USDA Office of the Chief Scientist
U.S. DEPARTMENT OF AGRICULTURE

USDA STRATEGY TO ADDRESS ANTIMICROBIAL RESISTANCE 2023

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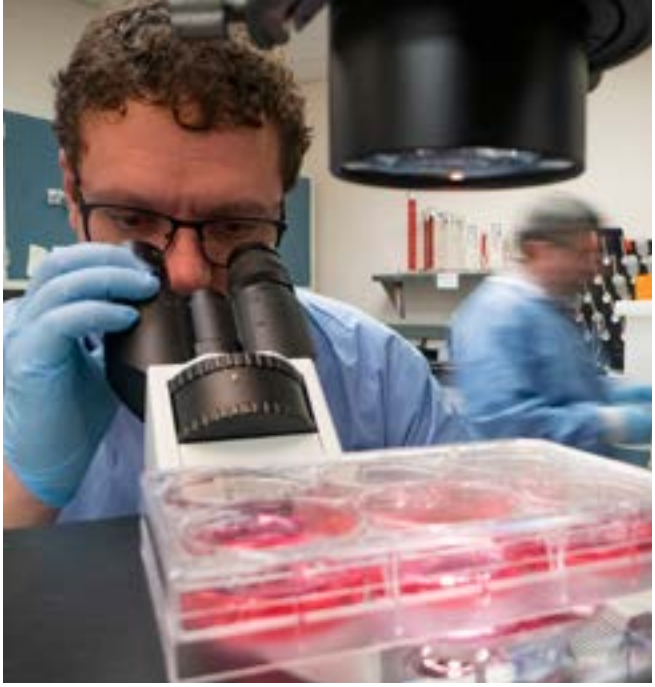

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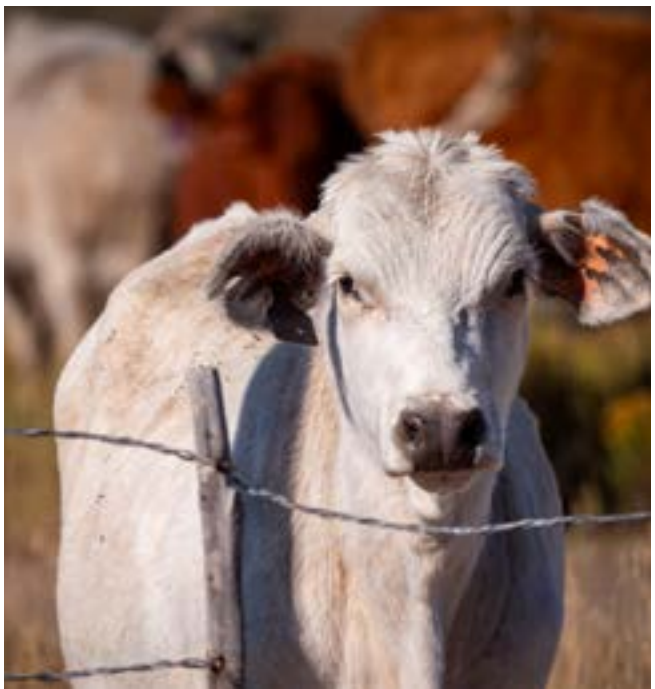

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Squash plant leaf infected with the Squash vein yellowing virus

Executive Summary

Science has advanced the understanding of antimicrobial resistance (AMR) through decades of domestic and global study. Recognizing that the health of humans, animals, and the environment are all interconnected[1], the scientific community has been increasingly working together to better understand and limit the health risks from AMR for all sectors as a shared responsibility. However, there is still much to learn about the risks that various AMR microbes and genes in different settings pose for human, animal, and environmental health before we can develop and implement effective risk mitigation strategies. Therefore, the United States Department of Agriculture (USDA) has developed this USDA Strategy To Address AMR (Strategy) by identifying priority areas in the food and agriculture sector that will contribute to accelerating our understanding of and efforts to mitigate AMR risk.

USDA has gained in-depth knowledge about AMR through its work on the agricultural environment, animal and crop health, and food safety. In 2012, the Department hosted a stakeholder workshop, the findings of which informed development of the **USDA AMR Action Plan** (released in 2014). The USDA AMR Action Plan formed the basis of the Department's input into the U.S. Government National Action Plan for Combating Antibiotic Resistant Bacteria released in 2015 and revised in **2020**. The USDA 2012 workshop and 2014 Plan focused on data gaps regarding AMR in the food animal sector. Since the 2012 workshop, we have seen the need to become more inclusive of sectors beyond food animals in addressing AMR.

The purpose of this Strategy is to serve as a guide to USDA agencies and their collaborators on priorities to accelerate our understanding of and minimize the risk from AMR, focusing on the terrestrial and aquatic food and agriculture sector. In August 2022, USDA hosted a public meeting. At this meeting, USDA presented highlights of what has been learned and challenges for furthering science on AMR across the One Health interfaces of food safety, animal and human health, and the environment and invited Federal partners and the public to do the same. USDA considered historical and collective experience as well as comments received in developing the Strategy. While there are numerous aspects of AMR that could be addressed, this USDA Strategy reflects priorities for expanding our understanding of AMR and innovating on solutions to address AMR risks across the human, animal, and environmental spectrum, taking into consideration accomplishments as well as challenges faced in implementing the 2014 Plan. USDA is composed of multiple agencies and offices with differing missions that can contribute to addressing AMR from each of their perspectives. This strategy is not an implementation plan but rather provides guidance for agency-specific planning or contributions to related Federal plans and strategies.

[1]For the purposes of this document, environment includes crops and wildlife, in addition to soil, air, and water.

The Strategy is organized around three Areas of Focus and 10 Priorities for collaborative action by USDA and its public and private partners:

AREA OF FOCUS 1
Reduce disease and pathogen transmission

PRIORITY 1
Improve animal and crop health

PRIORITY 2
Promote biosecurity

PRIORITY 3
Promote food safety

AREA OF FOCUS 2
Improve the scientific knowledge base on AMR risk

PRIORITY 4
Continuously improve data infrastructure using a One Health approach

PRIORITY 5
Support science and research across sectors to inform risk analysis

PRIORITY 6
Improve understanding of drivers of antimicrobial use[2] (AMU)

PRIORITY 7
Enhance feedback loops between (1) monitoring and surveillance; (2) research; and (3) education and outreach

AREA OF FOCUS 3
Improve communication and collaboration within USDA and with national, regional, and global partners to address AMR risk

PRIORITY 8
Enhance partnerships through building trust

PRIORITY 9
Improve knowledge dissemination and include contextual information

PRIORITY 10
Develop and deliver science-based solutions locally and globally

While USDA is not the lead regulatory authority addressing AMU, USDA is part of the solution in addressing AMR risk because the Department is responsible for protecting the American food supply and American agriculture. Through this Strategy, USDA will integrate and build upon the work its agencies and offices do every day and its collaborations with public and private partners to better understand and address AMR. USDA will also work with agricultural producers and other stakeholders who wish to voluntarily collaborate to help the Department find solutions.

USDA relies on sound science and risk-based approaches to inform multi-dimensional, simultaneous, pressing needs. As we look for ways to preserve antimicrobial tools for the most critical human and animal health needs, we must concurrently find ways to tackle issues related to agricultural productivity, sustainability, resilience, and food security, domestically and globally. Using available resources, we need to find science-based solutions for providing the most impact that benefit all equitably. This strategy improves navigability, readability, and accessibility to the need for understanding AMR risk.

What is AMR?

AMR is a natural process in which microbes continually evolve to resist and survive substances that should kill or inhibit them, whether these substances are produced by the environment, other microbes, or are antimicrobials developed by people. AMR microbes are everywhere–intimately linked with humans, soils, plants, and in food-producing and companion animals. One important aspect of AMR is that some microbes develop resistance to antimicrobials resulting in loss of effectiveness of those antimicrobials.

What is One Health?

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.

[2]Antimicrobial use is the term used in reference to the administration of antimicrobial drugs to humans and animals. Antimicrobial usage is the term used in reference to the application of antimicrobial pesticides to crops. The term, antimicrobial use will encompass both these terms for the purposes of this document.

Challenges and Opportunities

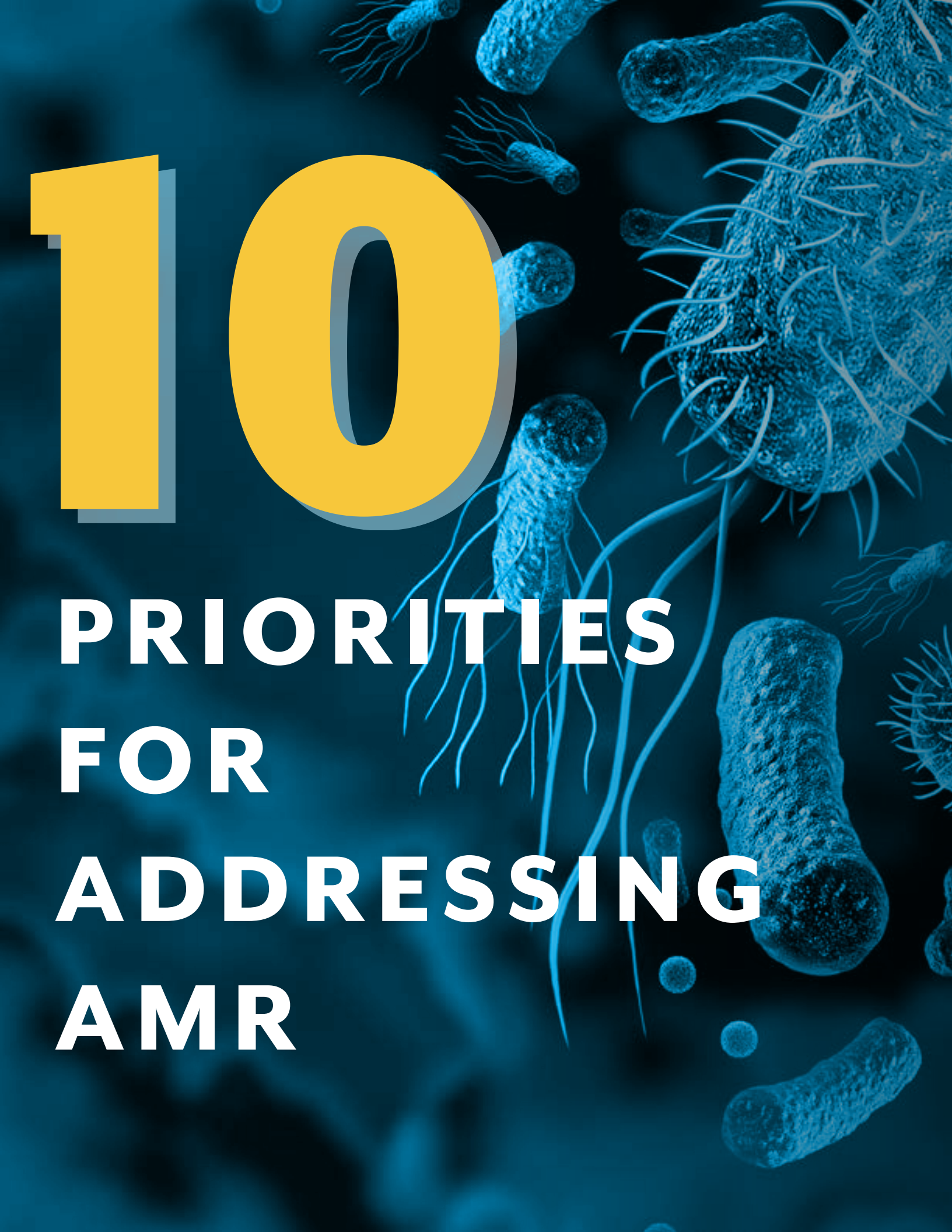
Challenges that USDA has encountered in addressing AMR can also present us with opportunities for future direction. For decades, AMR science has focused on the "what." Now we must increase focus on the "why." For example, we have over time improved ways to determine presence and absence of microbes, monitor trends, quantify amounts of antimicrobials sold or used, and developed technology to generate large quantities of data. Now we must make greater strides in understanding why we see what we see and what to do about it to make the information useable for scientists, policymakers, and stakeholders.

Numerous studies over decades have contributed to the body of knowledge on what AMR microbes and genes are present. Understanding the "why" behind their presence presents a challenge. Understanding the context behind the presence of an AMR microbe in a specific setting provides the opportunity to understand transmission pathways in different settings and better characterize the risk posed by the presence of the AMR pathogen hazard.

Scientists have come a long way in improving methodologies to identify microbes and AMR more efficiently, and, over decades, have observed trends. However, understanding the context of why certain strains of AMR microbes or genes persist or diminish in various settings presents a challenge. Using trends to guide hypothesis-driven research that uncovers why we see these trends can aid in identifying appropriate mitigation strategies.

Knowing the amounts of antimicrobial drugs sold or used provides some information. However, understanding all the reasons behind antimicrobial use is more challenging. Forming partnerships to understand the reasons behind antimicrobial use provides the opportunity to find mutually beneficial solutions for understanding disease challenges, needs for targeting research, and questioning potentially outdated norms.

Accumulating a large amount of data becomes easier every day. Understanding the context of why we see what we see in the data presents challenges. Building multidisciplinary partnerships to provide context to data provides opportunities to develop more inclusive and innovative solutions.



10 PRIORITIES FOR ADDRESSING AMR

AREA OF FOCUS 1

Reduce disease and pathogen transmission

PRIORITY 1
Improve animal and crop health

A commitment to protecting the health and preserving the value of American agriculture, including crops and animals, is part of a One Health approach, which recognizes the interdependence of human, animal, and environmental health. And efforts to improve animal and crop health will protect against the transmission and spread of susceptible and resistant pathogens and reduce the need for antimicrobial drugs. But microorganisms keep evolving, so disease challenges will continue to persist. Therefore, we need to find innovative approaches to combat disease and improve health.

Understanding the mechanics of the disease triangle of host-pathogen-environment relationships is complex. Numerous factors are at play, such as host immunity, disease progression, pathogen virulence, climatic conditions, and transmission routes. Each of these factors may present opportunities to interrupt the host, pathogen, and environmental conditions necessary to produce disease.

Antimicrobials are just one of many tools for ensuring healthy animals and crops. Efforts to improve animal health have traditionally included developing new and improved vaccines, diagnostics, and therapeutics, as well as developing new and improved disease mitigation tools to reduce pathogen transmission. Similarly, crop health professionals incorporate disease forecasting tools into planning for overall crop health encompassed within

integrated pest management (IPM). We need to continue to improve these tools as well as continue to develop new ones and understand the barriers to their commercialization and adoption by incorporating social sciences and economics into our traditional biological sciences.

While we have made progress in some areas, progress can also present new challenges. While we have developed alternatives to antibiotics and continue to develop more, we need to concurrently show alternatives are safe and effective, keeping in mind that some alternatives may also exacerbate AMR, and that we do not have alternatives to replace all antimicrobials for many diseases. We need to advance research on the optimal dose and duration of existing antimicrobial drugs in animals. Use of certain vaccines may be cost-prohibitive or trade-restrictive and necessitate economic considerations.

Continued innovation in areas such as breeding and growing for disease resistance, precision agriculture, and digital technologies to reduce stress and intervene early in disease processes, as well as understanding the microbiome in animals and various environments and production systems are imperative for staying ahead of the disease curve. Changes in climate and the environment can affect pathogens and their transmission so climate-smart strategies may inform disease occurrence, monitoring for emergence of pathogens, and disease prevention. Barriers to implementation of new technologies, including accessibility, socioeconomic drivers, and communication challenges, will need to be considered and addressed in tandem for new technologies to be effective.

Addressing environmental health will benefit animal and human health, as well as crop protection. Including disciplines that study the health of soils, air, water, and wildlife in a One Health approach will enable more comprehensive health solutions. Promoting animal, crop, public, and environmental health infrastructure domestically and globally enables prevention and control of infection and disease, thereby reducing the need for antimicrobials.

PRIORITY 2
Promote biosecurity

U.S. agriculture has decades of experience in innovating in and improving biosecurity practices. Biosecurity is one method the United States has used to eradicate and limit the spread of devastating animal and crop diseases. But movement of masses of people and agricultural products, changing weather patterns, changing species distribution patterns, and changes in population growth can create new opportunities for the emergence and spread of new infectious diseases. Therefore, we need to find ways to enhance biosecurity and the uptake of biosecurity practices to reduce pathogen and AMR transmission from the environment to agricultural operations.

Biosecurity is one part of food animal husbandry and good land and water management. Biosecurity decreases opportunities for the spread of infection and disease. If we can innovate on novel approaches and enhance the uptake of biosecurity in animal husbandry and land and water management practices, then we can reduce disease and reduce the need for antimicrobial drugs. But knowledge is not always enough to overcome barriers for adoption. For example, there may be competing needs such as allowing for outdoor access requirements to meet specific animal welfare standards. We need to incorporate social sciences and economics into work in the biological sciences to increase understanding of barriers to adoption of best practices. A multidisciplinary approach will facilitate finding innovative ways to meet competing needs.

Considering a One Health approach, we also need to consider the environment and the interaction of wildlife and domestic animals and crops. Identification of AMR risk pathways enables better understanding of the role of the environment in sustainable biosecurity practices.

What is Integrated Pest Management (IPM):

Biosecurity involves the protection of food and agricultural systems from pests and diseases in the context of IPM strategies. IPM is a science-based decision-making process that combines tools and strategies to identify and manage pests. As defined in 7 U.S.C. § 136r, IPM is "a sustainable approach to managing pests by combining biological,

cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks." Innovation to improve nonchemical biocontrol technologies, such as finding microbes that replace pathogens can enhance crop health and minimize the need for antimicrobials. `

PRIORITY 3
Promote food safety

Advances in food safety can decrease both AMR and susceptible pathogens. If we can improve food safety practices, then we can reduce the foodborne AMR disease burden. But microorganisms evolve and adapt to changing conditions and we continue to have data gaps on what makes foodborne pathogens, including those that are resistant to antimicrobials, evade existing interventions. Therefore, we need to find ways to enhance food safety interventions and practices from farm-to-fork.

Foodborne AMR contributes to a subset of AMR risks to human health. Continuous improvement of food safety reduces the foodborne AMR burden by decreasing the incidence of both susceptible and resistant foodborne pathogens. While we have identified hazards and critical control points for effective risk management actions from farm to fork, we need to continue to investigate the persistence of human disease caused by foodborne pathogens. Farm-to-fork food production chains are complex and dynamic to allow food production to continue in the face of environmental, economic, and social stresses. Similarly, microorganisms evolve and adapt to changing conditions. Thus, to ensure food safety, there is a continuous need for research to understand how foodborne pathogens, including those that are AMR, evolve and evade interventions.

We need to develop, evaluate, and apply more sensitive and robust pathogen detection methods. Further, we need to explore AMR risks from less studied sources of pathogens, such as imported products, aquaculture, minor species, and emerging food trends and processes. Integration of different approaches to understanding the risks posed by foodborne pathogens is critical to finding feasible solutions. Science and risk-based information on sources of foodborne AMR pathogens and genes from farm-to-fork, supports development of effective, targeted interventions as part of a comprehensive risk mitigation strategy.

To ensure that everyone's food is safe, the USDA, Food Safety and Inspection Service (FSIS) continuously monitors slaughter and processing establishments and actively monitors and investigates foodborne illnesses. In support of its food safety and public health mission, FSIS collects and analyzes more than 115,000 microbiological samples each year. The Agency's actions are designed to help ensure that industry decreases contamination from pathogens and other foodborne hazards, and these goals and strategies are reflected in FSIS' Strategic and Annual plans.

To ensure that everyone's food is safe, the Food Safety and Inspection Service (FSIS) Strategic Plan (2023-2026) focuses on reducing foodborne illness linked to FSIS-regulated products via three goals: (1) Prevent Foodborne Illness and Protect Public Health, (2) Transform Inspection Strategies, Policies, and Scientific Approaches to Improve Public Health, and (3) Achieve Operational Excellence. FSIS is currently retooling its strategy to reduce *Salmonella* illnesses attributable to poultry. FSIS will consider targeting other pathogen-product pairs using the poultry experience and guided by public health impact.

AREA OF FOCUS 2

Improve the scientific knowledge base on AMR risk

PRIORITY 4

Continuously improve data infrastructure using a One Health approach

Quality data with context are essential for accurate risk assessments and impactful decision-making. And if we can develop the infrastructure and workforce necessary to process, harmonize, and evaluate enormous quantities of disparate data, then we can make effective decisions. But data are becoming increasingly sophisticated and so is the workforce needed to process and evaluate them. Therefore, we need to continuously improve our data infrastructure and build the workforce to maintain and use it.

While USDA and Federal partners have been monitoring antimicrobial susceptibility, antimicrobial sales, and intermittently, AMU data for decades, there is a need for continual improvement of data collection methods, standardization, storage, analysis, and interpretation. As we introduce more sophisticated methodologies, a need for a national workforce with proficiency in bioinformatics, modelling, statistics, software engineering, risk analysis and artificial intelligence grows. Those engaged in the biological sciences with the ability to interpret results and provide epidemiologic and phenotypic contexts working alongside with data scientists will help find solutions to complex challenges, such as understanding and mitigating AMR risk.

Within USDA, further development of shared dashboards can improve knowledge of ongoing and past projects to make collaboration related to food safety, animals, the environment, and crops easier across agencies. USDA has begun developing AMR data dashboards to

help visually convey complex information. For example, the USDA, Animal and Plant Health Inspection Service (APHIS) has developed a data dashboard describing its **National Animal Health Laboratory Network Pilot Project** available to the public. Future dashboard and other data visualization efforts across USDA should aim to connect people, projects, and outcomes to be a source for scientists and decision-makers within USDA, as well as our public and private partners. Addressing confidentiality and data security concerns will facilitate engagement of more external partners in data collection and improve data quantity and quality for use in risk assessments and modeling, with a look to disease forecasting and artificial intelligence.

While integration across sectors and developing one interoperable database is often a goal, it is quite challenging because different strains of bacteria may be responsible for causing disease in animals, humans, and crops, so we may not generate comparable information or easily combine data across sectors. A One Health approach is more than having interoperable databases. *A One Health approach is about engaging multidisciplinary expertise to bring sector-specific data to the table to co-create mutually beneficial solutions.* Developing an infrastructure of multidisciplinary experts to provide context for data must be a part of any goal for improving data infrastructure to inform a comprehensive approach for finding effective applications of data.

PRIORITY 5
Support science and research across sectors to inform risk analysis

USDA has gained in-depth knowledge about AMR through its work on animal health, crop protection, food safety, and the agricultural environment. And if we can continue to improve our understanding of AMR risk, then we can improve our ability to identify effective risk management options. However, despite extensive work on identifying hazards, many data gaps exist to assessing the risk that AMR poses to human, animal, and environmental health in various scenarios. Therefore, we need to fill data gaps and identify research synergies to inform our understanding of AMR risk to develop proportionate risk mitigation strategies.

A One Health approach helps us explore data gaps beyond human health and livestock to intersections with other sectors such as crops, wildlife, and companion animals. USDA's role is to help produce the science, including the science to improve understanding of the relationship between AMU and AMR, to inform regulations and policy. Additionally, USDA contributes to risk assessment and risk management strategies that may affect products of importance to agriculture. That includes helping to understand the factors that influence AMR development, persistence and spread; the sources of AMR that pose risks to human, animal, crop, and environmental health; the transmission pathways within and between sectors; and the development of science-based risk-informed mitigation strategies.

Opportunities exist for synergistic efforts across organizations to mitigate AMR risk; and these efforts should begin by establishing or contributing to a common framework of "risk", such as the Guidelines for Risk Analysis of Foodborne Antimicrobial Resistance **CXG 77-2011**. If we have a common understanding of AMR risk, we can identify situation-appropriate risk mitigation options that lead to successful health outcomes.

Risk-benefit analyses can be employed as a tool to identify risk mitigation strategies that lead to optimal tradeoffs between the costs of the mitigation measures and the achieved risk reduction. Evaluation of risks and benefits need to consider areas such as animal health and welfare, crop protection, environmental health, and food security. We should explore economic impacts to inform and optimize risk mitigation options and help facilitate adoption.

What is the difference between a hazard and a risk and what is risk assessment?

A hazard is a biological, chemical, or physical agent with the potential to cause an adverse health effect.

Risk tells us how likely it is that a hazard will cause harm.

Risk Assessment is a scientifically based process consisting of the following steps: (i) hazard identification, (ii) hazard characterization, (iii) exposure assessment, and (iv) risk characterization. While presence of an AMR pathogen can represent a hazard, a risk assessment provides information on likelihood of an adverse health effect posed by the hazard. Understanding the risk posed by a hazard helps us identify appropriate options to manage the risk.

What comprises risk analysis?

Risk Analysis is a process consisting of three components:

- **risk assessment**
- **risk management**
- **risk communication**

USDA's Agricultural Research Service (ARS)

Performs hypothesis-driven, solution oriented, intramural research to address AMR by developing and transferring science-based solutions and alternatives to antibiotics to reduce the risk associated with AMR in agriculture. ARS contributes to understanding the risk to human, animal, and environmental health; identifies critical control points in food production and processing environments that impact disease outcomes; and develops alternatives to antibiotics and environmental mitigation strategies to reduce the need for antimicrobials and the risk to human, animal, and environmental health. This research is reflected in the ARS AMR Research Strategy which identifies four interrelated priorities to detect, prevent, and control AMR and to develop antibiotic alternatives, including (1) Risk detection, (2) Systems biology and detection strategies, (3) Mitigation, and (4) Science outreach.

PRIORITY 6
Improve understanding of drivers of AMU

Understanding the drivers of AMU is key to optimizing AMU. If we can better understand the needs driving AMU, then we can improve antimicrobial stewardship, animal health, and crop protection. But we do not know all the conditions driving the use of antimicrobials in various sectors, and these conditions change. Therefore, we need to enhance our understanding of the drivers of AMU.

Healthy animals and crops support a healthy human population and provide for food security and safety. Antimicrobial agents are one tool used to help ensure animal and crop health, but AMU results in costs to producers, as well as greater societal costs. Users are employing a cost-benefit analysis when using tools, including antimicrobials. Therefore, improving understanding of the drivers of AMU can help inform optimizing AMU appropriately and targeting research to areas of need to minimize disease, and potentially reduce the need for antimicrobials.

While collection of AMU data has been heavily emphasized in global and national discussions, there has been less focus on understanding the drivers of AMU. Sales data, because they are easier to collect, are most often collected globally. But sales data are not equivalent to AMU data. Sales data also do not offer opportunities to understand drivers of AMU. For example, sales data do not tell you when, where, and how an antimicrobial is used. Products may have multiple approved uses and may be stored for some time before they are administered in animals or applied to crops. Therefore, it is difficult to assess where AMU occurs and how AMU may contribute to AMR from sales data alone. We need to understand the context of why and when antimicrobials are used, such as disease pressures, population changes, environmental stressors, and economic inputs.

AMU data collection is difficult because reporting AMU data is resource intensive and burdensome. While AMU data collection in human medicine is challenging, AMU data collection in animals or crop production is further complicated by a lack of levers that are used in human medicine to collect data such as Medicare or more comprehensive insurance sources that could potentially aggregate data in a useful way. There is still a place for AMU data collection. Challenging ourselves to find

opportunities to partner internally and with Federal, State, and private partners to build on efforts in AMU data collection will enhance the data we have historically collected.

To optimize stewardship, research studies that contribute to a framework for understanding the risks and benefits of using antimicrobial agents are needed. For example, research on effective treatment regimens (dose and duration) in animals supports optimizing AMU to address health concerns appropriately. We should incorporate social sciences into efforts to optimize AMU to improve users' understanding and adoption of scientific and research findings. Focusing on how AMU can be managed to reduce the need for antimicrobials without impacting animal health and welfare or crop protection is vital for balancing needs for antimicrobial stewardship and food security.

How are antimicrobial pesticides in crops and antimicrobial drugs in animals regulated?

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) authorizes Environmental Protection Agency (EPA) to register antimicrobial pesticides applied to crops. The Federal Food, Drug, and Cosmetic Act gives Food and Drug Administration (FDA) the legal authority to approve and regulate antimicrobial drugs administered to animals.

What are examples of efforts to monitor AMU?

The National Animal Health Monitoring System in partnership with the USDA, National Agricultural Statistics Service (NASS) has incorporated questions into periodic national surveys on the health and management of U.S. livestock, poultry, and equine to better understand drivers of AMU in animals for decades. In addition, the Agricultural Chemical Use Program of NASS is the Federal Government's official source of statistics about on-farm and post-harvest commercial pesticide use and pest management practices. NASS conducts field crop agricultural chemical use surveys in cooperation with USDA's Economic Research Service (ERS) as part of the Agricultural Resource Management Survey (ARMS). Through the ARMS, NASS has also periodically obtained data on AMU in animals. As USDA surveys rely on responses from farmers and ranchers, partnerships and outreach with USDA partners and stakeholders help strengthen these important data including farm management practices related to AMU.

PRIORITY 7

Enhance feedback loops between (1) monitoring and surveillance; (2) research; and (3) education and outreach

Monitoring and surveillance identify trends and novel AMR; research helps us understand the root causes and impacts of those trends; education and outreach convey scientific findings to inform solutions. And if we use a feedback loop of monitoring, research, and education and outreach, we will improve our ability to address AMR risk over time. But integration of the components of the feedback loop, particularly in multiple sectors is challenging. Therefore, we will strengthen the feedback loop between monitoring, research, and education and outreach activities for AMR using a One Health approach.

While USDA and its public and private partners have been working for decades to understand the incidence, sources and transmission of AMR, there is still more to learn. AMR in the environment develops as a response to bacterial competition; many bacteria develop natural resistance as a result. Therefore, AMR is ancient and can be found in natural ecosystems around the world, and there are many known and hypothesized pathways among people, domestic and wild animals, and the environment connecting microbial populations and settings. Numerous factors can contribute to the persistence of AMR such as co-selection and the presence of toxic compounds, heavy metals, as well as environmental factors such as stress, temperature, pH, and osmotic pressure. Just as use of antimicrobial drugs in animals may contribute to selection of AMR bacteria in farm or wildlife environments, exposure to raw and treated effluent from wastewater treatment plants could affect the AMR found downstream on farms or wildlife environments. While AMU is one driver for selection of AMR bacteria, it is not the only driver. Unless we understand the contributions of different sources, drivers, and their interconnectedness for AMR development and its risk potential, the mitigation strategies we apply may not be effective in AMR risk reductions.

Conducting monitoring and surveillance of AMR bacteria from a variety of sources, such as animals, environment, and humans increases the capacity for early detection and response to acute threats. The data also contribute to identifying potential hazards, trends, and hypotheses for further evaluation through research. While findings from monitoring and surveillance are used to identify hazards and trends, they do not allow for measurement of risk. Findings must be combined with other information, such as data type, methodology, context, including assumptions, dose/response studies and exposure pathways to evaluate risks to humans, plants, and animals of concern. Further, dissemination of results is necessary to communicate risk and facilitate development of effective mitigation.

Research is necessary to: (1) understand patterns and test hypotheses uncovered through monitoring and surveillance to identify cause and effect; (2) identify effective management and risk mitigation strategies; (3) develop new technologies and therapeutics, including safe and effective alternatives to antibiotics; and (4) develop and enhance methodologies to identify and predict AMR more accurately and rapidly. Data from monitoring and surveillance and research drive education and outreach efforts. The impact of education and outreach can then be evaluated through more monitoring and surveillance for continual improvement.

What are examples of efforts to monitor AMR?

The National Antimicrobial Resistance Monitoring System (NARMS) has been tracking changes in the antimicrobial susceptibility of intestinal bacteria since 1996. NARMS is a collaboration between FDA, the Centers for Disease Control and Prevention, USDA, State and local public health departments, and universities. NARMS serves as the United States' national public health monitoring system for enteric AMR bacteria. From its inception, NARMS operationalized a One Health approach by bringing together multiple sectors and disciplines to develop, run, and collectively understand data generated through the program. APHIS has been collecting information on AMR in enteric bacteria through the National Animal Health Monitoring System since 1995, and the National Veterinary Services Laboratories (NVSL) and the National Animal Health Laboratory Network (NAHLN) regularly collect AMR data on animal pathogens. The Fungicide Resistance Action Committee (FRAC) provides resistance management guidelines and monitors AMR in crops. Through expert fora and working groups, such programs provide technical inputs along with research data for risk analysis.

AREA OF FOCUS 3

Improve communication and collaboration within USDA and with national, regional, and global partners to address AMR risk

PRIORITY 8
Enhance partnerships through building trust

The scientific community has come a long way in breaking down the complexity of AMR over decades of study. And if we can leverage partnerships, then we can generate even better data to find innovative solutions to address AMR while also addressing concurrent challenges such as agricultural sustainability and food security. But trust needs to be strengthened amongst partners to enhance data collection. Therefore, we need to find ways to enhance trust and build productive partnerships.

Building trust with partners will help to increase opportunities for collaborations and development of better data to inform science-based policy. We need everyone who is engaged in the system to want to participate and not feel threatened by doing so. This goal requires specific attention to listening to diverse stakeholders; providing science and risk-based information, accessible to diverse audiences; providing appropriate sector-specific contexts to data; and ensuring data protections and confidentiality for data provided voluntarily. Public scrutiny of individuals or industries that voluntarily participate in data collection efforts stymies voluntary participation. Future focus on AMU data collection needs to enhance positive collaborations with public and private partners to contribute to the collective good versus individual scrutiny.

One of the major strengths for resilience of the U.S. food production system is the diversity of production types, including by size and production practices, resulting in

multiple choices for consumers. USDA recognizes the need to address AMR risk across diverse production systems equitably. Building trusting partnerships across these diverse systems will inform comprehensive solutions.

USDA activities to address AMR cover a broad breadth of topics, with expertise in food safety, animal and plant health, the agricultural environment, research and development, and international trade. That said, USDA does not have the resources, the reach, or the regulatory authority to address AMR alone. USDA will need to leverage existing relationships with public and private partners and build new public-private partnerships to enhance data collection efforts and scientific collaborations.

PRIORITY 9
Improve knowledge dissemination and include contextual information

USDA is leading the way to new discovery and innovation in agriculture. And if we can make findings accessible and actionable to stakeholders, then they can employ effective strategies. But scientific findings are often challenging to interpret and apply. Therefore, we will improve our science communication to disseminate knowledge with appropriate contexts for varying audiences.

Improving content delivery with messaging tailored for specific audiences will help build trust and credibility. USDA will continue to explore better methods for disseminating information about AMU and AMR in agriculture, including better use of social media tools and working with communication brokers, such as extension specialists and agricultural journalists. We need to package information in easily digestible formats, such as infographics and dashboards, virtual webinars, and face-to-face meetings to share results from studies.

Risk communication is an important component of the risk analysis process and should be carefully considered in every step of risk analysis. A specific concern that AMR pathogens pose over antimicrobial susceptible pathogens is the potential for treatment failure in humans due to the inability to treat an illness resulting from an AMR pathogen. Similarly, animals can also experience treatment failures due to illness from AMR pathogens, though we know less about the overall impact of AMR in animals. But every detection of a resistant gene or pathogen does not pose the same risk to health. Therefore, it is important to provide context related to detections of AMR and accurate interpretation. For example, an understanding of changing animal populations, the epidemiology of pathogens and their prevalence, and sampling conditions can provide important context.

The Cooperative Extension System

Supported by USDA's National Institute of Food and Agriculture (NIFA), translates research into action by bringing innovative discoveries from research laboratories to those who can put knowledge into practice. Leveraging the Cooperative Extension System to provide information to farmers and producers on antimicrobial stewardship provides an important tool for dissemination of information.

PRIORITY 10
Develop and deliver science-based solutions locally and globally

Science provides a foundation for a common global understanding from which to build. And global scientific cooperation can accelerate our ability to understand risks and to find and implement effective risk mitigation strategies. But because risks, priorities, resources, and cultural practices vary from country to country, there is no one-size-fits-all solution. Therefore, we need to enhance scientific collaborations to identify sources of risk and develop risk-based mitigation strategies tailored for local conditions and needs that simultaneously contribute to global progress in addressing AMR.

Food production is globally connected through trade, such that AMR evolving in one country can easily affect other countries across the globe. Thus, AMR should be addressed on the global stage, with science-based solutions. Promoting a scientific and risk-based underpinning to considerations in all international venues will help enable effective strategies to address AMR risk.

There are differences in species present and the structure of animal and crop production and food products produced among and within countries. Further, there are regional variations in pathogens of concern, antimicrobial susceptibility patterns of these pathogens, antimicrobial accessibility, and effectiveness of antimicrobials in specific species for specific diseases. Countries also have regional, legislative, cultural, and infrastructure

variation. Microbiological hazards, which include AMR microbiological hazards, are from living organisms that can reproduce in foods and are ubiquitous in the environment. Addressing microbiological hazards effectively requires risk assessment approaches based on local conditions and risk management strategies that seek to keep risks within tolerable limits. Implementing international policies that are not science and risk based can have unintentional negative impacts on animal health and welfare, crop protection, food security, or trade.

Guidance for assessing risk from foodborne AMR is described in the Codex Guidelines for Risk Analysis of Foodborne AMR (**CXG 77- 2011**). Global cooperation in addressing research and data gaps to inform international standards for risk assessment can move the world in the direction of global goals of risk reduction equitably over zero risk approaches.

USDA participates in multiple international engagements to address AMR. For example, USDA expert participation in bodies that set international standards (World Organization for Animal Health, Codex Alimentarius Commission, and International Plant Protection Convention) is a priority for enabling science-based solutions to address AMR risk. Providing scientific and agricultural contexts in multilateral initiatives, such as the Transatlantic Task Force on Antimicrobial Resistance, as well as one-on-one technical exchanges, also advance collective scientific understanding. Informing the work of international organizations, such as the World Health Organization, the Food and Agriculture Organization, and the United Nations Environment Program, will further ensure that scientific and agricultural contexts including animal health and welfare, crop protection, and food security are considered in developing global strategies to address AMR risk. Although focused on domestic agriculture, USDA should expand its efforts globally as AMR is not confined to national borders.

Article 5.1 of the Agreement on the Application of the Sanitary and Phytosanitary Measures

Describes how risk mitigation measures must be based on an assessment, as appropriate to the circumstances, of the risks to human, animal or plant life or health, taking into account risk assessment techniques developed by the relevant international organizations [World Organization for Animal Health, Codex Alimentarius Commission, International Plant Protection Convention].

USDA's Foreign Agricultural Service (FAS)

Administers programs that help U.S. and foreign participants collaborate on understanding and mitigating AMR. For example, participants in the FAS-administered Faculty Exchange Program have addressed AMU and AMR in the context of capacity building for teaching at veterinary colleges. FAS also collaborates with international organizations, like the African Union and the InterAmerican Institute for Cooperation on Agriculture, to assist Member States on AMU and AMR priorities.

Agricultural disease Detection Dog (in-training) Pepper, quickly and accurately inspecting rows of pepper plants to detect chlorotic spot virus

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