] MedlinePlus. "Antibiotics." *MedlinePlus*, National Library of Medicine, 14 Jan. 2022, medlineplus.gov/antibiotics.html. Accessed 26/7/24

Antibiotic Stewardship

Is a systematic approach to educate and support health care professionals to follow evidence-based guidelines for prescribing and administering only the appropriate and obligatory antibiotics. [4]

Antimicrobial

Something that can kill, inhibit, and prevent the growth of microbes, including bacteria and mold.[5]

Antimicrobial Resistance (AMR)

The ability of microorganisms to persist or grow in the presence of drugs designed to inhibit or kill them which are called antimicrobial drugs.[6]

Fungus

Parasitic spore-producing eukaryotic typically filamentous organisms formerly classified as plants that lack chlorophyll and include molds, rusts, mildews, smuts, mushrooms, and yeasts. [7]

Bacteria

Microscopic, single-celled organisms that exist in their millions, in every environment, both inside and outside other organisms. Some of them can be harmful for our system and cause diseases. [8]

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[4] World Health Organization. "Promoting Antimicrobial Stewardship to Tackle Antimicrobial Resistance." *Www.who.int*, 2021, www.who.int/europe/activities/promoting-antimicrobial-stewardship-to-tackle-antimicrobial-resistance. Accessed 26/7/24

[5] Simeonova, Maria. "What Is an Antimicrobial." *BioCote*, 2021, www.biocote.com/what-is-antimicrobial-technology-explained/what-is-an-antimicrobial/. Accessed 26/7/24

[6] "What Is It? | Antimicrobial Resistance | Food and Agriculture Organization of the United Nations." *Www.fao.org*, www.fao.org/antimicrobial-resistance/background/what-is-it/en/. Accessed 26/7/24

[7] "Definition of FUNGUS." *Merriam-Webster.com*, 2019, www.merriam-webster.com/dictionary/fungus. Accessed 26/7/24

[8] Brazier, Yvette. "What Are Bacteria and What Do They Do?" *Www.medicalnewstoday.com*, MedicalNewsToday, 12 Feb. 2019, www.medicalnewstoday.com/articles/157973. Accessed 26/7/24

Pathogens

A pathogen is any organism that causes a disease. Viruses, bacteria, fungi, and parasites are all instances of pathogens.[9]

Antifungal

A drug that treats infections caused by fungi.[10]

Superbugs

Antibiotic resistant strains of bacteria, viruses, parasites or fungi.[11]

”OneHealth” approach

It’s a long-term focused multisectoral, transdisciplinary method that seeks to promote the best possible health outcomes by acknowledging the interconnection between people, animals and plants in their shared environment. [12]

BACKGROUND INFORMATION

Significance of AMR

The history of Antimicrobial Resistance dates back to the invention of the first Antimicrobial Drug, namely, penicillin, by Alexander Fleming in 1928. When antibiotics were first discovered it was

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[9] “What Is a Pathogen? 4 Types and How They Spread Disease.” *Healthline*, Healthline, 2019, www.healthline.com/health/what-is-a-pathogen. Accessed 26/7/24

[10] “Https://Www.cancer.gov/Publications/Dictionaries/Cancer-Terms/Def/Antifungal.” *Www.cancer.gov*, 2 Feb. 2011, www.cancer.gov/publications/dictionaries/cancer-terms/def/antifungal .

[11] Tosh, Pritish K. “Protect Yourself from Superbugs.” *Mayo Clinic*, 2018, www.mayoclinic.org/diseases-conditions/infectious-diseases/expert-answers/superbugs/faq-20129283 . Accessed 8 Aug. 2024.

[12] “One Health Global.” *World Health Organization*, 2023, www.who.int/health-topics/one-health#tab=tab_1 . Accessed 19 Aug. 2024.

a great step for the medical field as countless lives were able to be saved. However, after a number of individuals refused to use antibiotics appropriately by increasing the dosages of antimicrobials, using leftover antibiotics or not completing certain treatment courses, both for them and for their animals and plants, AMR emerged as a serious issue. The development of antibiotic resistant strains of bacteria called "superbugs" started becoming more and more frequent, creating difficulties in treating diseases and infections. Therefore, because of genetic alterations that occur naturally, the misuse and overuse of antimicrobial drugs, a lack of alternative treatments, the tendency of microorganisms to share resistant genes with one another, along with other socioeconomic factors, AMR has become a hazard for the international community ever since its first appearance. Nowadays, it is listed among the top 10 menaces for the public health sector.[13] As already mentioned, more than 5 million deaths have been attributed to AMR in 2019 and it is predicted that the number of deaths will exceed that of 2019 by 5 million more resulting in a total of 10 million deaths per annum if left unsupervised by 2050, according to the UN Environment Programme (UNEP)[14]. Nowadays, Haiti, Bolivia, Guatemala, Guyana and Honduras are considered the top 5 countries with the highest mortality rates attributed to AMR whereas, Canada, U.S., Colombia, Cuba, Panama, Costa Rica, Chile, Venezuela, Uruguay and Jamaica have the lowest.

If we were to compare the number of infections resistant to antimicrobial drugs before and during the COVID 19 pandemic in the U.S., we would come up with an increase of 20% during the pandemic.[15] The example above illustrates that pandemics contribute significantly to AMR. The reason for this is that during covid-19, antibiotic use was elevated in order to treat secondary bacterial infections that already infected patients with the germ that caused the pandemic in the first place. Generally, in order to prevent a bacterial infection, some specific antibiotics are often prescribed, however sometimes these antibiotics kill both harmful and helpful bacteria causing the development of resistant strains of bacteria. Increased hospital stays and invasive procedures that require the doctors to enter someone's body either for treatment or diagnostic purposes increase the risk of securing resistant infections. The predominant factors affecting AMR are overuse and

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[13] Environment, U. N. "Antimicrobial Resistance: A Global Threat." *UNEP - UN Environment Programme*, 17 Sept. 2020, www.unep.org/topics/chemicals-and-pollution-action/pollution-and-health/antimicrobial-resistance-global-threat . Accessed 7 Aug. 2024.

[14] ---. "Antimicrobial Resistance: A Global Threat." *UNEP - UN Environment Programme*, 17 Sept. 2020, www.unep.org/topics/chemicals-and-pollution-action/pollution-and-health/antimicrobial-resistance-global-threat .Accessed 7 Aug. 2024.

[15] "COVID-19 & Antimicrobial Resistance." *Antimicrobial Resistance*, 2024, www.cdc.gov/antimicrobial-resistance/data-research/threats/COVID-19.html . Accessed 7 Aug. 2024.

abuse of antimicrobial drugs, pollution from pharmaceutical companies and agriculture, mass movement of populations as it permits microorganisms to travel around the world, climate change and biodiversity loss, paucity of innovative medicines under development, access to clean water and sanitation considering that in areas that are limited to adequate access to the above, the contamination of microorganisms and bacteria that the water carries and may be resistant to antimicrobials, is highly possible. Lastly, a lack of diagnostic tests prior to prescribing antimicrobial drugs contributes significantly to this issue. Also, the strong lust that describes humanity for money plays a catalytic factor as both the healthcare and animal industries concentrate on revenue. For instance, in agriculture and many farming industries, the use of antibiotics is exceptionally elevated as they can help animals gain weight rapidly and prevent diseases from spreading among them making them more eligible for meat processors, direct consumers and livestock auctions.

AMR can be diagnosed in a number of ways. The most common one is through the Antimicrobial Susceptibility Testing (AST). Specifically, the doctor collects a sample of fluid or tissue collected from the infection site and sends it to the lab to identify the microorganism responsible for the infection, as well as exposing it to a variety of antibiotics to determine which antibiotics are effective and which are not. Lastly, fast diagnostic tests are being developed that could identify resistant bacteria in a minimum amount of time. For instance, in June 2023, the PA-100 AST System by a Swedish diagnostic company called Sysmex Astrego, was launched that could point out the existence of a bacterial infection in 15 minutes and also offer antibiotic susceptibility results in 45 minutes in contrast to the present one that takes up to 2-3 days. The procedure is similar to the AST one with a few differences such as the technology used to analyze the samples in the PA-100 AST System is extremely more advanced than the one in the standard AST procedure.

Germs that are affected by antimicrobial resistance

E.Coli

Escherichia coli (E.coli) is a type of bacteria that in most cases is harmless to both humans and animals and inhibits in healthy intestines. However, in some cases it can cause bloody diarrhea, severe stomach cramps and vomiting. Someone could get infected only when exposed to contaminated water or food. AMR associated with the E.coli pathogen cases are reported to be more common in developing countries rather than more industrial ones. A standard treatment for E.coli is an antibiotic called cephalosporin, however it is found that in some countries E.coli infections are resistant to 3rd generation cephalosporins because of constant improper use of this antibiotic, as

presented in the following map (Figure 2). 3rd generation cephalosporins are a class of antibiotics that are effective against a host of bacterial infections specifically, bacteria that have a certain cell wall structure. E.coli is able to be resistant to this kind of antimicrobial drug primarily because of Extended-Spectrum Beta-Lactamases (ESBLs) which are enzymes created by strains of the E.coli bacterium that can completely decompose 3rd generation cephalosporins.

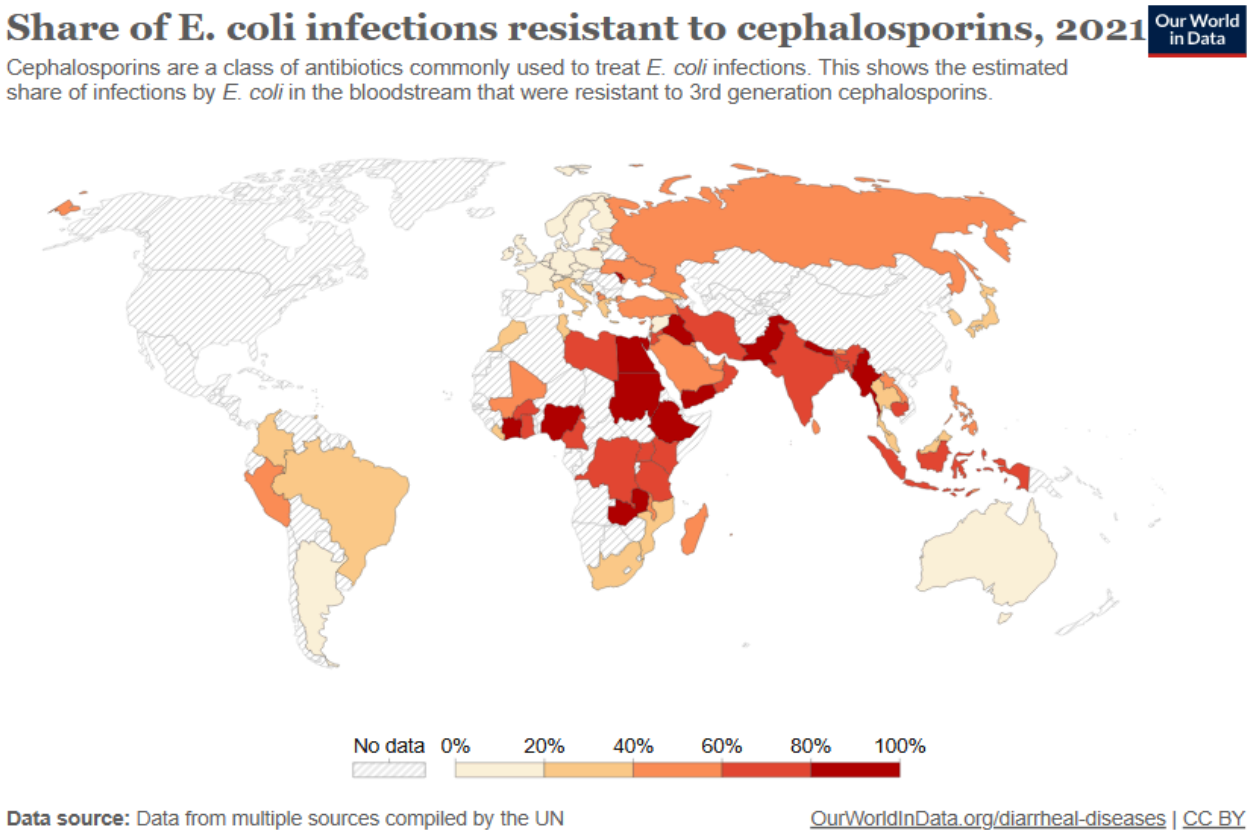

Figure 2 : Map of Share of E.coli infections resistant to cephalosporins in 2021[16]

Gonorrhea

Another form of multi-drug resistant bacterium is gonorrhea or Neisseria gonorrhoeae , which is a Sexually Transmitted Infection (STI) that could severely affect someone's genital organs, throat, rectum, eyes, joints and other regions of the body. It is usually treated with 3rd generation cephalosporin antibiotics because it is completely resistant to almost every other antibiotic used for its treatment such as penicillin, fluoroquinolones and tetracycline. However, this infection is currently

[16] "Share of E. Coli Infections That Are Resistant to 3rd Generation Cephalosporins." *Our World in Data*, ourworldindata.org/grapher/share-of-e-coli-bloodstream-infections-due-to-antimicrobial-resistant-bacteria . Accessed 8 Aug. 2024.

facing resistance to cephalosporins, the last class of antibiotics that remains effective. Gonorrhea develops AMR because of several factors, the primary one is genetic mutations which are alterations in the DNA sequence that forms a gene and are caused by the radiation of chemicals or through the process of DNA replication and many more. Another significant factor that contributes to the development of AMR in gonorrhea is through the transfer of resistance genes from other bacteria and organisms as well as the factors mentioned before that cause the spread of AMR in general. The first case that was reported that the treatment was ineffective was in Japan and since then the same instances have occurred in many countries across the globe.

Tuberculosis (TB)

Tuberculosis is a contagious disease attributed to a bacterium called Mycobacterium tuberculosis which mainly affects the lungs. Multidrug-resistant tuberculosis (MDR-TB) occurs when germs are resistant to the two most potent TB medicines, namely, isoniazid and rifampin. The duration of treatment for multidrug-resistant tuberculosis (MDR-TB) is extended and much more ineffectual than the treatment for non resistant TB patients. The following chart presents the number of people who live with MDR-TB (prevalence) each year as it is considered a chronic condition alongside tuberculosis itself, in contrast to the number of new cases annually (incidence). Generally, there are two types of MDR-TB; pre-extensively drug-resistant TB (pre-XDR-TB) and extensively drug-resistant TB (XDR-TB). The difference between them is that pre-XDR-TB is resistant to drugs called fluoroquinolones, isoniazid, rifampin and a few other injectable drugs whereas XDR-TB is resistant to much more anti-TB drugs than pre-XDR-TB making it very challenging, time-consuming and toxic to treat it. In practice, it is important for someone to be able to differentiate those two in order to determine a proper treatment.

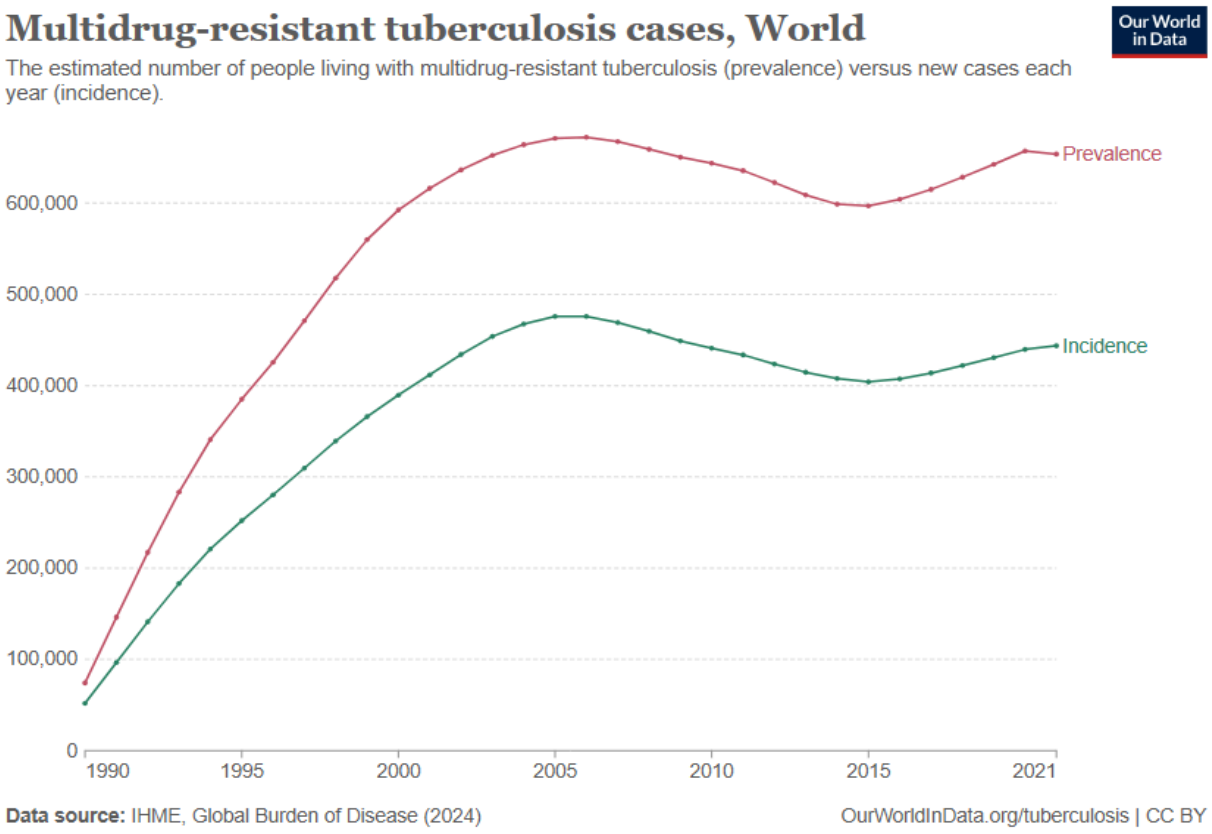

Figure 3 : Map of Multidrug-resistant tuberculosis cases worldwide in the period of 1990-2021[17]

Impact of antibiotics

Antibiotics seem to rapidly lose the fight against superbugs. The misuse and abuse of antibiotics, antifungal and antimicrobial drugs in humans, animals and agriculture drastically enhances the rates of AMR cases worldwide creating a "Silent Pandemic"[18] that could result in higher mortality rates. That being said, it is undeniable that the impact it has on public healthcare is enormous. As already mentioned, being resistant to certain antimicrobial drugs makes it harder for diseases and infections to be treated, hence, people stay longer at hospitals, having higher medical fees whereas the hospital resources are being used up. To add to this, AMR poses an international health threat questioning the effectiveness of modern medicine.

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[17] "Multidrug-Resistant Tuberculosis Cases." *Our World in Data*, ourworldindata.org/grapher/multidrug-resistant-tuberculosis-without-extensive-drug-resistance . Accessed 9 Aug. 2024.

[18] Rayan, Rehab A. "Flare of the Silent Pandemic in the Era of the COVID-19 Pandemic: Obstacles and Opportunities." *World Journal of Clinical Cases*, vol. 11, no. 6, 26 Feb. 2023, pp. 1267–1274, www.ncbi.nlm.nih.gov/pmc/articles/PMC10013119/ , Accessed 7 Aug. 2024.

Impact on the environment

AMR and the environmental sector are strongly connected. Antimicrobial pollutants can reach the environment through a host of different channels, notably rainwater from farms, floods caused mostly by climate change, pharmaceutical and healthcare industry wastewater and erroneous medicine disposal. However, the ill-founded discharge of residues that came from antimicrobial drugs used in livestock and crops, into the environment, significantly accelerates the spread of AMR[19]. As a result, environmental degradation, the absorption of antimicrobial resistant pathogens in soil, water and air is a frequent phenomenon, making the spread of AMR to both humans and animals effortless. The natural microbial communities which are different groups of microorganisms including the ones that can be affected by AMR that coexist in a host of environments and help maintain ecosystem function and sanity, are prone to complete disruption and destruction alongside other ecosystem processes such as water purification (poor water quality) and decomposition, which can ultimately influence soil fertility, biogeochemical cycles and the health of marine ecosystems.

Impact on scientific innovation

AMR gives rise to a lot of challenges regarding scientific innovation such as research priorities. Scientists and researchers are instructed to conduct research in order to specifically enhance comprehension on antimicrobial resistant mechanisms, find more effective antimicrobials and develop alternative treatments. The research costs are high, making it difficult for many to actually work in this field without a sponsor, or funds. However, funding agencies allocate resources to whatever they reckon is of high importance, making researchers align their work with what the agencies believe, shifting their research priorities. Thus, this has become a financial obstacle causing the hindrance of innovation and ultimately, society's opportunity tackling AMR. A handful of countries have considered solving this issue by developing funding models. For instance, the UK has established a subscription style payment scheme for the development of more than 2 antibiotics annually with a maximum contract value of 10 million pounds per each drug. [20]

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[19] "Environment | Antimicrobial Resistance | Food and Agriculture Organization of the United Nations." www.fao.org/antimicrobial-resistance/key-sectors/environment/en/ . Accessed 9 Sept. 2024.

[20] "UK's Antibiotic Subscription Funding Model – a Route to Market Sustainability?" *Yahoo! Finance*, Yahoo!, finance.yahoo.com/news/uk-antibiotic-subscription-funding-model-101238229.html?guccounter=1&guce_referrer=aHR0cHM6Ly9lZGdlc2VydmljZXMuYmluZy5jb20v&guce_referrer_sig=AQAAAA5kHakm

As previously mentioned, without funds or sponsors scientists and researchers are in no position to conduct research. Even though it is quite common for governments to provide funds and invest in the scientific work of their researchers, especially in More Economically Developed Countries (MEDCs), AMR can become a huge economic burden to a country. In fact, a negative Gross Domestic Product (GDP) growth globally as well as a deterioration of current inflation rates are two highly likely financial issues that could occur. Specifically, Gross Domestic Product (GDP) is a "snapshot" of the economic status a country has over a particular period of time, typically a span of a year.

Impact on food production

Food production plays a vital role in spreading AMR. It can cause severe infections in both livestock and crops, significantly minimizing their productivity and yields alongside increasing farmers' costs. Naturally, AMR elevates the mortality rates of both livestock and crops. Most importantly, antimicrobial resistant strains of bacteria that are inside the food supply chain are a huge menace to human health since they can transmit serious infections to their consumers. Food prices are also affected when AMR enters food chains, as the financial damages attributed to medical support for the animals, loss of livestock and decreased production are passed on to consumers. Finally, international trade could be affected due to restrictions on food exports due to hygiene policies. Governments impose trade restrictions on food exports because of hygiene policies that are implemented to guarantee food safety and hence, prevent diseases from spreading including AMR.

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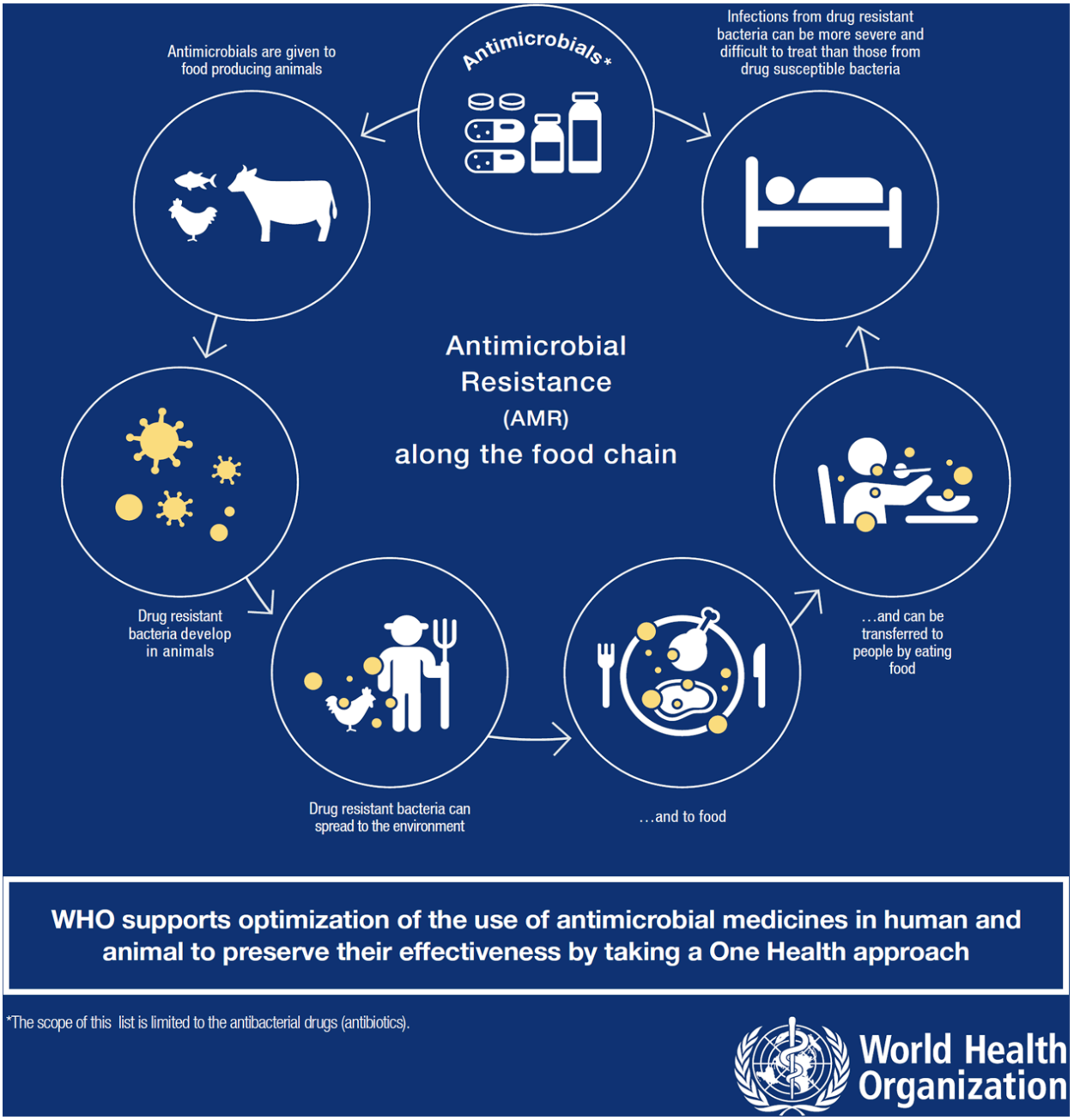

Figure 4 : Antimicrobial resistance along the food chain[21]

MAJOR COUNTRIES AND ORGANIZATIONS INVOLVED

India

India has the highest AMR rates in the world and has the largest consumption of antibiotics. The reasons why India has acquired the above and the situation is currently deteriorating, are firstly

[21] "Fig. 1 Antimicrobial Resistance in the Food Chain Infographic from WHO...." *ResearchGate*, www.researchgate.net/figure/Antimicrobial-Resistance-in-the-Food-Chain-infographic-from-WHO-This-figure-is-covered_fig1_333250805 . Accessed 8 Sept. 2024.

because of the living conditions and more specifically due to the limited access to clean water, hygiene, sanitation, healthcare infrastructure and availability of antibiotics which in return can not contribute to controlling infections. Secondly, India has one of the largest burdens of infectious diseases and hence more antibiotics are needed. Finally, due to the lack of medical resources and diagnostic facilities, many healthcare workers prescribe antibiotics for precaution, meaning that these antibiotics are used to prevent a currently non-existent health issue. As a result, misuse or overuse is highly possible alongside disrupting the harmony of beneficial bacteria that exist in the human body permitting the development of resistant bacteria. AMR has caused, in total, around 1,042,500 deaths.[22]What has India done to combat this issue is the development of a National Action Plan on AMR (NAP-AMR) in 2017 that provides strategies that in general focus on raising awareness and it encourages appropriate use of antimicrobials. Also, the Drug Controller of India (DCGI) that is responsible for the approval of licenses of drugs has banned 40 fixed-dose combination and antibiotic stewardship programs that were implemented in a handful of healthcare facilities to optimize the misuse and overuse of antibiotics.

Sweden

Sweden has one of the lowest AMR rates in Europe, thanks to the country's constant efforts to combat this issue. More specifically, Sweden has addressed this health crisis by enforcing legislations, promoting international collaboration among organizations, emphasizing on antibiotic stewardship and encouraging transparency and inclusivity on data regarding the consumption of antibiotics. Furthermore, in 2012 Sweden endorsed the Swedish Intersectoral Coordinating Mechanism (ICM), which is a collaboration led by the Public Health Agency of Sweden and Swedish Board of Agriculture, aiming to combat AMR mainly through sector cooperation. Sector cooperation is used as a strategy in Sweden's National Strategy to combat AMR in order for data to be collected regarding changes and developments of the current situation in Sweden. Also, it is used for the country to guarantee that this issue is not only being dealt with in the healthcare sector but in the agricultural, veterinary medicine and environmental sector as well. Lastly, it is used in the national collaborative function which is the collaboration between the Public Health Agency of Sweden and

[22] *Google.gr*, 2024, www.google.gr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi276bgpe2HAxU4xgIHHd0yGRQQFnoECBcQAw&url=https%3A%2F%2Fwww.healthdata.org%2Fsites%2Fdefault%2Ffiles%2Ffiles%2FProjects%2FGRAM%2FIndia_0.pdf&usg=AOvVaw1bBUoEks2rZMqf7O-Mzg4m&opi=89978449.
Accessed 11 Aug. 2024.

the Swedish Board of Agriculture and involves 21 government agencies and 5 organizations that was established in 2012 and all of them work together in order to combat AMR. It is regarded to be a very fruitful mechanism as in every strategy that it was incorporated it contributed a lot and it helped Sweden reach its goals regarding combating AMR.

United Kingdom (UK)

The UK has relatively high rates of antimicrobial resistance but is working hard to address them. The government has endorsed a National Action Plan which aims to tackle the issue of AMR by 2029 by minimizing unintentional exposure to antibiotics and antimicrobial drugs, managing their usage,raising awareness and investing in innovation and research. Additionally, not only does the UK adopt the "OneHealth" approach, but it also conducts extensive surveillance and research through the UK Health Security Agency (UKHSA) monitoring antibiotic consumption and resistance cases in order to create appropriate guidelines and enforce the necessary measures. Surveillance refers to regular monitoring and collection of data on public health issues such as contagious diseases, vaccine effectiveness and environmental dangers. It helps combat AMR since it tracks changes around the country, helps in grasping how exactly the resistance is spreading and whether or not the current approach is fruitful. Lastly, because the UKHSA collaborates with other organizations globally, it is mandatory to share their findings and the data they have collected in order to develop effective strategies to tackle AMR.

United States of America (USA)

The USA has significant rates of AMR with 2.8 million antimicrobial-resistance infections occurring annually.[23] This issue intensified during the COVID-19 pandemic leading to a 20% increase in hospital resistant pathogens.[24] What the US is currently doing to minimize and further prevent this issue is endorsing the National Action Plan for Combating Antibiotic-Resistant Bacteria (CARB) aiming to increase surveillance, create faster diagnostic methods and focus on researching new antimicrobials. Additionally, the Centers for Disease Control and Prevention (CDC) focuses upon

[23] ---. "Antimicrobial Resistance Facts and Stats." *Antimicrobial Resistance*, 22 Apr. 2024, www.cdc.gov/antimicrobial-resistance/data-research/facts-stats/index.html . Accessed 14 Aug. 2024.
[24] ---. "Antimicrobial Resistance Threats in the United States, 2021-2022." *Antimicrobial Resistance*, 16 July 2024, www.cdc.gov/antimicrobial-resistance/data-research/threats/update-2022.html . Accessed 14 Aug. 2024.

ameliorating infection control measures as well as the use of antifungals and antibiotics. CDC also incentivizes health departments in the US to participate in the CDC's Antimicrobial resistance Laboratory Network which aids local responses to tackle AMR.

Global Antimicrobial Resistance and Use Surveillance System (GLASS)

The GLASS was established on the 22nd of October 2015 by the WHO in order to enhance what we already know about AMR through continuous research and surveillance. It includes a host of different technical modules for its surveillance system that aids countries in tracking AMR related data. Furthermore, by collecting AMR related data, this organization can be informed about how big the impact is on a local, regional and global level.This way GLASS aims to be able to develop strategies and the appropriate guidelines for countries to sufficiently tackle AMR.

Interagency Coordination Group on Antimicrobial Resistance (IACG)

The IACG was initiated by the United Nations Secretary-General in March 2017, aiming to promote collaboration among different sectors and international organizations, developing strategies and schemes to tackle AMR while also raising awareness on an international basis. Also, high-level representatives from a host of sectors, organizations and UN bodies are included in this group , promoting the "OneHealth" approach, assisting countries with the creation and implementation of National Action Plans, publicly supporting research and innovation and keeping track of the process made to combat AMR globally.

UN Environment Programme (UNEP)

The UN Environment Programme (UNEP) is the world's leading environmental authority. Specifically, the environmental sector contributes significantly to the spread and advancement of AMR worldwide. Thus, the UNEP offers science-based data that could aid the tackling of this issue. Also, the UNEP collaborates with other intergovernmental and international organizations, forming the Quadripartite Alliance aiming to maintain antimicrobial effectiveness while also ensuring long-term fair access to antimicrobial drugs for responsible and sensible use in humans, animals and plants.

World Health Organization (WHO)

The WHO is actively addressing the issue of AMR both directly and indirectly. The WHO collaborates with organizations, establishes surveillance and monitoring programs and initiates activities such as public awareness campaigns, namely the World Antimicrobial. Awareness Week to educate the public. This UN body has endorsed the Global Action Plan on AMR in May 2015 and relentlessly supports the development of national action plans in both MEDCs and LEDCs. Lastly, WHO encourages and coordinates research on the development of new antimicrobials and diagnostic materials in order to keep up with the impact and changes of AMR.

TIMELINE OF EVENTS

Date	Description of Event
September 28 1928	Alexander Fleming invented penicillin.
November 1 1981	The Alliance for the Prudent Use of Antibiotics (APUA) was endorsed.
May 30 2012	Sweden endorsed the Swedish Intersectoral Coordinating Mechanism (ICM).
March 2015	The U.S. National Action Plan for Combating Antibiotic-Resistant Bacteria (CARB) was released.
May 2015	The Global Action Plan (GAP) was endorsed at the World Health Assembly in order to address AMR.
22 October 2015	The Global Antimicrobial Resistance and Use Surveillance System (GLASS) was established.
19 April 2017	The National Action Plan was launched.
March 2017	The Interagency Coordination Group on Antimicrobial Resistance (IACG) was initiated.
20-29 May 2019	The Seventy-Second World Health Assembly took place.

December 2019	The COVID-19 pandemic started.
April 2021	The UK Health Security Agency (UKHSA) began combating AMR.
December 2021	Began discussion for the Pandemic treaty.
17 March 2022	The Quadripartite Alliance was formed.
21 September 2023	The 2023-2030 Europe roadmap on antimicrobial resistance for the WHO European region began.
May 8 2024	The UK AMR National Action Plan for 2024 to 2029 was launched.

UN INVOLVEMENT: RELEVANT RESOLUTIONS, TREATIES AND EVENTS

2023-2030 Europe Roadmap on AMR

The 2023-2030 Europe Roadmap on AMR for the WHO European region is a calculated framework inspired by the Global Action Plan, that aims to combat AMR mainly through the "OneHealth" approach alongside promoting equity. Thus, it shares the same goals with the rest of the Action Plans. More specifically, this roadmap urges Member States to create their own national action plans based on their priorities and vulnerabilities in their efforts to tackle AMR and offers guidance on how to develop it. This roadmap stresses the importance of global cooperation and the fact that it concerns every individual worldwide.

Seventy-Second World Health Assembly- Resolution on AMR[25]

The Seventy-Second World Health Assembly, Agenda item 11.8, WHA72.5 resolution on antimicrobial resistance is based on previous efforts made in order to combat AMR as well as the goals of the Global Action Plan. It also stresses the significance of the "OneHealth" approach which is that it coordinates activities across human,animal and environmental health sectors alongside improving surveillance and promoting strategies to optimize and minimize the spread of AMR. This resolution encourages Member States to initiate the creation of clinical guidelines and criteria regarding the usage of antimicrobial drugs (clause 2, sub-clause 3) which is one of the most

[25] *SEVENTY-SECOND WORLD HEALTH ASSEMBLY WHA72.5 Agenda Item 11.8 Antimicrobial Resistance*. 2019.https://apps.who.int/gb/ebwha/pdf_files/WHA72/A72_R5-en.pdf

significant proposals written down on this resolution since by doing so, antibiotic stewardship can be guaranteed. This resolution also ensures adequate, equal access to safe, effective and cost efficient antimicrobial drugs alongside urging member states to invest in research for the development of alternative treatments and new antimicrobial drugs.

Pandemic Treaty

The pandemic treaty or Pandemic Accord is a global agreement currently being negotiated by the WHO and its 194 Member States. It was first brought to the table back in 2021 right after the outbreak of COVID-19 because the international system's response to the pandemic was ineffective. This treaty addresses AMR and ultimately prevents epidemics that have been caused by it through international collaboration. A few ideas that were brought forward at previous World Health Assemblies that took place in May and June of 2024, were first to promote the "OneHealth" approach and also strengthen the current healthcare workforce. Second, ensure equitable distribution of medical resources and access to microorganisms for research. However, the issue here is that the WHO together with its Member States should have already finalized their decision on passing this treaty or not but have failed to do so. The main reasons are financial differences, access to fair resources for pandemic response and intellectual property rights regarding vaccines, treatment methods and countries opposed to international agreements such as fair-right groups in the UK who reckon that this treaty could negatively affect the country's autonomy. It is expected that they should come to a decision by the next World Health Assembly that will take place in May 2025.

Global Action Plan (GAP)

The GAP was initiated in 2015 at the World Health Assembly in order to address AMR. More precisely, this plan aims to ensure awareness and the better understanding of AMR, widen our knowledge on this topic so that we can address it in the best of our abilities, minimize antimicrobial resistant infection cases, manage the usage of antimicrobial drugs, as well as accelerate investment on new medical resources. The Global Action Plan is predicated on a framework specifically developed to address AMR through international and intersectoral collaboration. Thus, countries are strongly urged to create their own National Action Plan in accordance with this one. Finally, by accommodating the "OneHelath" approach this plan also promotes global cooperation and unity when addressing AMR.

Quadripartite Alliance

The Quadripartite Alliance was established in March 2022, formed by the UN Environment Programme (UNEP), the Food and Agriculture Organization (FAO), the WHO and the World Organization for Animal Health (WOAH). This alliance's primary goal is through cooperation, to tackle worldwide issues revolving around health by using and promoting the "OneHealth" approach. This partnership concentrates on accelerating cooperation through multi-stakeholder venues and advocating for change by correlating the efforts of international leaders and experts. What this alliance does effectively to combat AMR is conduct research, implement a variety of frameworks to prevent and optimize health problems and offer instructions to countries and shareholders on how to ameliorate their schemes for tackling health issues.

PREVIOUS ATTEMPTS TO SOLVE THE ISSUE

Alliance for the Prudent Use of Antibiotics (APUA)

The APUA is a non-profit organization established on November 1st 1981 that has fairly succeeded its mission because of its continuous efforts to combat AMR. It aims to bolster defenses worldwide against infectious diseases by promoting antibiotic stewardship. APUA is one of the Major Organizations conducting research globally as well as educating the public regarding appropriate antimicrobial treatment and resistance. In addition to that, they provide on-site consultations held at locations such as hospitals,healthcare facilities, government offices and other institutions globally, about guidance for healthcare workers and other shareholders about AMR in general and how to optimize it. Lastly, this organization is under the aegis of the international Society of Antimicrobial Chemotherapy (ISAC) to enlarge the impact of ISACS's and APUA's efforts against AMR. Through this cooperation APUA has ameliorated its ability to conduct research, offer education and encourage appropriate antibiotic use.

US National Action Plan for Combating Antibiotic-Resistant Bacteria (CARB)

The US's efforts to address the topic of AMR are predominantly evident through its national action plan namely CARB. The CARB 2020-2025 outlines calculated goals and actions to increase the

US Government's response to AMR and is endorsed by a Federal Task Force. It is based on the previous US National Action Plan launched for combating-resistant bacteria in 2015 however, in this one there are more proven activities that can help address AMR effectively. Additionally, this plan has five major goals, hindering the development of resistant bacteria and taking proactive measures to prevent the spread of resistant infections, enhancing the "OneHealth" approach and surveillance, increasing the conduction of researches and the development of alternative treatments, antimicrobials and quick diagnostic methods, and lastly promote international collaboration. This approach of the USA to tackle this issue is fairly effective but it continues to face important challenges such as insufficient funding.

UK National Action Plan

The UK AMR National Action Plan for 2024 to 2029 is a calculated framework that bears an enormous commitment on following the guidelines and actions proposed in the plan. It aims to completely mitigate AMR within the UK with a vision of 20 years. This plan focuses on limiting the demand and unintentional antibiotics, optimizing their usage, investing in innovation and promoting global cooperation. Additionally, this plan is applied with the guidance of a host of agencies, domestic departments, and shareholders. This plan is based on the previous fruitful 2019-2024 UK action plan on AMR attained numerous accomplishments such as it improved the country's surveillance system and educating the public about AMR. However, what it failed to do was to impel the development of new antibiotics and alternative treatments. Pharmaceutical companies struggled a lot financially and faced scientific barriers in introducing new antimicrobials to the market. Overall, this approach has made significant progress in tackling AMR and promoting accountability and public participation.

POSSIBLE SOLUTIONS

Promoting Global Cooperation

Global cooperation is a holistic approach for tackling AMR and a quite critical one for a variety of reasons. There are a handful of countries and organizations that are currently collaborating on an international level but they need to improve their system. Global cooperation is essentially research collaboration, surveillance and data sharing, providing resources and emergency responses when a crisis occurs and that's how countries actually collaborate with each other and other

organizations. The actions they usually partake in are the development of National Action Plans, funding implementation of regulatory measures and policies. The global leaders group on AMR for instance, was established to ensure AMR is being combatted and remains a high priority until it is completely solved. Global cooperation could occur with the help of international organizations such as the United Nations, where countries collectively address an issue. That being said, international agreements, policies, regulations, collaborative projects could all help encourage collaboration among nations whereas, government leaders, experts and professionals from a host of fields could supervise the efforts made. The only issue with this approach however, is that without discipline and honesty from every party involved it could cause the exact opposite result.

Investing in Research

Prioritizing finding alternative treatments and investing in research is one fruitful way to combat AMR. Scientists could develop either new antimicrobials to fight against resistant strains of bacteria and other pathogens while also ensuring that they are effective. Plus, developing alternative treatments could significantly minimize the use of antimicrobials and hence cases of AMR. There are already several countries such as the USA and Germany that allocate funds for research and invest in the development of alternative treatments, but they should also ameliorate and maximize their efforts. These funds could be coming from NGOs, academic institutions, international organizations or from the government itself. More specifically, alternative treatments could be provided from hospitals or from medical personnel who would normally prescribe antibiotics. Also, they could involve numerous stakeholders such as pharmaceutical corporations, government agencies (ex. FDA,CDC) and both NGOs and international organizations.

Enforcing Policies and Regulations

Focusing on the legal aspect of the topic, by enforcing strict policies and regulations on the appropriate use of antibiotics in agriculture, any potential abuse and misuse that could occur when farmers use antimicrobials as a prevention method could be avoided. These regulations and policies will target landowners and farmers who use their land to grow food or to graze their livestock. Specifically, these policies and regulations will state that the use of antimicrobial drugs on agriculture should be restricted and used only when necessary. Otherwise, the creation of the appropriate penalties to those who fail to adopt them would be a fitting solution. Plus, the implementation of

regulations regarding antimicrobial drug distribution and sale for agricultural purposes is a fitting approach, in order for antimicrobial usage to be appropriate and in the right dosage. As a result, the efficacy of antimicrobials will be maintained while the growth of resistant bacteria will be reduced.

Promoting Antibiotic Stewardship

In many countries and especially LEDCs, healthcare workers prescribe antibiotics either as a precaution or due to time constraints. Many healthcare facilities lack healthcare workers causing the facilities to be full of untreated patients of which some of them have more severe injuries, hence need to be prioritized. That being said, a handful of healthcare workers prescribe antibiotics as a precaution. Thus, the improper use of antibiotics is highly possible causing more cases of AMR. Antibiotic stewardship in other words is the prudent use of antimicrobials and is one of the best optimal strategies governments have to combat AMR. More specifically, by implementing guidelines for people who work in healthcare and can prescribe antimicrobial drugs. These guidelines will be strict, regarding the prescription of only necessary drugs and in the appropriate amount. They will be overseen by either hospital infection control teams or antimicrobial stewardship committees. An example of a guideline would be to perform consistent reviews of patients' prescriptions to guarantee that they are suitable and mandatory for the infection being treated. As a result, not only will the misuse and overuse of antibiotics be prevented, but the effect of antibiotics will also be preserved.

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