HUMANS, ANIMALS AND THE PLANET.

VITAL TO OUR FUTURE.

ANTIBIOTIC SYMPOSIUM
10TH ANNIVERSARY | NOVEMBER 2-4

White Paper information was summarized by the National Institute for Animal Agriculture's Symposium, "Humans, Animals and the Planet: Vital for our Future," conducted November 2-4, 2020. Full presentations are available by contacting communications@animalagriculture.org.

DISCLAIMER: The information provided in this White Paper is strictly the perspectives and opinions of individual speakers and discussions at the 10th Annual NIAA Antibiotic Symposium.

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BACKGROUND

The Symposium, *Humans, Animals, and the Planet: Vital to Our Future*, conducted on November 2-4, 2020, was the tenth annual antibiotic Symposium hosted by the National Institute of Animal Agriculture (NIAA). Three days of presentations and discussions brought together a wide range of stakeholders to continue addressing antimicrobial resistance and stewardship. Representatives included:

- Producers, producer organizations, and other industry leaders
- Veterinarians
- Public health professionals
- Representatives of pharmaceutical and technology companies and diagnostic laboratories
- University researchers
- Federal and state regulatory officials

These individuals remain committed to the collaboration necessary to address the growing challenge of responsible antibiotic use from a *One Health* perspective. Their work collectively considers antimicrobial stewardship involving animals, people, and their environments, as well as the synergistic interactions between them.

The 2020 symposium marked the 10th anniversary of an international dialogue hosted by NIAA. Discussions continue to focus on using antibiotics in food animals and the science surrounding antimicrobial resistance. These challenges remain one of the most important priorities for the animal agriculture industry and its allies.

The NIAA is a non-profit, membership-driven organization that unites and advances animal agriculture for the challenges facing affiliated industries, including aquatic, beef, dairy, equine, goat, poultry, sheep, and swine. NIAA is dedicated to eradicating diseases that pose a risk to the health of animals, wildlife, and humans; promoting the efficient production of a safe and wholesome food supply for our nation and abroad; and promoting best practices in environmental stewardship and animal health and well-being.

The 2020 10th Annual NIAA Antibiotic Symposium was funded in part by the Beef Check-Off, ASTHO Leadership Institute, the United Soybean Board, Norbrook, Inc., Phibro Animal Health Corporation, and the KC Animal Health Corridor.

2020 SYMPOSIUM PLANNING COMMITTEE

Co-chairs:

Leah Dorman, DVM, Director of Communications and Consumer Engagement, Phibro Animal Health. Dr. Leah Dorman serves as a resource to all those interested in animal agriculture. She is committed to providing honest, accurate answers to questions about how food from animals is produced. Dorman is part of Phibro Animal Health's commitment to encouraging and supporting open dialogue about producing safe food, promoting animal health, and balancing the needs of people, animals, and the planet. She has been trained as a Foreign Animal Disease Diagnostician, which includes specialized training in biosecurity and recognizing diseases that are not established in the US. She also has experience in emergency response and planning for an animal disease incident. Dorman received her DVM from The Ohio State University in 1995.

Eric Moore, DVM, Director of Technical Services, North America, Norbrook, Inc. Dr. Eric Moore received his DVM from Kansas State University's College of Veterinary Medicine in 1994. He is a second-generation veterinarian from south-central Nebraska. Moore began his career in rural private practice in western and central Kansas, specializing in cow/calf, stocker, and feedlot operations. In October 2004, he joined Kansas State University as a clinical instructor in agricultural practices. In 2006 he joined Schering-Plough Animal Health as a technical services manager. Moore is currently employed with Norbrook, Inc. as Director of Technical Services, North America. He is a member of AABP, AASV, AVMA, and NIAA. He currently serves AVMA on the Animal Agriculture Liaison Committee. For NIAA, Moore serves on the executive committee and co-chairs the Antibiotics Council. He is a long-time member of AVC and has served as a former co-chair and member of the Cattle Health and Well Being committee and member of the Scholarship Committee.

Committee Members:

Michael Costin, DVM, MBA, Assistant Director, American Veterinary Medical Association (AVMA). Dr. Michael Costin is a 2003 graduate of Kansas State University's College of Veterinary Medicine. Upon graduation, he worked in a four-doctor mixed animal practice and in 2004 he accepted a position in an eight-doctor dairy practice where he was made a partner in 2006. In 2012, Costin sold his partnership, became a Technical Services Veterinarian with an animal health distributor, and enrolled in the University of Wisconsin's Executive MBA program. Upon completing his MBA in 2014, Costin was promoted to Technical Services Manager for his company and managed the veterinary services team. In 2015, he accepted the Assistant Director position with the AVMA. Costin serves as the staff liaison to the

AVMA's Animal Agriculture Liaison Committee (AALC) and the Committee on Antimicrobials (CoA), as well as the AVMA's liaison to the United States Animal Health Association (USAHA).

Heather Fowler, VMD, MPH, PhD, Director of Producer and Public Health, National Pork Board. Dr. Heather Fowler completed her Veterinary Medical degree at the University of Pennsylvania School of Veterinary Medicine in 2010, a Master's in Public Health in Applied Biostatistics and Epidemiology at the Yale School of Public Health in 2011, and a PhD in Environmental and Occupational Hygiene from the University of Washington School of Public Health in 2017. She is board certified in veterinary preventive medicine and has expertise in zoonotic disease, public health, worker safety and health, and *One Health* application. In the summer of 2017, Fowler became the Director of Producer and Public Health at the National Pork Board, where she oversees public health and occupational safety and health issues as they relate to swine production in the United States.

Andy J. King, PhD, Assistant Professor, Greenlee School of Journalism and Communication, Iowa State University. Dr. Andy King researches strategic health communication, focusing on campaign design and evaluation. His work advances applied communication theorizing relevant to message design and message processing in health-related contexts, with the goal of contributing to improving public health through evidence-based practice. Much of his research has looked at visual imagery's role and influence in strategic health messages. King has published over 30 peer-reviewed journal articles in outlets including *Journal of Health Communication*, *Cancer Epidemiology*, *Risk Analysis, Journal of Communication* and *Health Communication* and has received research funding from the Health Resources and Services Administration and the National Institutes of Health. He serves on the editorial boards for *Communication Monographs*, *Health Communication,* and *Journal of Health Communication*. King received his PhD in Communication from the Purdue University Brian Lamb School of Communication in 2012; his secondary areas of study included Research Methods and Social Psychology. He received his MA in Communication from Purdue in 2008; his secondary area of study was Social Influence. And he graduated with a BS in English Education from the University of Wisconsin-Whitewater in 2006 Cum Laude with a Minor in Speech Communication. King has participated in the NIAA Antibiotic Symposium for several years as a steering committee member. His health communication and persuasion skills have helped NIAA address the complexities of communicating about antimicrobial stewardship in animal agriculture.

Megin Nichols, DVM, MPH, DACVPM, Enteric Zoonoses Lead of Outbreak Response and Prevention Branch, National Center for Emerging and Zoonotic Infectious Diseases. Dr. Megin Nichols works on multistate outbreaks of Salmonella and E. coli resulting from animal and animal product exposure. She received a Bachelor's degree in Animal Science from New Mexico State University, a Doctorate in Veterinary Medicine from Colorado State University, and a Master's of Public Health in Food Safety and Biosecurity from the University of Minnesota. Nichols' research interests include the exotic pet trade's impact on native species, zoonotic disease, food safety and biosecurity, public health law, and pediatric vaccine-preventable diseases.

Paul Plummer, DVM, PhD, Professor and Anderson Chair of Veterinary Diagnostic and Production Animal Medicine and Veterinary Microbiology and Preventative Medicine, College of Veterinary Medicine, and Executive Director of the National Institute of Antimicrobial Resistance Research and Education (NIAMRRE), Iowa State University. Dr. Paul Plummer is a Professor in the Departments of Veterinary Diagnostic and Production Animal Medicine and Veterinary Microbiology and Preventative Medicine at the Iowa State University College of Veterinary Medicine. His clinical specialty is internal medicine and infectious disease of ruminants. Plummer received his PhD from Iowa State University in 2009. He was a Veterinary Microbiology Resident at the University of Tennessee in 2004, and a Large Animal Medicine Intern at Texas A&M University in 2001. He received his DVM in Large Animal Medicine and Surgery from the University of Tennessee in 2000 and his Veterinary Medicine BS from the University of Tennessee in 1999. Plummer is a Microbiology Diplomate with the American College of Veterinary Internal Medicine, and a Large Animal Internal Medicine Diplomate with the European College of Small Ruminant Health Management. NIAMRRE, housed at the Iowa State University Research Park, was developed in 2018 from a national search led by the Association of Public and Land-grant Universities (APLU) and the American Association of Veterinary Medical Colleges (AAVMC) to identify a collaborative center to lead *One Health* efforts in antimicrobial resistance (AMR).

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Roxann Brooks Motroni, DVM, PhD, National Program Leader for Animal Health, United States Department of Agriculture (USDA), Agricultural Research Service (ARS)

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Amanda Beadoin, DVM, PhD, Director of the *One Health* Antibiotic Stewardship Collaborative, Minnesota Department of Health and Adjunct Professor, College of Veterinary Medicine, University of Minnesota

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Jay L. Garland, PhD, Research Scientist, Office of Research and Development, United States Environmental Protection Agency

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Neena Anandaraman, DVM, MPH, Veterinary Science Policy Advisor to the USDA's Chief Scientist, United States Department of Agriculture (USDA)

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Clara Davis, PhD, Foreign Affairs Officer, Office of International Health and Biodefense, United States Department of State

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Lynn Filpi, PhD, Senior Global Health Advisor and Antimicrobial Resistance (AMR) Team Lead, Office of Global Affairs, United States Department of Health and Human Services

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Eric Moore, DVM, Director of Technical Services, North America, Norbrook, Inc.

EXECUTIVE SUMMARY

The National Institute for Animal Agriculture (NIAA) has been convening stakeholders to discuss the worldwide antimicrobial resistance (AMR) crisis for the past decade. The 10th Annual NIAA Antibiotic Symposium, ***Humans, Animals, and the Planet: Vital to Our Future***, was held November 2-4, 2020. Convening under the *One Health* umbrella, topics included animal health, environmental, and human health concerns surrounding this multi-faceted, complicated issue.

In 2020, more than ever before, consumers have questions about how their food is raised. And those questions include animal care topics that agriculture professionals must continue to address with a deft balance of science and compassion.

Antibiotics are used in animals for the same reason they are used for people - to prevent pain and suffering. However, up to 75 percent of antibiotics administered to animals orally move through their systems and show up in the manure. When this manure is applied to agricultural fields as an organic source of fertilizer, water run-off from these fields may go into surface water and eventually end up in our water systems, affecting human health.

The NIAA brings together a vast and complicated diversity of stakeholders to address AMR, including veterinarians, researchers, and academics, as well as producers and farmers. Animal agriculture industry representatives, government officials, and policymakers also provide essential voices in this discussion.

Before the Coronavirus pandemic, more than 2.8 million antibiotic-resistant infections occurred among humans in the United States each year. More than 35,000 people die annually as a result. While some resistant pathogens are exclusive to humans and others are found only in animals, at least six pathogens affect both groups, highlighting this issue's interconnectedness.

Antimicrobial stewardship is the actions taken to preserve antimicrobial drugs' effectiveness and availability for both animal and human treatment. These actions occur through conscientious oversight and responsible medical decision-making while safeguarding animal, human, and environmental health.

The development of antibiotic resistance is a global threat to public health. In 2013, the Centers for Disease Control (CDC) issued its first AMR Threat Report. Today, more than 135 countries worldwide are addressing AMR, including leadership from the United Nations.

The NIAA has chosen to address this threat from a *One Health* perspective that encompasses animal, human, and environmental health while considering how each affects the others. This includes a growing commitment to diagnostic testing and surveillance efforts such as water and soil monitoring to combat resistance.

As naturally-occurring environmental contaminants, antimicrobials, resistant genes, and resistant pathogens are present in the environment and amplified in target organisms. Therefore, dealing with these issues and designing monitoring, sampling, and analysis to track compounds is exceptionally

complex. Efforts to begin addressing AMR's surface water issues are underway because some US drinking water includes up to 15 percent of their source water from treated wastewater.

While NIAA members are committed to emphasizing the science of antimicrobial resistance as we tell the story of stewardship, we have ongoing challenges communicating with consumers and members of the media. A Symposium speaker shared that 42.2 percent of content about antibiotic use and livestock resistance in three major national newspapers between 1996 and 2017 cited or quoted no scientific source when writing about this issue. Social media is also growing in importance for AMR communications.

Antimicrobial resistance is a priority topic for both the United States Department of Agriculture (USDA) and its Agricultural Research Service (ARS). Multidisciplinary, systems-based, solutions-oriented research continues to reduce AMR's emergence, persistence, and spread. They are also accelerating basic and applied research to develop new antibiotics, non-traditional therapeutics, optimized treatment regimens, and vaccines.

The environmental discussion surrounding AMR includes factors affecting the water, the agricultural environment, and plants. Due to widespread bacterial infection in Florida, Citrus Greening has resulted in a gradual decline in productivity since 2004. And, multiple wastewater effluent treatment strategies are being evaluated to remove the emerging environmental contaminants of antibiotics, antibiotic-resistant bacteria, and antibiotic-resistant genes.

Antimicrobial resistance is a problem for human and animal health. Inappropriate use of antibiotics is likely as high for veterinarians as in human health care, where more than 30 percent of outpatient prescriptions are inappropriate or unnecessary. Researchers found that 41 percent of animals receiving an antibiotic had no evidence of infection. Bacteria causing these infections for humans, agricultural and companion animals, and the antimicrobials used to treat those infections are all part of the problem.

Acquired resistance – when an antimicrobial that previously worked to kill an organism loses its effectiveness – is especially concerning. Antimicrobial stewardship preserves antimicrobial drugs' success and availability through careful oversight and responsible medical decision-making while protecting animal, public, and environmental health.

Veterinary professionals are setting the highest priority on drugs that are also important for human therapies, known as "medically important antimicrobials." They are also transitioning more over the counter products to being available only by prescription. And they are defining the use of medically important antibiotics used in animal feeds and water to maintain effectiveness while minimizing exposure.

These stakeholders share the public's concern about antibiotic resistance and believe we all have a role in addressing this critically important issue. In today's "tribal" society, these stakeholders are focused on building trust as respected influencers.

Efforts are working. There have been 18 percent fewer deaths from antibiotic resistance overall and 28 percent fewer deaths from antibiotic resistance in hospitals since 2013. And today, 85 percent of hospitals meet the CDC's Core Elements of Antibiotic Stewardship standards, up from only 41 percent in 2014.

Domestic sales and distribution of medically important antimicrobial drugs approved for use in food-producing animals have decreased 28 percent since 2009, the first year of reported sales. And they have fallen 43 percent since 2015, the peak year of sales and distribution.

Even more significant opportunities for reduced antimicrobial use in the veal, dairy, and beef industries are being identified with a growing emphasis on staff training. And a 17 year tracking across swine farms for antibiotic resistance validates that cases are not going up as is often reported in the popular press. Manure management systems, crop rotations, and prairie strips are also showing promise to reduce AMR content and limit environmental impact.

The NIAA is dedicated to eradicating diseases that pose a risk to the health of animals, wildlife, and humans; promoting the efficient production of a safe and wholesome food supply for our nation and abroad; and promoting best practices in environmental stewardship and animal health and well-being.

There are still too many resistant infections and too many deaths from antibiotic-resistant threats each year. Some resistant infections are increasing, and new resistant pathogens have emerged.

Therefore, NIAA will continue to provide leadership in the *One Health* fight against antibiotic resistance and ensure agriculture remains a valued part of the discussion. We will keep bringing together stakeholders for this conversation, including the environment, humans, and animal health. And we will continue addressing AMR issues from communication through global policy as we seek to be a part of the solution in this global battle.

PRESENTATION HIGHLIGHTS

SECTION 1:

IMPROVING COMMUNICATION ABOUT ANTI-MICROBIAL STEWARDSHIP

What Makes Communication About Antimicrobial Stewardship Difficult?

Andy J. King, PhD, Assistant Professor, Greenlee School of Journalism and Communication, Iowa State University

Dr. King began his introductory remarks with a definition of antimicrobial stewardship. These are actions taken to preserve the effectiveness and availability of antimicrobial drugs through conscientious oversight and responsible medical decision-making while safeguarding animal, public, and environmental health.

"Antimicrobial stewardship considers various behaviors, including responsible use of antibiotics, integrating alternative medical solutions, and a focus on disease prevention strategies," explained King. "It is a *One Health* approach encompassing animal, human, and environmental health and how each affects the others."

The communications content of the 2020 Symposium was in direct follow-up to discussions from last year's Symposium work. At that time, 2019 attendees were tasked with identifying audiences, motivations, and goals related to their antimicrobial resistance communications. Symposium attendees were divided into four groups including (1.) veterinarians, researchers, and academics, (2.) producers and farmers, (3.) industry representatives, and (4.) government officials to address the audiences, motivations, and goals surrounding this issue.

One of the first questions posed in 2019 was, "*What makes communication about antimicrobial stewardship difficult*?" Responses from attendees could be grouped into the following four broad challenges:

- Consumer misperception about antibiotic use, particularly in animal agriculture
- Lack of knowledge about agriculture in general by members of the public
- Misleading or incomplete news media coverage about antibiotic use in agriculture
- Social media and social network misinformation about antibiotics

While individual responses pointed to specific sub-groups within these broad classifications, overall response and discussion focused on these four challenges.

Members of these four groups were next asked, "*Who are your key audiences of interest for communicating about antimicrobial stewardship and resistance*?" Key audience differences among these four groups were as follows:

- For producers and farmers, consumers, media members, and policymakers were their audiences of interest
- Academics, veterinarians, and researchers were primarily interested in communicating with veterinary students and producers
- For industry representatives, consumers and retailers were their key audiences of interest
- Government officials pointed to producers and legislators as their key audiences

While there was some overlap, it is important to remember these target groups have additional segmentation within the broad group. Therefore, message content should address this diversity.

"A common point of frustration expressed during the 2019 Symposium was how participants wanted people to change based on the information they provided," King shared. "Sometimes, the change was knowledge or perhaps consumer behavior, but it was often unspecified."

These findings were used to design the 2020 Communications Section of the NIAA Antibiotics Symposium. King introduced the section by explaining, "This section's speakers are all people with 'boots on the ground' experience in agricultural communications who will present various strategies they use every day."

Last year, there was also a significant focus on the accuracy of scientific information reaching audiences. Yet, King pointed out, "While it is a paramount goal, accuracy alone is rarely enough to be a successful strategic communications strategy. Other audience factors to consider include things like ability, motivation, norms, and values." The following speakers addressed these contributing factors through their experiences, practices they are currently engaged with, past industry efforts, and the next generation of communications strategies for agriculture.

King researches strategic health communication, focusing on campaign design and evaluation. His work advances applied communication theorizing relevant to message design and message processing in health-related contexts, with the goal of contributing to improving public health through evidence-based practice. Much of his research has looked at visual imagery's role and influence in strategic health messages. King has published over 30 peer-reviewed journal articles in outlets including *Journal of Health Communication*, *Cancer Epidemiology*, *Risk Analysis, Journal of Communication* and *Health Communication* and has received research funding from the Health Resources and Services Administration and the National Institutes of Health. He serves on the editorial boards for *Communication Monographs, Health Communication,* and *Journal of Health Communication.* King received his PhD in Communication from the Purdue University Brian Lamb School of Communication in 2012; his secondary areas of study included Research Methods and Social

Psychology. He received his MA in Communication from Purdue in 2008; his secondary area of study was Social Influence. And he graduated with a BS in English Education from the University of Wisconsin-Whitewater in 2006 Cum Laude with a Minor in Speech Communication. King has participated in the NIAA Antibiotic Symposium for several years as a steering committee member. His health communication and persuasion skills have helped NIAA address the complexities of communicating about antimicrobial stewardship in animal agriculture.

Observations in Hindsight

Terri Moore, Vice President of Communications, American Farm Bureau Federation

Moore challenged Symposium participants to consider what can be learned from ways agriculture has handled antibiotics issues in the past. "When we realized antibiotic use was a growing concern, we relied on science and facts to make our arguments," she recalled. "We minimized people taking up the issue as ill-informed or activists stirring things up." There wasn't a coordinated effort by agriculture to frame the issue.

"Once the agricultural community started to engage with antibiotics use, we focused on farmer benefits," Moore added. "We talked about farm efficiencies and cost-effectiveness, rather than values that connected with consumers." The agriculture industry failed to focus on the powerful message that *antibiotics are used in animals for the same reason they are used for people, to prevent pain and suffering.*

Many groups chose to regard that powerful message as "elementary" and something that didn't need to be said. "Instead, we decided to focus on science and data," explained Moore. "However, values are three to five times more powerful in building trust than science and facts."

Early in the dialogue, agriculture was reluctant to acknowledge we shared the public's concern about antibiotic resistance. "Some people even felt by saying that, we were accepting blame for the problem," she said. "If we can't say we share a growing concern with the public, then we're probably going to find ourselves in trouble."

Moore described how our use of scientific terms and jargon talked over people. "It doesn't matter how accurate you are if no one understands what you're saying," she explained. Finding that balance on a topic this complicated was a challenge for ag. "Our goal should be to communicate on an eighth grade level of understanding to reach the broadest audience, and we missed that goal by a wide margin."

Our common vocabulary is not necessarily familiar to everyone. Consider questions such as "What are the minimum residue levels? Can you compare and contrast resistance vs. residue?" As communicators, we must step back from our messaging to evaluate it objectively, and this has been one of the most challenging aspects of addressing antimicrobial stewardship.

"We also did a poor job addressing the concern that agriculture was responsible for human antibiotic resistance," she added. The first thing ag did was point the finger at human health and the overuse of antibiotics in that community.

"Rarely does the blame game build trust," Moore pointed out.

We didn't say, "This is a shared concern. We all have a role to play, and here's some information about the various contributing factors." Instead, our wide diversity of voices within agriculture was confusing because we hadn't coalesced into one voice, consistently addressing the public's concerns.

Moore also believes agriculture should have engaged the food supply chain much sooner regarding this issue. "Once the major restaurant chains began promoting antibiotic-free meat, the battle became so much bigger," she explained. But, we've learned from our mistakes, and agriculture is doing a much better job engaging the food system today.

"We also had a fair amount of criticism of alternative practices in the ag community," Moore added. Harsh things were said about antibiotic-free animals. We saw criticism and the shaming of practices the public aligned with strongly. "That makes finding common ground exceptionally difficult."

"When the conversation heated up about a ban on growth promotion, we didn't accept responsibility and appeared to be unsupportive," she said. And this was at a time when the vast majority of the country thought this was a responsible move in the right direction. "Our approach could have been very, very damaging. Fortunately, our bickering didn't sidetrack the eventual success of the strategy."

Moore concluded her remarks by reminding listeners, "This isn't a new challenge." Finding shared language and values in communication efforts surrounding antimicrobial issues can be very useful. Moore encouraged symposium participants to access our circle of friends and run statements past them as we develop our messaging. Ask, "What do you think of this? What do you think this means?" to help ground our messaging. "How important is it to use a scientific term if people don't understand its meaning?" she questioned.

People telling their story is also a powerful way to communicate shared values. "Throughout the conference and afterward, be thinking about how you can tell YOUR story of antimicrobial resistance and stewardship," Moore recommended. "It can be very powerful. Yet, the scientific community is often the most reluctant because they rely on this issue's science and data."

"We have moved to a tribal society," she explained in closing. "We used to respect voices of authority, but now we look to people we can relate to and have built trust with instead." Consider saying, "I'm a dad first, and nothing is more important to me than feeding my kids safe food. I would never do anything otherwise. So let me tell you what I know about antibiotics in meat." That immediately opens the door to other parents, and they think, "He cares about what I care about."

Moore leads American Farm Bureau Federation communications at the national level, coordinating with affiliated Farm Bureaus in all 50 states to serve nearly 6 million members. Previously, she led communications operations at the state and federal levels, including as Deputy Director of Communications at the White House, Director of Communications at USDA, Chief of Staff in the US Senate, and Communications Director for the Governor of Nebraska. Moore also worked as a communications consultant in the private sector and for the Center for Food Integrity. She began her career as a broadcast news reporter and anchor. Her more than 20 years of experience in strategic, government, and crisis communications provide insight into best practices for effective communications, media engagement, and consumer trust-building. Moore studied communications at the University of St. Thomas.

Farm Tours: Sharing the Story of Responsible Farming

Claire Masker-King, Director of Sustainability Communications, National Pork Board

More than ever before, consumers have questions about how their food is raised. That includes questions about antibiotic use on livestock farms. Therefore, the agricultural industry has a greater responsibility to answer those questions.

"At the National Pork Board, we hear those questions and concerns," Masker-King explained. "We're committed to helping consumers understand how antibiotics are used on pig farms across the country."

The National Pork Board has been able to accomplish this outreach for the past several years through Farm Tours. Over the past several years, more than 200 influencers have visited about 20 farms. Visitors include public health officials, social media influencers, media, and registered dieticians.

"Our goal is to create a farm tour experience that helps tell that story," Masker-King explained. "We want to build a better understanding of responsible pig farming." For each tour, the National Pork Board invites 10 to 12 influencers to visit a specific farm and learn how pigs are raised.

"We intentionally keep the tours small because we believe in the one-to-one experience and interactions with farmers, veterinarians, and their staff," she said. "We focus on influencers in the social media space or public health officials because we want them to feel confident asking questions."

Tribal communications mean we trust those influencers. Masker-King explained how research indicates some Gen Zers believe individuals they follow on YouTube know them better than their friends or family. "We want to reach out and work with influencers," she added. "That's why we think it's a good investment of a farm's time."

Masker-King outlined four keys to successful farm tours as follows:

1. **Preparation**: "We work one-on-one with the host farms to help them feel as prepared as possible," she explained. "This includes pre-farm tours and walking through potential questions that might be asked." National Pork Board staff describes how farmers can answer questions while simultaneously sharing their values, so this information has a more significant impact.
2. **Communication**: "We communicate openly with our farm tour participants. For example, we explain showering-in to keep animals healthy, which means less antibiotic use," she said. Staff also makes sure to have shower-in kits that include the individual sizes participants need to make this step as easy as possible.
3. **Transparency**: Open and transparent storytelling happens on National Pork Board farm tours. "No question is off-limits for our influencers to ask," she shared. "We let the farmers know they can answer the questions themselves."
4. **Expertise**: "Farmers don't farm alone," Masker-King concluded. "We have a full team including veterinarians, agronomists, and other experts from whom influencers can also learn." The National Pork Board believes this helps their guests believe farmers are doing what's right for the animals they steward. She added, "This is especially important for antibiotics use and working hand-in-hand with veterinarians."

Masker-King shared a powerful photo of a food blogger from Michigan who had the chance to assist a sow in delivery. She summarized, "With these four keys to farm tour success, the National Pork Board could allow our farm tour guests to have these once in a lifetime experience."

Their focus on preparation matters, as demonstrated in pre- and post-surveys. "We move a majority of individuals to extremely favorable attitudes about the use of antibiotics on the farm," she shared. One farm tour participant answered the question, "What is your opinion on how pig farmers use antibiotics on their farms to treat pigs?" with the following reply:

"I get it 100%. Antibiotics are used sparingly and only when necessary to ensure the pigs' comfort and health, but antibiotics do not make it into the food chain for us as consumers."

"We're interacting with farm staff, we're asking tough questions, and we're open and honest in our answers," Masker-King explained. And that commitment is impacting guests long after they leave the farm.

One of the influencers from a National Pork Board tour shared the following on her social media account after her farm experience:

"Having seen the entire operation, all the pigs are healthy. I stand behind farmers and their methods. It makes me feel good about where my food comes from."

Posting this quote demonstrates positivity. "We use influencers because they are so much better able to tell their story to the mass consumer audience," Masker-King said. "For public health officials, they can have tough discussions with this experience in mind."

The National Pork Board is very proud of its farm tours program. And while they also offer virtual tours, the board has found the in-person tours the most impactful.

The organization selects influencers depending on their audience. "We've recently focused on public health officials and dieticians, especially those in grocery stores," she said. "We want to provide them with the resources they need."

For social media influencers, Masker-King recommends choosing both a macro- and a micro-influencer for each tour. "We look for the middle of the road individuals. If they are against eating meat, we're not going to have the opportunity to change their mind and have a positive conversation." But for those individuals looking for information or to learn more about where their food comes from, the National Pork Board farm tour program welcomes them with genuine hospitality.

Masker-King leads sustainability communications planning, assists with issues management, and conducts proactive media relations outreach. She also serves as the communications liaison to the International Marketing Staff of the Pork Board. She earned her BS in Animal Science with an Agriculture Education Communications option from Iowa State University. She also earned her MS in Agriculture Education from Iowa State University.

Connecting Academia and Industry: The Potential of Agricultural Communications Education and Research

Courtney Meyers, PhD, Associate Professor of Agricultural Communications, Department of Agricultural Education and Communications, Texas Tech University

The United States Department of Agriculture's National Institute of Food and Agriculture (USDA NIFA) funded Dr. Meyers' grant to develop multimedia case studies on controversial agricultural issues. One of those issues was "Antibiotics in Animal Agriculture." Research details are publicly

available at www.communicatingagissues.wordpress.com. The results have been integrated into coursework at more than ten universities nationwide, including Meyer's own "Communicating Agriculture to the Public" course at Texas Tech University.

In the case study, "Antibiotics in Animal Agriculture," students learned to describe the problem of antimicrobial resistance and its connection to antibiotics usage in animal agriculture. This includes the terminology unique to the issue, which is especially important for students from non-farm backgrounds.

Students defined sources of scientific controversy and analyzed how those manifest in this issue. To answer the question, "Why are antibiotics in animal agriculture of concern?" the case study asked the following two questions:

> 1.) "Is this a fundamental scientific controversy?" And the answer is no. There are few to no fundamental scientific controversies in the issue of antibiotics in animal agriculture.
> 2.) "Is this a secondary scientific controversy?" This time, the answer is yes. The issue includes many secondary controversies, and this is where much of the communication centers for animal antibiotic use. One critical secondary debate poses the question, "What sector is the main culprit?" Answering this question includes exploring the role of human health in the antimicrobial issue.

The scientific controversy surrounding this issue also includes conflict over applications. Students in this case study explored the therapeutic uses of antibiotics vs. growth promotion uses in animal agriculture.

An additional source of scientific controversy stems from the conflict between scientific idea and non-scientific viewpoint. "Consumers believe they are consuming antibiotics in animal products," explained Meyers. The case study also reviewed the influence of food marketing and absence labeling -- which focuses on what is not in a product -- and how this also influences consumers.

Students applied relevant risk processing theories and concepts to write effective key messages about the topic in the case study's final stages. This includes people's reliance on emotion to make choices, even when significant information is available. Students used audience analysis based on the importance of knowing your audience. Socio-demographics taken into consideration included age, gender, and education. Psychographics such as values, opinions, and feelings were more challenging to include.

Risk information processing theories can be described as how people make choices based on their feelings. Meyers adds, "It helps us understand how people may think about the topic of antimicrobial stewardship."

"Farmers and veterinarians experience the benefits of antibiotics directly," Meyers explained. This results in a vividness of benefits and possible strong feelings. "They have witnessed how antibiotics can help an animal recover from illness."

People responding to this issue from an animal welfare point of view are making choices based on emotional feelings, as well as a logical basis. Still, others may be aware of and understand risk probabilities.

"But most people don't have that vivid connection to antimicrobial stewardship," she said. The exception may be when general consumers see media coverage of people who have contracted "superbugs." The resulting illness and death portrayed in these stories may include a vividness of horribleness resulting in overall negative feelings. "In contrast, the benefits of antibiotic usage on farms are unfamiliar or unknown," according to Meyers.

The agricultural communications professor next shared additional related research titled "A multi-media study of the influence of online and traditional media on public opinion of antibiotic use in livestock" conducted by Garrett Steede in 2018. Steede is now an assistant professor at the University of Minnesota.

Meyers and Steede looked at this topic to better understand how online and traditional media discuss antibiotics in livestock, including the development of antibiotic-resistant bacteria. They wanted to determine what impact that presentation had on public opinion by looking at three phases.

In Phase One, Twitter content analysis reviewed 844 tweets that mentioned livestock, antibiotic, and resistance over eight months. The top 10 key influencers had a combined total of more than 350,000 followers. "Seven of these individuals had no defined scientific credentials," pointed out Meyers. "And, none of the content created and shared by these accounts discussed the topic of antibiotic use in livestock positively."

In Phase Two, the researchers analyzed national newspaper content about antibiotic use and livestock resistance between 1996 and 2017. The three newspapers were the *New York Times, Washington Post,* and *USA Today*. They specifically explored the role of scientific sources used in content appearing in these papers and found:

27.4% cited or quoted a government scientist
19.3% used a human or animal medical doctor as a source
18.9% cited the work of a university scientist
13% quoted an industry scientist
8.5% used another type of scientist as their source
42.2% cited or quoted no scientific source when writing on antibiotic use and livestock resistance

Therefore, the reliance on information accuracy may not be reaching the end-user through these media outlets alone.

"We also looked at how national U.S. newspapers frame the antimicrobial stewardship issue," Meyers added. The primary lens or way the issue is being described or defined may be characterized by the following:

- Change: This lens recognizes the industry is trying to change and includes growth promotion, the threat to human health, and policy change information
- Blame: This lens often references the flawed 80 percent Food and Drug Administration (FDA) figure and focuses on animal welfare. "Approximately one quarter of these articles used the flawed FDA figure and indicated antibiotics were used in livestock to combat poor animal welfare practices," explained Meyers.
- Human Impact: This lens defines antibiotic resistance through medically important antibiotics, focusing on human misuse and sickness.

Phase Three of the survey contained an embedded experiment and involved almost 300 people. Participants were randomly assigned a fake Twitter account. "The content was framed based on the results of Phase Two," explained Meyers. "The Twitter accounts consistently provided information framed by a Change, Blame, or Human Impact lens."

The respective themes of the fake accounts may be described as follows:

- Change: "We are here to work with human and animal medicine to make a legislative change to protect human health."
- Blame: "Farmers and ranchers pour antibiotics into livestock to keep them healthy in the deplorable conditions they are kept in."
- Human Impact: "Bacteria develop the ability to resist the effects of antibiotics when we do not use antibiotics prescribed by our doctors appropriately."

"After reading their assigned fake Twitter profile, we found respondents who saw the Blame frame were most likely to change their opinion," she shared.

"Consumers were more likely to trust the information when framed as an issue caused by the livestock industry." However, these participants were also more likely to seek additional information on the topic. "this may be a communications opportunity."

according to Meyers. When addressing the issues of antimicrobial stewardship and resistance, consider using the approach, "You may have heard….but these are the facts…."

Dr. Meyers recommended stakeholders practice the following steps when addressing this issue:

- Social media monitoring: Know what's being said and who's saying it.
- Creating tailored content, targeting the needs of the audience
- Including scientific sources to help explain the issue
- Communicating information regarding animal welfare and antibiotics used in livestock, as well as new developments and discoveries regarding antibiotic use in livestock
- Highlighting the impact of the Veterinary Feed Directive (VFD) on livestock's contribution to the development of antibiotic-resistant bacteria

"All communication should focus on two things, your audience and your purpose," Meyers concluded. "Keep those in mind to ensure you are developing the right key messages to the right people in order to achieve the outcome you desire."

Meyers serves as the Agricultural Education and Communications Department's graduate studies coordinator. Her research explores message development about agricultural science topics and message effects on information processing, attitude formation, and behavior change. She teaches undergraduate and graduate courses in web design, public relations writing, and online media strategy with an emphasis on service learning. Recognized as a Texas Tech Integrated Scholar, Meyers is a member of Texas Tech's Teaching Academy. She has received several teaching awards at the college, university, and national levels, including the Texas Tech's Chancellor's Council Distinguished Teaching Award in 2018, the US Department of Agriculture's New Teacher Award in 2015, and the Texas Tech President's Excellence in Teaching Award in 2014. Meyers also received the Outstanding Agricultural Communications Educator Award in 2019 from the American Association for Agricultural Education. She earned her BS from Kansas State University, her MS from the University of Arkansas, and received her PhD from the University of Florida.

BREAKOUT SESSION: Improving Communication About Anti-Microbial Stewardship

Hugh Sanburg, Vice-Chair of Beef Promotion Operating Committee for the Cattleman's Beef Board

"Farmers and ranchers are feeling pressure like never before around the perceived links between antimicrobial resistance in humans and food animals," said Sanburg. "Livestock producers work hard every day to maintain the health of the animals they care for, and they must be engaged in the conversations surrounding antibiotic use. Producers must be empowered with the knowledge, skills, and resources to allow their voices, values, and experience to be heard."

"Consumers want to know more about their food," he added. "They want to know how it was raised and fed and kept healthy." The cattleman encouraged stakeholders to visit www.drivingdemandforbeef.com for more information.

Sanburg introduced the Breakout Sessions focused on the afternoon's theme of Improving Communication about Anti-Microbial Stewardship.

Sanburg is a cow/calf and seed stock producer in Eckert, Colorado. He raises registered Hereford cattle at his Cedar Park Ranch, as well as a commercial beef herd. Sanburg is actively engaged in the Colorado Farm Bureau Federation, the Colorado Cattleman's Association, and the Delta County Farm and Livestock Bureau. He was also the US Meat Export Federation representative to the Cattlemen's Beef Board. Sanburg received a BS degree in Mining Engineering from the Colorado School of Mines in 1983.

SECTION 2: UPDATES ON HUMAN HEALTH AND RESEARCH

Carbapenemase-Producing Organisms and CDC Strategy to Prevent Spread In U.S. Healthcare Facilities

Maroya Spalding Walters, PhD, ScM, Epidemiologist, Division of Healthcare Quality Promotion, United States Centers for Disease Control and Prevention (CDC)

Carbapenemase-producing organisms are an urgent public health threat. They spread rapidly in healthcare settings and cause infections with limited treatment options. The CDC has developed a containment strategy to prevent these organisms' spread while learning lessons about outbreaks and public health response.

Dr. Walters leads the Antimicrobial Resistance Team in the Division of Healthcare Quality Promotion at the CDC. She presented information on the "Shedding of OXA-181 Carbapenemase-producing *Escherichia coli* from companion animals after hospitalization in Switzerland." This outbreak occurred in 2018.

Walters also addressed transmission between companion animals and humans, and specifically transmission between dogs and humans. The direction of transmission is unknown.

The control of Carbapenem-resistant Enterobacteriaceae (CRE) is dependent on the following factors:

- Ability of veterinary clinical laboratories to detect
- Companion animal identification and risk factors
- Spread in veterinary settings to animals, providers, and owners

- Public health response in veterinary settings including messaging to owners

These factors can support effective interventions in veterinary settings.

Walter's summarized that the containment strategy has worked well in clinical settings to detect hidden outbreaks and prevent further spread. This has been augmented by outstanding detection and response capabilities. She noted, "Emerging resistance is most easily controlled in healthcare settings."

Both international and domestic reports indicate Carbapenemase-producing organisms (CPOs) are a rare but possibly growing concern to veterinary settings. A coordinated approach is needed to keep animals, veterinary workers, owners, and the public safe.

"While this is extremely concerning, we have evidence we can get it under control with the right resources," Walters concluded. "The promising data shows it is possible to manage with intervention strategies."

Walters leads the Antimicrobial Resistance Team in the Division of Healthcare Quality Promotion at the US Centers for Disease Control and Prevention (CDC). She completed a BA in Chemistry at Carleton College, a Master of Science in Epidemiology, and a PhD in Biochemistry and Molecular Biology, both from the Johns Hopkins Bloomberg School of Public Health. Walters joined the Epidemic Intelligence Service at the CDC in 2011 and continued at CDC as a staff epidemiologist. She and her team prevent the spread of emerging antibiotic resistance like bacteria-harboring Carbapenemase enzymes and the drug-resistant yeast Candida Auris through disease surveillance and public health response activities.

United States Department of Agriculture Agricultural Research Service: Providing Solutions for Agriculture

Developing and implementing antimicrobial resistance solutions for healthy people, healthy animals, and a healthy environment

Roxann Brooks-Motroni, DVM, PhD, National Program Leader for Animal Health, United States Department of Agriculture (USDA), Agricultural Research Service (ARS)

"The Agricultural Research Service (ARS) conducts research addressing agricultural issues of high national priority," explained Dr. Motroni. Antimicrobial resistance is a priority topic for both the USDA and ARS." The efforts include multidisciplinary, systems-based, solutions-oriented research to reduce AMR's emergence, persistence, and spread.

ARS has the unique expertise and infrastructure to conduct research to identify factors associated with AMR's emergence and develop tools that mitigate AMR. These tools can be used when working in processing facilities, on-farm, and in the agricultural environment.

Today, under the *One Health* framework, AMR research is being conducted in projects under multiple national programs of the USDA, including:

- Food Safety
- Animal Health and Production
- Aquaculture
- Soil and Air
- Plant Health
- Product Quality
- New Uses

ARS touches on many different AMR aspects as they seek solutions for the many stakeholders impacted by this challenge.

The National Strategy for Combatting Antibiotic-Resistant Bacteria (CARB) was recently revised for 2020-2025 and just published. However, the goals did not change and remain as follows:

> Goal 1: Slow the emergence of resistant bacteria and prevent the spread of resistant infections
> Goal Two: Strengthen national *One Health* surveillance efforts to combat resistance
> Goal Three: Advance development and use of rapid and innovative diagnostic tests for identification and characterization of resistant bacteria
> Goal Four: Accelerate basic and applied research and develop new antibiotics, other therapeutics, and vaccines
> Goal Five: Improve international collaboration and capacities for antibiotic-resistance prevention, surveillance, control, and antibiotic research and development

The Agricultural Research Service (ARS) is primarily involved in goals two, three, and four.

Motroni shared that reporting in the next year will include work on Goal Two, strengthening national *One Health* surveillance efforts to combat resistance. The ARS will support the national infrastructure for antibiotic resistance surveillance across *One Health* by improving capacity, utility, timeliness, and the use of harmonized terminology.

“We will also establish new capacities for collecting antibiotic resistance data from the environment, including water and soil,” she explained. “ARS is working with the Environmental Protection Agency (EPA) on pilot studies, determining how data will be collected and analyzed.”

Work towards Goal Three, advancing the development and use of rapid and innovative diagnostic tests to identify and characterize resistant bacteria, will include developing and validating new diagnostics. "We plan to develop new or enhance existing diagnostics that use isolates and primary samples," she explained. "These isolates and samples will help us determine the presence, severity, or antimicrobial susceptibility or resistance of bacterial or fungal infections and identify appropriate treatment."

The ARS hopes to support ten new antibiotic resistance-related diagnostics projects across the U.S. government by 2021 through funding, scientific or technical support.

"Some of the ARS' most ongoing work is included within Goal Four," said Motroni. "We plan to enhance basic research on antibiotic resistance mechanisms and support translational and clinical research on therapeutics, vaccines, and diagnostics." The National Institutes of Health (NIH) will support at least 1,000 publications focused on basic, translational, and clinical research to combat antibiotic resistance by 2021. "Conducting basic research includes looking for alternatives to antibiotics," she added.

A second activity within Goal Four includes supporting new investigators and new entrants in the field to improve research capacity on antibiotic resistance. "We plan to provide support to at least 60 new or early-career investigators by 2021, also working with NIH," she shared. The ARS will also enhance interagency collaborations to accelerate basic and applied research for developing new antibiotics, therapeutics, and vaccines.

Work within Goal Four also includes expanding fundamental and applied interdisciplinary research to understand better the emergence, spread, and persistence of antibiotic resistance. "We will work to develop mitigation strategies for antibiotic resistance in human, animal, agricultural, and environmental settings," she explained.

Additional objectives include advancing the understanding of the emergence, spread, and persistence of antibiotic resistance. ARS plans to intensify basic, translational, and clinical research to support the discovery and development of new treatments, including antibiotics, non-traditional therapeutics, and optimized treatment regimens.

"We plan to support the discovery and pre-clinical development of new therapeutics by awarding ten new projects aimed at therapeutic discovery or development by 2024," she explained. "We also plan to identify one candidate therapeutic for bacterial infections in human medicine for further research and development by 2022." The ARS hopes to identify one candidate therapeutic for bacterial infections in agriculture for further research and development by 2021. They will be reporting these success stories in both human health and agriculture initiatives.

The ARS will intensify basic, translational, and clinical research to support the discovery and development of new preventative products or strategies. They will include projects with both human medicine and agricultural uses.

Motroni next shared ARS research highlights from the past couple of years. They have been working with Methicillin-Resistant Staphylococcus Aureus (MRSA) in swine to address public health concerns. The goals of this study are to provide answers to the following questions:

1. "How genetically related are the ST5 isolates obtained from swine to ST5 isolates obtained from humans?"
2. "Do production practices like the use of in-feed zinc as an anti-diarrheal agent contribute to MRSA's emergence and spread in U.S. swine populations?"
3. "What is the potential for ST5 isolates obtained from swine to cause disease in humans?"

The study showed different antimicrobial resistance (AMR) profiles between swine and humans. And, the majority of the resistance was consistent with antimicrobial use in the industry.

"A majority of resistance genes are harbored on Multi Genetic Elements (MGEs) with different MGEs encoding resistance in each subset," she added. "This indicates a potential for transfer of resistance."

Distinct differences in large animal (LA) MRSA and clinical MRSA isolates were identified. Two distinct clades of different bacterial families were formed between LA MRSA and clinical MRSA. The antimicrobial resistance genes also differed between subsets and seemed to relate to selection pressures. Virulence factors were absent from LA-MRSA ST5 isolates, including immune evasion genes, ACME, and speG.

A second research study Motroni outlined was focused on the environment and titled, "Multi-layered system of environmental media for the removal of antibiotics from wastewater." The study was

"We know wastewater effluent has antibiotics in it, as well as antibiotic-resistant bacteria," Motroni explained. "The question is, 'What do we do about it?'"

conducted by Drs. Ashworth and Ibekwe of the ARS's US Salinity Lab in Riverside, California.

Additional Waste Water Treatment Plant (WWTP) effluent treatment strategies are needed to remove antibiotics, antibiotic-resistant bacteria, and antibiotic-resistant genes, which are considered emerging environmental contaminants. Existing approaches have both advantages and disadvantages.

"Simple, low-cost, but effective approaches with a wide range of applicability would be ideal," she explained. Such approaches need to be assessed in terms of antibiotic removal efficiency under a wide range of conditions. "The goal is to prevent these antibiotics and antibiotic-resistant bacteria from getting out and into the environment."

Aims and objectives of Drs. Ashworth and Ibekwe's research study were to design and test a system of layered environmental media for antibiotic removal from water. They sought treatments that were low cost, simple, and scalable.

The researchers also desired to make the processes controlling antibiotic removal clearer to understand. They wanted to identify the media or combinations of media that offered the best antibiotic removal efficiency. And to assess the potential for antibiotic resistance to develop within the system; this specific work remains in progress.

The researchers developed several gradients and measured various treatments' ability to remove different antibiotics from the wastewater. They found the system was very effective at the removal of Amoxicillin, Cephalexin, and Tetracycline. It was less effective for the removal of Sulfadiazine.

"Decreasing the flow rate improved effectiveness, whereas the presence of dissolved organic matter decreased effectiveness," she explained. "Degradation within the system was the primary loss pathway for all compounds."

The different media layers included sand, soil, Biochar, and gravel. And each of the media interacted differently with the various compounds. "This suggests that combinations of layers may be important to effectively remove the wide spectrum of antibiotic compounds typical of wastewater," Motroni summarized. In other words, no one medium will be useful for all compounds.

The final research presented by Motroni was "L-glutamine as an antibiotic alternative" by Dr. Jay Johnson at the Livestock Behavior Research Unit in Lafayette, Indiana. L-Glutamine (LG) is a conditionally essential amino acid. Supplementation is required during times of increased stress, such as the weaning and transport of pigs.

"L-Glutamine inhibits inflammation and is a major energy source for the intestine," said Motroni. "It is also commonly used as a dietary supplement in humans." Researchers sought to determine if it was an alternative to a prophylactic antibiotic for weaned and transported pigs.

Over the past several years, LG research has shown that it improves pig growth performance similarly to prophylactic dietary antibiotics. ARS is continuing to explore the mechanisms of why it improves performance. Motroni referred to this as the "science of why."

"LG inhibits inflammatory biomarkers similarly to prophylactic antibiotics," she added. "It also improves markers of intestinal health compared to prophylactic dietary antibiotics." Further, LG improves behavioral indicators of stress similarly and increases intestinal microbial diversity relative to prophylactic dietary antibiotics.

As she concluded her remarks and review of recent and ongoing ARS research, Motroni noted, "I hope the industry will be able to adapt to these recommendations."

Motroni provides the strategic direction and national coordination for the USDA's intramural research program focused on bacterial and parasitic diseases of importance to animal health in nine research locations across the country. She is actively involved in coordinating and communicating the agency's research in antimicrobial resistance (AMR). Additionally, she serves as the ARS's representative on many interagency groups. Motroni holds a Doctor of Veterinary Medicine and a PhD in Comparative Pathology from the University of California, Davis. And, she completed advanced training in food animal ambulatory and production medicine at the University of Tennessee. Motroni also raises beef cattle and mentors pre-vet and veterinary students, as well as American Association for the Advancement of Science (AAAS) Fellows.

SECTION 3: COMPANION ANIMAL AND EMERGING PATHOGENS UPDATE

Antimicrobial Use and Stewardship in Companion Animal Practice

Amanda Beadoin, DVM, PhD, Director of the One Health Antibiotic Stewardship Collaborative, Minnesota Department of Health and Adjunct Professor, College of Veterinary Medicine, University of Minnesota

"Antimicrobial resistance is a problem for human and animal health," opened Dr. Beadoin. She cited the recent American Veterinary Medical Association (AVMA) Report: *Antimicrobial Resistant Pathogens Affecting Animal Health in the United States*. Bacteria causing animal infections for both agricultural and companion animals and the antimicrobials used to treat those infections are all part of the problem.

"Animal pathogens are increasingly associated with resistance to first-line antimicrobials," she explained. "And some of these organisms also impact human health." The objective of the AVMA report cited is to raise awareness of the AMR threat and encourage action.

The report identified several pathogens of concern in canine and feline patients, including Staphylococcus spp., Enterobacteriaceae, Acinetobacter spp., Pseudomonas aeruginosa, Enterococcus spp., and Campylobacter jejuni. The AVMA calls on veterinarians to use antimicrobials only when indicated, use diagnostic testing to inform treatment decisions, and implement infection prevention and antimicrobial stewardship programs.

"Preventing infections is crucial to preventing resistant infections," Beadoin noted.

“Companion animals and their treatment are directly related to the broader problem of antimicrobial resistance,” she added. “Companion animals exhibit clinically relevant resistance, and we need tools to treat their conditions.”

However, bacterial culture and sensitivity tests are often not being conducted in veterinary practice. Antibiotics are not always well-targeted, and broad-spectrum antibiotics might be selected empirically.

“Companion animals today receive medically important antimicrobials,” Beadoin explained. “This leads to a potential spread of antimicrobial resistance.” Direct and close contact with humans, as well as pet-to-pet transmission, especially in facilities, further complicates this challenge.

Couples in households with dogs have more similar microbiomes than those living without a dog because of additional shared microbial sources. “Having a dog in the home adds bacterial diversity to adult skin,” she summarized.

Carbapenem-resistant Enterobacteriaceae (CRE) in Companion Animals is one of the specific groups of resistant pathogens that are an emerging concern for pets and people. In 2018-2019, a New Delhi Metallo-beta-lactamase-producing carbapenem-resistant Enterobacterales (NDM-CRE) outbreak occurred in a Small Animal Veterinary Teaching Hospital, and transmission lasted for more than one year. Affected patients each received several antibiotics.

Sources of CRE, modes, and the frequency of CRE transmission are mostly unknown for veterinary settings. “We do know that humans who experience close direct contact with companion animals share microbiota in the home through contact and common environments,” Beadoin explained. “Therefore, transmission is possible from owners to pets and vice versa.” While the risk to owners is likely low, underlying medical conditions or medical devices might increase the risk.

Steps for the veterinary profession to address CRE include ensuring timely detection and defining their responsibility to communicate with public health officials when outbreaks occur. “We also need to establish messaging for owners, as well as information about infection prevention and antibiotic stewardship,” she added. Detecting, preventing, and communicating about these organisms is important for the veterinary medicine profession.

"Antimicrobial use drives the emergence and proliferation of resistant organisms," said Beadoin. Therefore, she highlighted the AVMA's Core Principles of Antimicrobial Stewardship, which includes:

- ***Commit to stewardship***
- ***Advocate for a system of care to prevent common diseases***
- ***Select and use antimicrobial drugs judiciously***
- ***Evaluate antimicrobial drug use practices***
- ***Educate and build expertise***

Companion animal prescribing guidelines are available from the International Society for Companion Animal Infectious Diseases (ISCAID). These guidelines for prescribing antibiotics are available for urinary tract infections in canines and felines, respiratory infections in canines and felines, and canine superficial bacterial folliculitis. The American College of Veterinary Internal Medicine (ACVIM) consensus statement on therapeutic antimicrobial use in animals and antimicrobial resistance is an additional resource Beadoin highlighted.

A 2015 survey of veterinary antimicrobial prescribing practices among licensed veterinarians in Washington State evaluated antimicrobial use in companion animals. The survey found Culture and Sensitivity (C&S) diagnostic testing was used by 76 percent of respondents, but the cost was a significant barrier.

Inappropriate use of antibiotics is likely as high for veterinarians as it is in human health care, where more than 30 percent of outpatient prescriptions are inappropriate or unnecessary.

"These companion animal prescribing practices demonstrate room for improvement," Beadoin succinctly noted.

A task force survey of AVMA members found 16 percent of practitioners reported routinely using antibiotics for clean surgical procedures. "DVMs should be encouraged to avoid prophylactic antimicrobials for routine surgeries," she noted. "They should also practice excellent infection control in the operating room and make appropriate drug selection, especially with urinary tract infections and respiratory infections."

Studies have shown 49 percent of human inpatients receive antibiotics during their hospitalization. A preliminary study at the University of Minnesota Veterinary Medical Center showed animal care has a corresponding treatment rate at 44 percent receiving antibiotics.

Researchers found that 41 percent of animals receiving an antibiotic had no evidence of infection, identifying additional opportunities for antimicrobial stewardship. ISCAID prescribing guidelines for improved stewardship are needed for more conditions.

Information on these and other initiatives may be found at the University of Minnesota Antimicrobial Resistance and Stewardship Initiative (ARSI) website (https://arsi.umn.edu), including the *Handbook of Antimicrobial Stewardship in Companion Animal Settings* and a *Pocket Guide for Antimicrobial Prescribing for Common Small Animal Diseases*. "Several additional research initiatives are underway and will hopefully lead to national estimates of antimicrobial use in veterinary hospitals throughout America," Beadoin concluded.

Beaudoin holds a DVM degree from Cornell University, a PhD in veterinary epidemiology from the University of Minnesota, and American College of Veterinary Preventive Medicine board certification. She has clinical experience in equine and small animal medicine. Beaudoin has worked for the Centers for Disease Control and Prevention, providing technical assistance to foreign governments and hospitals establishing antibiotic resistance surveillance. Currently, she leads stakeholders to advance antibiotic stewardship in human, animal, and environmental health.

Emerging Pathogen Update: NIAMRRE, AVMA, and CDC

Michael Costin, DVM, MBA, Assistant Director, American Veterinary Medical Association (AVMA)

Dr. Costin outlined the 2020 activities of the AVMA Committee on Antimicrobials (AVMA CoA) that was formed five years ago. Today, it includes 18 representatives from species-specific allied veterinary organizations. He explained, "The Committee is advised by the CDC, USDA, FDA, and the Animal Health Institute as we develop resources for our membership."

AVMA CoA activities in 2020 included responses to numerous external stakeholders. Committee members are currently developing presentations and pursuing advocacy outlining AVMA resources. Costin added, "This includes the AVMA's definitions of antimicrobial uses for prevention, control, and treatment of disease from the AVMA Convention held in August of 2020."

The CoA is reviewing the following AVMA policies:

- Joint AVMA-FVE-CVMA statement on responsible and judicious use of antimicrobials. (FVE stands for Federation of Veterinarians of Europe)
- The Role of the Veterinarian in Animal Antimicrobial Use
- Veterinary Foresight and Expertise in Antimicrobial Discussions

• National Antimicrobial Resistance Monitoring Systems (NARMS)

They have also developed resources on antimicrobial-resistant pathogens affecting animal health in the US and responsible veterinary oversight of antibiotic drugs in US animal agriculture. Costin summarized, "This documentation will be used in Washington, D.C. advocacy efforts, among other outreach work."

Costin is a 2003 graduate of Kansas State University College of Veterinary Medicine. Upon graduation, he worked in a four-doctor mixed animal practice and in 2004 he accepted a position in an eight-doctor dairy practice where he was made a partner in 2006. In 2012, Costin sold his partnership, became a Technical Services Veterinarian with an animal health distributor, and enrolled in the University of Wisconsin's Executive MBA program. Upon completing his MBA in 2014, Costin was promoted to Technical Services Manager for his company and managed the veterinary services team. In 2015, he accepted the Assistant Director position with the AVMA. Costin serves as the staff liaison to the AVMA's Animal Agriculture Liaison Committee (AALC) and the Committee on Antimicrobials (CoA), as well as the AVMA's liaison to the United States Animal Health Association (USAHA).

AVMA Antimicrobial Resistance in Animal Pathogens Report: A One Health Approach to Examining Antimicrobial Resistance

Megin Nichols, DVM, MPH, DACVPM, Enteric Zoonoses Lead of Outbreak Response and Prevention Branch, National Center for Emerging and Zoonotic Infectious Diseases

In 2019, the CDC released the "Antibiotic Resistance Threats in the United States" report, highlighting that more than 2.8 million antibiotic-resistant infections occur domestically each year. More than 35,000 people die as a result.

"The report lists multiple pathogens characterized by the levels of Urgent, Serious, and Concerning Threats, as well as those appearing on a Watch List," said Dr. Nichols. "It also highlights the interconnectedness of antibiotic resistance, which affects humans, animals, and the environment."

Nichols highlighted that some pathogens are exclusive to humans in the CDC report, and some are found only in animals as outlined in the AVMA report. But several pathogens appear in both reports, including:

- Enterobacteriaceae
- Acinetobacter
- Multi-drug resistant Pseudomonas aeruginosa
- Drug-resistant nontyphoidal Salmonella
- Campylobacter

- Methicillin-resistant Staphylococcus aureus

This list provides opportunities for both innovation and collaboration in the future.

"The CDC report also highlights many challenges in human healthcare that provide learning opportunities for veterinary medicine," she added in summary. These include preventing the spread of germs, the importance of Containment Strategy adoption, and the consistent implementation of CDC recommendations. "Recognizing emerging threats from outside the U.S. and remaining vigilant against serious threats such as 'nightmare bacteria' CRE should also be considered."

Nichols works on multistate outbreaks of Salmonella and E. coli resulting from animal and animal product exposure. She received a Bachelor's degree in Animal Science from New Mexico State University, a Doctorate in Veterinary Medicine from Colorado State University, and a Master's of Public Health in Food Safety and Biosecurity from the University of Minnesota. Nichols' research interests include the exotic pet trade's impact on native species, zoonotic disease, food safety and biosecurity, public health law, and pediatric vaccine-preventable diseases.

Antimicrobial Resistant Pathogens Affecting Animal Health in the United States

Paul Plummer, DVM, PhD, Professor and Anderson Chair of Veterinary Diagnostic and Production Animal Medicine and Veterinary Microbiology and Preventative Medicine, Executive Director of the National Institute of Antimicrobial Resistance Research and Education (NIAMRRE), College of Veterinary Medicine, Iowa State University

"The AVMA recently released the report 'Antimicrobial Resistant Pathogens Affecting Animal Health in the United States' as another tool in the veterinarian's toolbox," began Dr. Plummer. The goal of the report is to highlight:

- The growing importance of antimicrobial resistance in veterinary medicine
- Specific bacteria responsible for animal disease that show evidence of increasing resistance
- Control measures veterinarians can use to mitigate this risk
- Resources for veterinarians making informed antimicrobial stewardship decisions

The report may also serve as a baseline for identifying and monitoring select bacterial pathogens and their impact on animal health.

"The report focuses on *Acquired Resistance,* which occurs when an antimicrobial that previously worked to kill an organism loses its effectiveness," he explained. Intrinsic Resistance pathogens were never susceptible to the antibiotic class and are therefore not included in this report.

Plummer also pointed out that not all tests are equal. "The Antimicrobial Susceptibility Testing (AST) evaluates phenotype by exposing bacteria to varying concentrations of antimicrobial drugs," he shared. "The outcome is a Minimal Inhibitory Concentration (MIC)." This is often reported as susceptible, intermediate, or resistant based on breakpoints.

The Clinical and Laboratory Standards Institute (CLSI) also has some great resources on testing interpretation. These include "VET09: Understanding Susceptibility Test Data as a Component of Antimicrobial Stewardship in Veterinary Settings" available at https://clsi.org/standards/products/veterinary-medicine/documents/vet09/.

Also included in this AVMA report are tests for Genotypic Resistance based on identifying genetic markers of resistance. But Plummer warned, "These markers do not always match with phenotype suggesting the heightened potential of resistance."

Therefore, veterinarians and producers should make informed decisions by knowing the situation of various pathogens showing antimicrobial resistance. "This report includes both phenotypic and genotypic resistance data. However, both tests have limitations, and both tests should raise the clinician's awareness of potential resistance," he summarized. "Clinical decisions should be based on the full understanding of the data, patient history, guidance documents, and clinical experience."

Antimicrobial stewardship refers to veterinarians' actions to preserve antimicrobial drugs' success and availability through careful oversight and responsible medical decision-making while protecting animal, public, and environmental health.

"The core principles of antimicrobial stewardship maintain animal health and welfare by using several strategies to prevent common diseases," he shared. "It is also important to use an evidence-based approach in judging the use of antimicrobial drugs and then using antimicrobials wisely, cautiously, and with frequent evaluation of therapy results, respecting the client's available resources."

These core principles of antimicrobial stewardship presented by Plummer include:

- Commit to stewardship
- Advocate for care systems to prevent common diseases
- Select and use antimicrobial drugs sensibly
- Evaluate antimicrobial drug practices
- Educate and build expertise

More details, including recommendations on implementing these core principles, are available on the AVMA website.

The report is structured for ease of use and is divided as follows:

Section 1: Introduction and Infographics provide a good overview. He highlighted, "One of the infographics summarizes the entire report in one page and is available for download and self-printing."
Section 2: Host Species Summaries includes information specific to dogs and cats, cattle, chicken and turkeys, equines, sheep and goats, swine, and fish and shrimp with color-coding that remains consistent throughout the publication.
Section 3: Bacterial Species Fact Sheets include a card for each pathogen included in the report. Highlights include "What you need to know," prevention actions, and resistance profiles.
Section 4: Technical Appendix for each Bacterial Species provides much more detail with additional resources for each pathogen.

"The level of detail and science increases with each section," he explained. The report is available for free at https://www.avma.org/sites/default/files/2020-10/AntimicrobialResistanceFullReport.pdf. Other AVMA resources available on the website include a stewardship checklist, dos and don'ts, and client education posters.

Plummer's clinical specialty is internal medicine and infectious disease of ruminants. He received his PhD from Iowa State University in 2009. He was a Veterinary Microbiology Resident at the University of Tennessee in 2004, and a Large Animal Medicine Intern at Texas A&M University in 2001. He received his DVM in Large Animal Medicine and Surgery from the University of Tennessee in 2000 and his Veterinary Medicine BS from the University of Tennessee in 1999. Plummer is a Microbiology Diplomate with the American College of Veterinary Internal Medicine, and a Large Animal Internal Medicine Diplomate with the European College of Small Ruminant Health Management. NIAMRRE, housed at the Iowa State University Research Park, was developed in 2018 from a national search led by the Association of Public and Land-grant Universities (APLU) and the American Association of Veterinary Medical Colleges (AAVMC) to identify a collaborative center to lead One Health efforts in AMR.

SECTION 4: FARM ANIMALS: KEY LEARNINGS FROM THE FIELD

Food Animals: Key Antimicrobial Learnings from the Field

Moderated by Heather Fowler, VMD, MPH, PhD, Director of Producer and Public Health, National Pork Board.

Dr. Fowler completed her Veterinary Medical degree at the University of Pennsylvania School of Veterinary Medicine in 2010, a Master's in Public Health in Applied Biostatistics and Epidemiology at the Yale School of Public Health in 2011, and a PhD in Environmental and Occupational Hygiene from the University of Washington School of Public Health in 2017. She is board certified in veterinary preventive medicine and has expertise in zoonotic disease, public health, worker safety and health, and One Health application. In the summer of 2017, Fowler became the Director of Producer and Public Health at the National Pork Board, where she oversees public health and occupational safety and health issues as they relate to swine production in the United States.

Anti-Microbial Resistance Updates from the Food and Drug Administration

William Flynn, DVM, MS, Deputy Director for Science Policy, Center for Veterinary Medicine (CVM), the Food and Drug Administration (FDA)

Important Milestones for the FDA's Center for Veterinary Medicine (CVM) include:

2003: Established process for assessing new products for food-producing animals
2009: Began publishing reports of antimicrobial drug sales
2012: Set goal to eliminate production uses of medically important antimicrobials in food-producing animals and bring them under veterinary oversight
2016: Began funding pilot projects to collect on-farm use data for AMR
2017: Fully implemented the 2012 goal
2018: Published five-year plan for fostering antimicrobial stewardship in animals
2019: Proposed process to bring other dosage forms of medically important antimicrobials under veterinary oversight
2020: Funded two research projects to collect antimicrobial use information in dogs and cats

Antimicrobial stewardship in veterinary settings is needed to optimize antimicrobial use and slow the development of antimicrobial-resistant bacteria.

The next steps include implementing the FDA's "5-Year Plan for Supporting Antimicrobial Stewardship in Veterinary Settings." Dr. Flynn explained, "We are now in the third year of this five-year plan for AMR."

CVM's key areas of focus and goals within the five-year plan include:

- Evaluating use conditions of approved animal antimicrobial products
- Promoting antimicrobial stewardship at the user level, including educational support
- Collecting data to monitor animal antimicrobial use and antimicrobial resistance; measures based on sound science that will move the needle in the right direction

"The CVM's approach to implementing these changes is risk-based," Flynn explained. "We are focusing on actions or mitigations on drugs of most significant concern." These drugs are important for human therapies and are also known as "medically important antimicrobials." To accomplish these goals, the CVM emphasizes collaboration and seeking cooperation from industry to voluntarily take action.

Ongoing critical projects within the Five-Year AMR Plan include updating the Medically Important List, also known as "Appendix A." "We have updated the process for ranking the importance of antimicrobials for human medicine," he said. This ranking guides risk-management strategies. The concept paper was published in October 2020, and a public meeting is planned for November 16, 2020, to welcome public comment.

A second ongoing project within the Five-year AMR Plan is transitioning over the counter products to being available only by prescription. "Because this impacts medically important antimicrobials that are still available over the counter, we propose a two-year phase-in period," he shared. Draft GFI #263 was published in September 2019, and the final GFI #263 is expected to be published in winter 2020.

Defining durations of use for medically important antibiotics used in animal feeds and water is a third ongoing project within the Five-year plan. "The objective is to update use conditions of affected products to determine when and for how long to administer," Flynn explained. The goal is for effectiveness to be maintained while the extent of exposure is minimized.

"This affects medically important antimicrobials used in feed," he described. "We hope to publish an initial concept paper by the end of the year, making sure any changes are based on science. We want these products to continue to be available for animal health but with improved administration."

FDA funding opportunities are available for studies that can help target and define durations of use for affected products. Two grants were awarded in 2019, and one in 2020—all three of these studies concerned cattle products.

Another ongoing project within the FDA's Five-Year Plan concerns the National Antimicrobial Resistance Monitoring System (NARMS). "The 2020-2025 Strategic Plan was announced in August 2020," he explained. "A public meeting was held in October 2020 for input on the plan, and we will

continue looking for opportunities for data collection." The theme is looking at the NARMS' plan through the One Health lens with opportunities for enhancement and expansion.

"The 2019 Sales and Distribution report is planned for publication in December 2020 in a similar format as the 2019 report," he explained in sharing a fifth ongoing project within the FDA's Five-Year Plan. "This reporting has been occurring annually since 2009."

Domestic sales and distribution of medically important antimicrobial drugs approved for use in food-producing animals decreased in these reports as described below:

- 33 percent between the years 2016 and 2017
- 43 percent since 2015, the peak year of sales/distribution
- 28 percent since the first year of reported sales in 2009

However, domestic sales increased by nine percent between 2017 and 2018. Flynn cautioned, "This is just one indicator, and it's important not to focus solely on sales data."

A sixth ongoing project within the Five-Year Plan is antimicrobial use data collection pilot projects. "For food-producing animals, two projects have been funded since 2016," he said. "One Includes beef and dairy cattle, while the second focuses on swine, chickens, and turkeys." For companion animals, two projects funded in 2020 are for dogs and cats.

The seventh and last ongoing project within the Five-Year FDA Plan Flynn shared is the AMR Assessment Report. "This report is intended to integrate and analyze available information on antimicrobial use in major food animal sectors beyond sales data," he concluded. This will involve reporting on the use, resistance, and animal demographics, among other measurements. The target is to publish the Assessment Report in the winter of 2020.

Flynn received an MS in Veterinary Preventative Medicine in 1987 and a DVM in 1991 from the Ohio State University. Following several years of private veterinary practice, he joined the Food and Drug Administration's Center for Veterinary Medicine (CVM) in 1993. He served in various capacities in CVM's Office of New Animal Drug Evaluation, focusing primarily on issues related to therapeutic drugs for food-producing animals. From 2003 to 2008, Flynn served as Director of CVM's Policy and Regulations Staff and is currently CVM's Deputy Director for Science Policy.

Antimicrobial Stewardship in Veal Production Systems

Greg Habing, DVM, PhD, DACVPM, Associate Professor and Veterinary Epidemiologist, Department of Veterinary Preventive Medicine, College of Veterinary Medicine, The Ohio State University

Dr. Habing's research team, "the One Herd Lab," combines production systems experience with expertise in traditional and molecular epidemiology. The Lab addresses critical One Health problems, including antimicrobial stewardship. Habing began his professional work as a practicing dairy veterinarian. The holistic approach in his lab includes several factors that impact epidemiologic research on farms. This includes decision-making by humans, exposure to infectious agents in the environment, and animal susceptibility.

Habing's presentation, "Antimicrobial Stewardship in Veal Production Systems," includes two take-home messages. "First, there are substantial challenges in the disaggregated male calf production chain," he introduced. ''In other words, the calf changes hands several times." And the second key message is that there are opportunities to reduce antimicrobial use through both prevention and targeted use for this dairy industry segment.

Habing went on to describe veal production as being a broken feedback loop. "Male calves receive discrepantly worse early-life care according to a study in the *Journal of Dairy Science*," he outlined. "This includes colostrum practices that impact their long-term health."

"Veal calves are sold from the dairy farm in the first week of life," he continued. "And while most dairy farmers believe their calves do well, they don't have a relationship with the growers to know where their calves end up." All these factors combine to create serious care challenges.

Most male calves are marketed through auctions after leaving their farm of birth. These facilities house calves in close contact and are usually not cleaned regularly. "93.8% of calves showed a prevalence of Salmonella in Ohio markets we studied," Habing reviewed. "While 99.1% of calves showed a prevalence for the same bacteria in Wisconsin markets."

Once they leave the auctions, these calves are distributed to a wide variety of farms. They are transported on trailers for up to 14 hours leading to additional stress on the calves. This process is disseminating multi-drug-resistant pathogens throughout a wide geographic area of the US.

"The result is that when these animals arrive at the veal grower, a disproportionately high number of animals exhibit failure of passive immunity (23 percent), dehydration (35 percent), and navel infection (27 percent)," he summarized. "Therefore, veal growers have an uphill battle improving antimicrobial stewardship and preventing disease." The result of this can be high antibiotic use.

Despite that, Habing noted, veal producers have done a good job in residue avoidance in formula-fed veal, according to the 2019 USDA National Residue Program.

A survey of veal producers conducted by Habing measured targeted antibiotic use. Approximately two-thirds of producers were using antibiotics when the veterinary protocol did not indicate they were necessary, presenting an opportunity to improve targeted use and therapies.

"We implemented antimicrobial stewardship training among these veal production systems," he described. "The intervention included didactic, in-person training on antibiotic resistance, decision-tree protocols to better target antibiotic use, and in-person veterinary training." They found that knowledge and attitudes, treatment accuracy relative to the veterinarian, and quantified antimicrobial use improved.

"Producers had more knowledge after the training. And they were better able to identify which products were antibiotics and which ones were not," he explained. "Treatment accuracy also improved with higher diagnostic sensitivity among trained farmers, although diagnostic specificity was sacrificed."

Total antimicrobial use by veal calf growers showed a high degree of variation throughout the study. However, antibiotic use was numerically lower for those receiving the antibiotic stewardship training intervention.

"Plans call for us to extend the training and resources for Midwestern calf producers through the Veal Quality Assurance Program," Habing shared in closing. "Regarding research, we also plan to identify the influencers and barriers for optimal early life care of male calves on dairy farms." The One Herd Lab will also be determining the effect of incentives or benchmarking on behavior change for dairy farm personnel, such as offering colostrum to veal calves.

Before joining The Ohio State University (OSU), Habing was a practicing veterinarian focused on dairy production systems. His research team at OSU, The One Herd Lab, combines production system experience with expertise in traditional and molecular epidemiology to address critical One Health problems, including antimicrobial stewardship and the foodborne transmission of pathogens. For example, his team is designing and assessing the impact of educational and behavioral interventions on antimicrobial use behaviors and antimicrobial resistance in dairy and calf production systems. Additionally, his team identifies pre-harvest interventions to interrupt the transmission of multidrug-resistant Salmonella spp. from livestock markets and calf production systems. Habing leads the food safety course within the Veterinary Public Health specialization for Master's of Public Health (MPH) students and teaches epidemiology and zoonoses courses to veterinary students at the College of Veterinary Medicine.

Management Opportunities to Enhance Antimicrobial Stewardship on the Dairy

Michael Capel, DVM, Partner, Perry Veterinary Clinic, Perry, New York

While antimicrobial stewardship focuses first and foremost on prevention, Dr. Capel's comments for the symposium focused on therapies and reductions of antimicrobial use in the dairy industry.

“The magnitude of mastitis is one of today’s greatest challenges in the dairy industry,” he described. “Clinical mastitis – an infection of the udder and the cow's milk-producing tissues -- is one of the highest incidence diseases of dairy cows.”

Mastitis is both a production loss and a welfare issue due to the significant pain which may result. It also leads to premature culling. He explained, “This is a high incidence disease, with approximately 25 percent of cows in dairy herds affected by clinical mastitis each lactation.”

The treatment and control of mastitis account for approximately two-thirds of antibiotic use on dairies for adult cows. “About 90 percent of cows who suffer from mastitis receive antibiotics,” said Capel. “Therefore, we have a tremendous opportunity for the reduction of antimicrobial use surrounding this diagnosis.”

“We have learned that only a small number of bacteria that cause mastitis respond to antibiotics,” he went on to explain. “Therefore, identifying the specific pathogen causing the mastitis case is extremely important for ideal treatment, especially in non-severe cases.”

Pathogen-based mastitis therapy (PBT) can reduce antibiotic use by up to 70 percent, with no adverse clinical outcomes. It is targeted antimicrobial use for non-severe clinical mastitis treatment and can help change the conversation from “what to use?” to “who do we treat?”

“Numerous trials in the past three to five years report no impact on clinical outcomes when using PBT as compared to blanket antimicrobial therapy,” he said.

Antimicrobial Dry Cow Therapy (aDCT) is a highly successful and widely adopted tool for improving milk quality. It is used at the time of dry off, near the end of a cow’s lactation when milk production ceases, and it accounts for approximately one-third of total antibiotic use by the dairy industry.

“Today, over 80 percent of farms employ Blanket Dry Cow Therapy, affecting more than 93 percent of dairy cows across America,” Capel explained. “This has the potential for a significant impact on antimicrobial stewardship.”

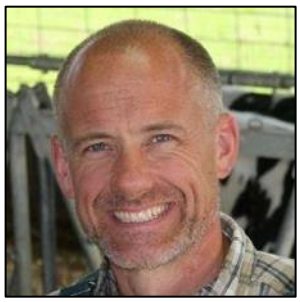
Over the past three decades, the dairy industry has made significant progress in udder health and mastitis prevention. In 1985, only 44 percent of cultures at dry-off returned negative results. Today, that statistic ranges from 73 to 95 percent.

“Far fewer cows have an infection at the time of dry-off on today’s dairies,” said Capel. “The national average for bulk tank somatic cell count – an indicator of mastitis infection in a herd -- in 1997 was 295,000 cell/mL. In 2014, it was 193,000 cell/mL.” In 1995, 27.2 percent of overall test days were over 400,000 cells/mL compared to 11.1 percent in 2016.

"This leads us to consider the opportunity for targeted antimicrobial dry cow therapies on dairies," he said.

Selective Dry Cow Therapy (SDCT) is the targeted antimicrobial use at dry-off based on individual or quarter level risk using either a culture-based or algorithm-based approach. The majority of trials report no impact on clinical outcomes though a few do report adverse clinical outcomes. Overall, SDCT can result in more than a 50 percent reduction in antimicrobial usage.

"With 9.3 million dairy cows in the U.S. and one of the highest incidence diseases that contribute to the highest antibiotic use, it's really exciting," said Capel. "I'm using this technique on the vast majority of the 250+ herds I work with in New York." These techniques are now being researched and implemented throughout America.



Capel has been a private practitioner in western New York since graduating from the Cornell College of Veterinary Medicine in 2000. He has been a partner at the Perry Veterinary Clinic for 18 years and focuses on dairy cattle, emphasizing milk quality, nutrition, antimicrobial stewardship, and clinical research. Capel is an active member of the American Association of Bovine Practitioners, chair of the Quality Milk Production Services Advisory Board, and a member of the Cornell College of Veterinary Medicine Dean's Advisory Board. He is actively involved in clinical research on farms, contract research for the pharmaceutical industry, and research in collaboration with academic institutions. He is an author or co-author of 12 peer-reviewed journal articles, covering topics such as transition cow disease and mastitis treatment strategies.

Beef: Follow-up from FDA Guidance 209 and 213 in the Field

Miles Theurer, DVM, PhD, Research Director, Veterinary Research and Consulting Services (VRCS), Hays, Kansas

Today, Dr. Theurer and his partners emphasize case definition. They work with crews to accurately identify the disease and select the appropriate treatment protocol. "This is primarily based on visual appraisal and follow-up diagnostics for conditions such as Bovine Respiratory Disease (BRD) using rectal temperatures," he explained.

The regimens are placed in a computer system, which then provides personnel with appropriate treatment. The education of personnel is based on appropriate visual diagnosis and entering treatment regimens into the system. This education was done before Guidance 209 and 213 but has been further emphasized for compliance.

One example provided by Theurer was with Laryngeal necrobacillosis, commonly referred to as diphtheria. "This is a disease of the respiratory system seen in feedlot cattle but is not BRD," he described. "*Fusobacterium necrophorum* is the most common bacterial agent that causes Diphtheria."

Fluoroquinolones cannot be used for this condition legally. It is illegal because it is not BRD, as stated on the product label. Furthermore, it will not work due to the drug spectrum. "It takes a lot of personnel training to determine the difference between diphtheria and BRD to ensure we are treating the appropriate syndrome," Theurer explained.

Today, all medically important antimicrobials administered through the feed require a Veterinary Feed Directive (VFD). "On the feedlot side of production, Tylosin and chlortetracycline (CTC) would be the main antimicrobials impacted," he said. "We have to ensure the product is labeled to be fed in combination with approved products." For example, Aureomycin with CTS is not authorized to be fed in combination with Rumensin. Implementation must also be considered.

"VRCS handles the use of CTC on a case-by-case basis," explained Theurer. "We will issue a VFD for the use of Tylosin in a feed yard based on an estimated number of cattle that will be fed over six months."

In closing, Theurer explained the use of a VFD has changed since Guidances 209 and 213 were issued. "We've emphasized education for feed yard management personnel to ensure everyone remains in compliance."

Theurer grew up on a family farm and cow/calf operation in south-central Kansas. He studied a dual DVM/PhD program at Kansas State University. His PhD was in Epidemiology, focusing on experimental design and statistical analysis. In his current role, Theurer evaluates data for the consulting group and their clients. He works directly with pharmaceutical companies, feed yard managers, and consultants to develop and execute research projects to improve cattle health and efficiency in the feed yard. The group's mission is to optimize the resources available to produce a safe and wholesome food supply. This is accomplished by practicing evidence-based medicine, data-driven decisions, personnel training, and animal welfare while maintaining the highest morals and ethics.

AMR Surveillance on Commercial Swine Farms

Scott Dee, DVM, PhD, Director of Applied Research, Pipestone Veterinary Services, Pipestone, Minnesota

"The Pipestone Antibiotic Resistance Tracker (PART) was launched in 2017 as an interactive, web-based tool that tracks and benchmarks antimicrobial use on farms," described Dr. Dee. It is fully Pipestone funded. Today, more than 154 producers across 800 sites are tracked by PART.

"This tool has tracked more than five million weaned pigs and upwards of three million market hogs in the past three years," he said. "At least 25 swine-focused veterinarians who make regular farm visits and quarterly reviews have been involved."

Dee shared an example of antibiotic use in water, feed, and injectables from producers. "The uses of antimicrobials are tracked over time for each site and compared in a benchmarking approach for all producers served by the practice," he explained. Least, intermediate, and most antibiotic use can be compared among producers. "This allows them to review antibiotic use levels at both the individual farms and in comparison to the entire group of farms served."

Significant work has been done concerning both human health and feed safety regarding AMR surveillance on the farm. Dee suggested the missing link has been livestock farms. Therefore, they have measured e coli, Gps, A suis, S suis, and Salmonella bacteria total cases from diagnostic labs for pigs in their care over time from 2003 until current.

"The surprising results indicate a relatively flat resistance over the past 17 years," he shared. "Cases are not going up as is often reported in the popular press."

Dee's work in the past few years has focused on the environment. "Tracking at the environmental level is also an important component for looking at resistance," he argued. "Our program has developed targets for the four NARMs pathogens, Salmonella, Campylobacter, Escherichia coli, and Enterococcus."

The ongoing AMR Surveillance IMAGINE project seeks to conduct AMR surveillance on commercial pig farms, identifying pathogens of food safety importance, according to NARMS, as well as the five pathogens of veterinary importance.

"We plan to compare the AMR data with antibiotic use and resistance data on our farms," said Dee. "Our goal is to validate a model AMR surveillance protocol for the US swine industry."

In year one of the IMAGINE project, Pipestone Veterinary Services is testing 160 sites, including managed sow farms and weaned to finish producers. "These sites will be tested two times each year, collecting environmental NARMS samples," describes Dee. "We are evaluating both healthy pigs and sick pigs for the five swine pathogens."

"Our metrics include phenotypic data compiled at South Dakota State University and genotypic data from the USDA," he explained. "Sample analytics include frequency of recovery and AMR trends and resistance over time and Abx usage data." Pipestone is securing second-year funding for the IMAGINE project and hope for it to run for between five and ten years.

Dee earned his DVM, PhD, and MS from the University of Minnesota. He is a board-certified veterinary microbiologist and a past President of the American Association of Swine Veterinarians. After practicing in swine for 12 years, Scott was a Professor at the University of Minnesota College of Veterinary Medicine. He studied the transmission and biosecurity of PRRSV and chaired the Admissions and Scholastic Standing committee for 12 years. In 2011, Dee joined Pipestone Veterinary Services, where he conducts collaborative research efforts with production companies across North America and Asia, comprising approximately two million sows. Dee has been awarded more than $11M in research funds, has published 159 papers in peer-reviewed journals, 200 scientific abstracts, 27 textbook chapters, and 434 proceedings papers. He has received the American Association of Swine Veterinarians (AASV) Practitioner of the Year and Howard Dunne Memorial awards, the Leman Science in Practice award, a Warrior Chip from the Federal Bureau of Investigations (FBI) Weapons of Mass Destruction Directorate, and was named a Master of the US Pork Industry. Pipestone Veterinary Services provides care to more than 300,000 sows. They utilize the Pipestone Antibiotic Resistance Tracker (PART) to monitor antibiotic resistance and demonstrate responsible antibiotic use. More information is available at www.PipestonePART.com.

Key Learnings from the Field: Global Poultry Insights

Dennis Erpelding, Consultant, Farm Animal View, LLC, Indianapolis, Indiana

"The International Poultry Council has recognized the need for an antimicrobial stewardship program," opened Erpelding. The Council has implemented a three-step process, including:

1.) Position Statement on Antimicrobial Use and Antimicrobial Stewardship Principles
2.) Adding the science and regulatory structures to the position statement, including common definitions on a global basis
3.) Best Practice Guide to reduce the need for antibiotics in poultry production at the end of 2019 including hygiene, medication, biosecurity, bird environment, and nutrition

The poultry industry asked, "Where's the scientific approach and the risk analysis of antimicrobial use?" They used the answers to develop policies for antimicrobial stewardship, including transparency of use.

"We reference best management practices with specific examples while ensuring compliance with national and global authorities," he described. These best practices will be used to develop international training throughout the poultry industry.

Erpelding then shared "Antimicrobial Use in Food Animals: Prudent Path Forward" and looked at government laws, regulations, guidelines, private sector policies, and practices. He highlighted the

importance of protecting certain drugs for human use only. "Veterinarians need to be involved in this decision-making as much as possible," he noted.

Finally, Erpelding reviewed the importance of labeling for informed consumer decisions from a global perspective. "The most basic need in developing countries is caloric intake," he counseled. "As the level of affluence grows, production practices, diet composition, and convenience take on greater importance." Global terminology in food packaging may include phrases such as:

- Antibiotic-free
- Organic
- Raised without Antibiotics
- No Growth Promoting Antibiotics
- No Critically Important Antibiotics
- No Medically Important Antibiotics

But, Erpelding noted, these labels are confusing for the average consumer. He concluded, ***"The One Health Certified label is a good alternative to provide valid information."***

Erpelding is a consultant and speaker focused on global policy and strategic counsel regarding corporate affairs, trade access, food safety, antimicrobials, sustainability, and international standards. In 2018, he founded Global Farm View, LLC to provide strategic counsel to food chain stakeholders, taking a view from the farm to the consumer. Erpelding has worked for and served Elanco, the Food and Agriculture Export Alliance, the US Dairy Export Council, the US Meat Export Federation, the International Poultry Council, the International Meat Secretariat, and the National Agri-Marketing Association. He received a Bachelor of Science degree in Dairy Science from Iowa State University in 1981, and in 1989 he earned a Master of Business Administration degree from The Ohio State University.

SECTION 5: ENVIRONMENTAL AND INTERNATIONAL UPDATES

Governmental and Regulatory Updates

Moderator: Paul Plummer, DVM, PhD, Professor and Anderson Chair of Veterinary Diagnostic and Production Animal Medicine and Veterinary Microbiology and Preventative Medicine, Executive Director of the National Institute of Antimicrobial Resistance Research and Education (NIAMRRE), College of Veterinary Medicine, Iowa State University

Plummer's clinical specialty is internal medicine and infectious disease of ruminants. He received his PhD from Iowa State University in 2009. He was a Veterinary Microbiology Resident at the University of Tennessee in 2004, and a Large Animal Medicine Intern at Texas A&M University in 2001. He received his DVM in Large Animal Medicine and Surgery from the University of Tennessee in 2000 and his Veterinary Medicine BS from the University of Tennessee in 1999. Plummer is a Microbiology Diplomate with the American College of Veterinary Internal Medicine, and a Large Animal Internal Medicine Diplomate with the European College of Small Ruminant Health Management. NIAMRRE, housed at the Iowa State University Research Park, was developed in 2018 from a national search led by the Association of Public and Land-grant Universities (APLU) and the American Association of Veterinary Medical Colleges (AAVMC) to identify a collaborative center to lead One Health efforts in AMR.

The Environmental Protection Agency's National Antimicrobial Resistance Monitoring System (NARMS) Surface Water Pilot Overview

Jay L. Garland, PhD, Research Scientist, Office of Research and Development, US Environmental Protection Agency

Dr. Garland is currently focused on advancing innovative water infrastructure approaches, including decentralized water reuse, and mitigating risks associated with antimicrobial resistance in the water cycle. "The EPA is in the early stages of planning work for a surface water pilot study," he explained. "Therefore, I won't be sharing results today. Rather, I'll be laying out the design issues and plans as we work to engage stakeholders."

The challenge for the EPA is the complexity of dealing with antimicrobial issues in the environment. "As an environmental contaminant, it's not just the presence of these genes and resistant pathogens, but also their amplification in target organisms," he pointed out. "The other unique aspect is that it's a naturally occurring contaminant."

NARMS is trying to respond to these challenges, and Garland highlighted the "Initiatives for Addressing Antibiotic Resistance in the Environment: Current Situation and Challenges" report. This 2018 international report focuses on environmental waters, including a review of the geospatial distribution of resistance to inform risk.

"The report is also trying to understand sources and selective pressures for amplification and transmission to develop widespread monitoring," he noted. "Given the complexity of these challenges, defining and standardizing sampling and analysis methods is necessary."

Garland next shared the following excerpt from the NARMS Strategic Plan 2020-2025:

> *"Following the NARMS Review Subcommittee recommendations to incorporate the three major domains of the One Health model (humans, animals, environment), an important theme of this strategic plan is the expansion of testing to examine resistance in animal pathogens and the environment. For environmental monitoring, what constitutes the best sampling points will be refined over time. Surface waters as confluence points of ecosystems differentially affected by built environments is a starting point."*

In response to the strategic plan, an environmental working group was formed with representatives from many affected agencies. This pilot effort defined Surface Water AMR Monitoring (SWAM) Objectives, including environmental efforts with a One Health-focused NARMS.

The environmental working group also developed a national-scale, quantitative assessment of AMR within surface water to include the following:

- Development of a monitoring plan that would provide a standardized measure and library of samples to monitor trends in environmental resistance as part of NARMS
- Input to models of AMR risks for various end uses of water, including recreational, drinking, agricultural, and water reuse
- Help to quantify drivers of occurrence and selective pressures for potential amplification
- Identifying critical control points and assess current and new mitigation studies

"The EPA is not arguing water is THE most important environmental consideration in the AMR challenge," Garland noted. "We are suggesting it is a good place to start our efforts."

Why is water the focus of the EPA's efforts in antimicrobial resistance? Because there are multiple impacts at a watershed level.

In the U.S., some drinking water contains more than 15 percent of their source water from treated wastewater. These are primarily river supplies, which may include AMR.

Untreated discharge also poses a risk for AMR contamination, usually due to sewage overflows during rain. Animal manure is also a significant contributor to surface water in many areas of the United States.

"Understanding these impacts will help us do a better job with the long-term monitoring program we are attempting to develop," he summarized.

Garland described designing the study with two alternatives for timing, big and slow or small and fast. "An example of a big and slow approach would be taking samples from every watershed region in the U.S.," he explained. "In this example, the sampling frequency would help determine the geospatial distribution of this issue. And target gene analysis is one of the tests already conducted on these samples every five years."

In comparison, a small and fast study design would focus on a specific river in a limited geographical area with intensive sampling and targeted testing for AMR components.

Determining the analytical targets for this study is another consideration for the EPA as described below:

> *"There is a need for rigorous QA/QC in data collection, as well as agreement in the community regarding standardized methods and reporting. Until priority monitoring targets are agreed on, analysis of a suite of culture-based and molecular-based indicators is logical*." Pruden et al. 2018 Environmental Science and Engineering framework for combating antimicrobial resistance.

"Given the lack of certainty today, a range of methods must be evaluated," summarized Garland. "These may include evaluations with cultures, targeted genes, and metagenomics."

In conclusion, the timeline for this work is that a team of 40 scientists from multiple agencies has been assembled, and their work is underway as described previously. The Pilot Study is planned to occur from FY 22 through 25. And the Final Assessment of Surface Water Surveillance in NARMS should happen in FY 2025 to identify if and what a monitoring system should look like.

"Engaging stakeholders for feedback in these plans is a critical component of our work, especially under a One Health approach," concluded Garland.

Garland joined the EPA's Office of Research and Development in 2011. He received a PhD in Environment Science from the University of Virginia and spent over 20 years working on the National Aeronautics and Space Administration's (NASA) efforts to develop closed, bio regenerative life support systems for extended human spaceflight. NASA recognized him for innovative technical achievements four separate times. He has worked on various topics, including microbial community analysis methods, factors affecting survival of human associated pathogens, and different biological approaches for recycling waste. Garland has completed visiting fellowships and professorships at the Institute for Environment Sciences in Japan, the University of Innsbruck in Austria, and the University of Buenos Aires in Argentina. His current efforts focus on advancing innovative water infrastructure approaches, including decentralized water reuse, and mitigating risks associated with antimicrobial resistance in the water cycle.

AMR Detection and Mitigation in the Agricultural Environment

Michelle Soupir, Associate Professor and Associate Chair for Research and Extension, Department of Agricultural and Biosystems Engineering, Iowa State University

Dr. Soupir's research program focuses on sustainable water systems emphasizing nonpoint source pollution control, watershed management, and water quality monitoring. She followed up on Dr. Garland's comments by introducing her work as the "small and fast" approach. Soupir uses rainfall simulation studies to measure how resistant genes and resistant bacteria move along surface flow paths. She is also trying to determine how prairie strip systems can mitigate them.

"The development of antibiotic resistance is a global threat to public health," she presented. "Yet they are necessary for keeping our animals healthy. Up to three quarters of antibiotics administered to animals orally move through their systems and show up in the manure. Antibiotic-resistant genes are also included in this manure."

Much of this manure is applied to agricultural fields as an organic source of fertilizer. Water run-off from these fields can go into surface water and eventually end up in our water systems.

"Large parts of the upper Midwest are drained through a tile drainage system to promote crop production," Soupir explained. "This lowers the water table, enabling machinery to have access to fields during the wet times of the year. But it also facilitates run-off to enter watershed surface water systems."

Animal production also occurs in many of these tiled areas. And environmental pathways of antimicrobial resistance have been mostly unexplored. AMR mitigation points include manure management, in-field management, and edge-of-field management.

"Through strategic manure management, we can mitigate AMR before it spreads in the environment," she said. "Monitoring includes testing for both phenotypic and resistance genes, but a national monitoring strategy is needed to understand better how AMR moves through the environment."

Two-stage storage facilitates manure being held for some time before being land applied. Centrifugation is another effective treatment for reducing AMR in manure. Anaerobic digestion and composting also show promise as treatment alternatives, especially at higher temperatures.

"Farm fields can be managed to reduce AMR movement to waters," explained Soupir. "Once applied in drained crop fields, antimicrobial-resistant bacteria (ARB) and antimicrobial-resistant genes (ARGs) in soil appear to return to baseline levels after about six months after manure application." Rates are higher for spring applications as opposed to those that occur in the fall.

Continuous corn cultivation also shows a greater tendency for a higher build-up of antimicrobials in the soil. For a corn-soybean rotation, ARG levels in the soil returned to baseline between six months and one year after manure application. Therefore, both crop rotation and manure application timing influence ARG movement to drainage water.

Soupir is also evaluating mitigation efforts for AMR that can occur at the edge of the field. "The popular practice of planting prairie strips can effectively intercept manure-derived ARB and ARGs," she noted. "This reduction happens through sedimentation and infiltration, which was evaluated through rainfall simulation experiments looking at large suites of ARGs using Biomark Fluidigm."

The engineer used 16s rRNA gene sequencing to show the effect of AMR reduction by prairie strip treatment. "Microbial communities from water samples that received manure and did not pass through a prairie strip showed more similarity to manure samples when evaluated by gene sequencing," she explained. "Communities from water samples that received manure and did pass through a strip showed more similarity to non-manured water samples."

Soupir has also evaluated AMR's presence in agricultural watersheds by collecting drainage and river water on the Iowa River's South Fork. This is an area of high manure application from swine operations. Her team has also been evaluating AMR export in two catchments of the Black Hawk Lake watershed. They found only minor changes in Best Management Practices (BMP) implementation levels during the study period. However, there were some seasonal differences when higher ARG levels were observed, such as post-harvest and pre-planting.

"To summarize, there are numerous opportunities for manure mitigation to control and improve antimicrobial resistance appearing in surface water," Soupir said. "Manure treatment before the application could prevent the environmental spread of AMR. But, advances in manure management strategies are needed."

ARG in drained soils returns to background levels between six and 12 months following the application of manure. Elevated ARB and ARG levels have been observed both in drainage run-off and downstream of manure-amended watersheds. And finally, edge-of-field practices may help mitigate the downstream movement of AMR.

The remaining questions include:

- How do we best monitor resistance in the environment?
  - Phenotypic resistance
  - Resistance genes
  - Mobile genetic elements
  - Defining and tracking the manure-derived community
- How will the VFD impact levels of environmental resistance?
- What role does environmental AMR have in human health?

Soupir's research focuses on sustainable water systems emphasizing nonpoint source pollution control, watershed management, and water quality monitoring. Her research projects work to answer basic and applied research questions regarding the occurrence, fate, and transport of pathogens, pathogen indicators, nutrients, and contaminants of emerging environmental concern (CoEECs) such as antibiotics and antimicrobial resistance (AMR) to surface and groundwater systems. Her work is focused on the impacts of agricultural practices on water quality, designing conservation practices to mitigate agricultural pollution's effects on downstream waters and reduce public exposure. Soupir has published 85 peer-reviewed articles and secured more than $18M in external funding. She serves as Technical Editor of the Environmental Microbiology section for the *Journal of Environmental Quality*. Soupir has been honored for achievements by her Kansas State University and Virginia Tech alma maters. She has also received awards for early achievement in research by the College of Engineering and the College of Agriculture and Life Sciences at Iowa State University and by the American Society of Agricultural and Biological Engineering (ASABE). Soupir serves as the Equity Advisor for the College of Engineering to advance equity, diversity, and inclusion efforts. She received a PhD and MS in Biological Systems Engineering from Virginia Tech University and a BS in Biological and Agricultural Engineering from Kansas State University. Her undergraduate Honors Program also included a Secondary Major in Natural Resources and Environmental Sciences.

Agricultural Antimicrobial Compounds and Pathogenic Bacteria In Plants

Christopher Vincent, PhD, Assistant Professor of Horticultural Sciences, Citrus Research and Education Center, University of Florida (https://treephysiologylab.com/)

The *One Health* approach to AMR includes plant health issues. Dr. Vincent's research program serves Florida perennial fruit crop producers by evaluating production methods and biological understanding to improve citrus crops' productivity and additional crops and crop systems in the traditional citrus region.

Vincent studies how plants move water and carbohydrates in response to environmental factors. This includes how antimicrobial compounds enter and circulate through citrus plants and their particular effect on citrus greening.

"Do agricultural antimicrobial compounds reach pathogenic bacteria inside the plant?" asked Vincent.

Citrus greening is caused by the infection of bacterium CLas: Candidatus Liberibacter asiaticus, which inhabits only the plant's phloem, the sugar transporting vascular tissue. This leads to a dysfunction that inhibits both growth and citrus yields.

"Today, this infection is found in most citrus plants throughout Florida," explained Vincent. "As a result, there has been a gradual decline in total citrus production since this bacterium was first

discovered in the state in about 2004." Citrus greening has pushed many smaller growers out of business and forced the remaining producers to seek desperate measures to stem this decline and remain in business.

In 2016, emergency exemptions for three bactericide products were approved, allowing streptomycin and oxytetracycline (OTC)-based treatments to address this infection. These products had previously been used in fighting fire blight with apples and pears.

"The long-term goal for citrus growers is to develop resistant or tolerant varieties," described Vincent. "However, this rapid decline and loss of both growers and acreage have caused people to search for more stopgap measures." Today, fewer growers apply these bactericides because research has been ambiguous regarding their efficacy to fight the bacterium.

Plant physiology began to address this infection by evaluating antimicrobials' delivery to the phloem, where they can affect the bacterium that causes Citrus greening. Citrus leaf morphology includes a thick waxy cuticle that overhangs stomata and is wedged between epidermal cells. This results in limited mesophyll conductance. Therefore, it is challenging for water containing antimicrobial compounds to enter citrus leaves, but it can occur.

"Field studies showed that injection resulted in better delivery of antimicrobials than any other treatment," he explained. Therefore, impacts in the field depend on arrival in the phloem. "Systemic movement occurs primarily in the xylem but also in the phloem," found Vincent. "Streptomycin appears to be less mobile than OTC."

Less than five percent of foliar-applied OTC is systemically moved. Most foliar-applied OTC remains in the leaf but does not move systemically. No foliar adjuvant increased the delivery of OTC.

"Only the injection method of antimicrobial delivery reduced CLas titer," concluded Vincent. "The effects on delivery explain the lackluster results on CLas in the field, which has led to much of this controversy."

The purpose of Vincent's research program is to serve Florida perennial fruit crop producers with production methods and biological understanding to improve the productivity of citrus crops and additional crops and cropping systems in the traditional citrus region. He studies how plants move water and carbohydrates within themselves and in response to environmental factors. In the case of anti-microbial compounds, along with collaborators, he has been assessing the degree to which anti-microbial products enter and circulate within citrus trees to reduce the bacterium that causes citrus greening. In 2016, Vincent received his PhD from the University of Florida in Interdisciplinary Ecology: Horticultural Science. He received his MS from the University of Arkansas in 2008, studying Horticulture: Fruit Production. And in 2006, he graduated with a BA from the University of Arkansas in Journalism and Spanish.

International Antimicrobial Resistance: Recent History

Neena Anandaraman, DVM, MPH, Veterinary Science Policy Advisor to the USDA's Chief Scientist, U.S. Department of Agriculture

"The Federal Combating Antibiotic-Resistant Bacteria (CARB) Task Force includes several participating agencies and offices throughout the Federal government. These include the Department of Defense, the Department of Health and Human Services, the USDA, the Centers for Disease Control, the National Institute of Health, and the Food and Drug Administration," introduced Dr. Anandaraman. "Our international work in antibiotic resistance falls under this CARB Task Force, and our efforts center on the science and the risk of this challenging issue."

The CDC Threat Report released in 2013 set the scientific foundation that continues to guide the USDA's work today. At the same time other domestic groups were beginning to prioritize AMR, the G8 made AMR a priority issue for their participating countries.

"In 2014, an executive order created the CARB Task Force and established a Presidential Advisory Council for CARB," she noted. "The executive order directed that International Coordination of this issue involves Health and Human Services, the State Department, and USDA. "

The following year, CARB released its National Action Plan, and the White House held its Stewardship Forum involving stakeholders from both the human and the animal sides of the issue. On the international side, the World Health Organization released its Global Action Plan directing all countries to develop their national action plans to address this issue.

"The Global Health Security Agenda also began implementing its action packages, one of which is antimicrobial resistance," explained Anandaraman. "And in the same year, both the Food and Agriculture Organization and the World Organization for Animal Health released resolutions endorsing the WHO's work." Also, in 2015, the Transatlantic Task Force on Antimicrobial Resistance Nations was created.

The work of the G7 on antimicrobial resistance had continued throughout this entire time, and in 2016 those efforts expanded to include the G20 and then the G77 countries. That political momentum then moved to the United Nations General Assembly, resulting in a commitment from global leaders to address AMR. The Food and Agriculture Organization and the World Organization for Animal Health released their action plans and strategies in 2016 to implement the WHO work.

Anandaraman pointed out, "This was only the fourth time the United Nations General Assembly had addressed a health issue. They directed the formation of a Tripartite to work within their sphere of expertise to approach this issue."

In 2017, the G7 Chief Veterinary officers issued some definitions addressing gray areas around therapeutic use, prevention, control, and treatment. The Codex Task Force on Antimicrobial Resistance met to update a 2005 Code of Practice and develop antimicrobial resistance surveillance guidelines.

The World Trade Organization Agreement on Sanitary and Phytosanitary Measures (SPS) includes Codex, the World Organization for Animal Health (OIE), and the International Plant Protection Convention. SPS's dual purpose is to protect human, animal, and plant health while ensuring fair food trade practices.

Article 5.1 of the Introduction to the WTO SPS Agreement states the following:

> "*SPS 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*."

This is why the three sister organizations' work to address this issue must remain science-based, according to Anandaraman.

In conclusion, the USDA Science Blueprint was just released earlier this year. The five themes it includes are:

- Sustainable Ag Intensification
- Ag Climate Adaptation
- Food and Nutrition Translation
- Value-Added Innovations
- Ag Science Policy Leadership

This Blueprint will provide a roadmap for USDA science work from 2020 until 2025, and the first and third themes specifically call out work to address antimicrobial resistance.

Anandaraman joined the United States Department of Agriculture's (USDA) Office of the Chief Scientist in 2014 as the Senior Advisor for Animal Health Production and Products to coordinate scientific collaboration and plan on high priority emerging animal health agricultural issues. She focuses on antimicrobial resistance, bio risk, and zoonoses. In coordinating antimicrobial resistance activities across USDA and with other federal partners, Anandaraman co-chairs the Task Force on Combating Antibiotic-Resistant Bacteria on behalf of USDA, is a Member of the Transatlantic Task Force on Antimicrobial Resistance, and serves as Alternate US Delegate to the Codex ad hoc Intergovernmental Task Force on Antimicrobial Resistance. Previously, she served as Lead for the Prevention and Control Team in the Applied Epidemiology Staff in the Office of Public Health Science, and as a Supervisory Veterinary

Medical Officer in the Office of Field Operations at USDA's Food Safety and Inspection Service. Before joining USDA, Anandaraman worked as an associate veterinarian at a mixed animal veterinary practice in Texas. She received her DVM from Texas A&M University in 1993 and her Master of Public Health from Tulane University in 2000. Anandaraman is a Diplomate of the American College of Veterinary Preventive Medicine.

International Antimicrobial Resistance: The Multilateral Landscape

Clara Davis, PhD, Foreign Affairs Officer, Office of International Health and Biodefense, US Department of State

"The State Department is in charge of the relationships with other countries and with multilateral organizations," explained Dr. Davis. "But we also work closely with the other domestic agencies for technical expertise and links with technical agencies in other countries. We are sensitive to the domestic effects of international actions."

The G7 is a leader's level summit begun in the 1970s as a forum on economic issues when members represented approximately 80 percent of the world's GDP. It includes the United States, the United Kingdom, France, Germany, Canada, Japan, and Italy. It has now expanded to include health education and other global issues. And today, the member countries represent 50 percent of the world's GDP.

"The G20 was formed in 1999 to expand the discussions of the G7 to include other rising economies," she shared. "This group now includes approximately 80 percent of the world's GDP with all the original G7 members plus 13 additional representatives."

Both the G7 and the G20 meet yearly, and they remain informal organizations without official headquarters. They provide opportunities to discuss shared issues and release statements of shared opinion. They do not negotiate treaties or other forms of international law.

"The Group of 77 or G77 does not include the United States. It was formed in 1964 as a coalition of developing economies," said Davis. "Today, it numbers 134 members." There is some overlap with the G20 (Brazil, Argentina, Indonesia, Saudi Arabia, and India), but this group focuses primarily on shared actions within the United Nations.

The Organization for Economic Cooperation and Development (OECD) was formed in 1961. All 37 members are high-income countries that are dedicated to democracy and a market economy. "This is a forum to discuss economic issues, compare experiences, and coordinate the policies of its members," she explained. "It is a platform to share knowledge, seek answers to common problems, identify good practices, and coordinate domestic and international policies." The OECD also publishes non-binding recommendations of its principles and standards for business conduct. And it provides a significant source of expert reports and reference materials on a wide range of economic issues.

The Global Health Security Agenda (GHSA) was launched in 2014 as a multi-sectoral health security effort. Davis explained, "Today, more than 70 countries participate. Key international organizations and non-governmental stakeholders are also members." This voluntary initiative seeks to:

- ***Enhance country capacities to prevent, detect, and respond to outbreaks***
- ***Emphasize global health security as a national leader-level priority***
- ***Promote communications and collaboration***
- ***Focus on common, measurable targets***

It is not a health-only initiative, nor is it a legally binding commitment. Furthermore, it is not a grant-making or research institution. And it is not a direct source for outbreak response, although it works to build capacity for outbreak response.

"Preventing antimicrobial resistance is one of the 12 GHSA Action Packages, including prevention initiatives regarding zoonotic diseases, biosafety and biosecurity, and immunization," described Davis. "Detection action packages address the National Laboratory System, surveillance, reporting, and workforce development. The response is coordinated through emergency operations centers, linking public health and law enforcement, and medical countermeasures."

The two major organizations most responsible for creating international law, treaties, and conventions include the United Nations and the World Trade Organization. These organizations can make binding treaties as they encourage trade among countries.

The CODEX Alimentarius develops international food standards, guidelines, and codes of practice. The goal is to have shared definitions and standards for international trade. Each country implements domestic laws to meet these standards. The CODEX is named by the World Trade Organization's Application of Sanitary and Phytosanitary Measures. Therefore, it is part of official treaties regulating international trade.

The hierarchy of documentation distributed by these entities is as follows:

1. Treaties and Conventions
2. Regulations
3. Guidelines and Standards
4. Resolutions and Statements

5. Recommendations
6. Expert Panel Reports

From shared opinions to laws, member countries utilize these methods to disseminate their decisions and strategies.

"The US does have an Antimicrobial Action Plan, and we voluntarily report on our progress," said Davis. "The goal is to share feedback with other member countries that also have similar action plans."

International agreements are often a long process, building up a coalition to take action. Multilateral meetings are not just about treaties but are also important for building a consensus. Multilateral diplomacy is often about working together to find areas of common interest and agreement.

"International organizations are part of agreeing to definitions or a common language," she concluded. "Agreements and decisions made are based on science and risk. International meetings are also part of agreeing to shared action at lower levels than treaties."

Davis covers antimicrobial resistance and global health security issues for the Office of International Health and Biodefense. She joined the office in January 2020, after serving as the Science and Technology Advisor to USAID/Indonesia, managing programs in Indonesia to build capacity in science and health. Before her work at USAID, Davis worked at the National Institutes of Health. She entered the US Government as a Science & Technology Policy Fellow with the American Association for the Advancement of Science, serving at the Department of State, Bureau of Democracy Human Rights and Labor. Before joining the US Government, she worked in biomedical research at the intersection of ecology, evolution, microbiology, and human health. Davis was a postdoctoral fellow in the Department of Microbiology and Immunology at the Stanford School of Medicine. She received her PhD in Biological Sciences from Stanford University, conducting dissertation research focusing on the evolution of antimicrobial resistance, and received her Master's degree from the University of California, San Diego.

International Antimicrobial Resistance: U.S. Implementation

Lynn Filpi, PhD, Senior Global Health Advisor and Antimicrobial Resistance (AMR) Team Lead, Office of Global Affairs, US Department of Health and Human Services

"We've seen significant progress made on the National Action Plan and the WHO Global Action Plan since 2015," opened Dr. Filpi. "The CDC created an AR lab network that takes a regional approach to domestic surveillance." Filpi also noted the formation of Combating Antibiotic-Resistant Bacteria (CARB-X) as an accelerator for new antibiotics created by BARTA and NIH. This also includes non-

traditional therapeutics and diagnostics. And it has become a global initiative for both agriculture and human health.

"In 2016, a high-level meeting at the United Nations (UN) on AMR changed the global governance conversation," she noted. "The Tri-partite that was established and focused on AMR resulted in really championing this cause."

This Tri-partite group pushed for AMR to become a priority topic at the G7 and G20. And they obtained hundreds of commitments to global action from a broad range of sectors and stakeholders. Yet, while national action plans were mostly completed, they have not been implemented consistently.

"When the conversation moved to the UN, it pulled in the G77," Filpi explained. "This was significant because it was no longer an issue that just the donor countries were focused on. Leaders from around the world began to consider how this issue was affecting their country."

The report "No Time to Wait: Securing the Future from Drug-Resistance Infections" was made to the United Nations' Secretary-General in April 2019 by the IACG. It contained advice and recommendations on future actions, including global governance that is One Health in nature.

"Of the four component recommendations included in this report, the Global Leaders' Group is farthest along," according to Filpi. This is a very small group that will soon be announced by the WHO and include high, political level advocates for AMR."

The Evidence Panel, a second recommendation from the report, is not as far along. The Tri-partite will appoint 10 to 15 experts for this panel, and they will be focused on scientific evidence surrounding AMR.

"The Partnership Platform will facilitate multi-stakeholder engagement on how to approach the AMR issue and will be a venue for information sharing," according to Filpi. The Platform will be the largest of the three recommended groups. Filpi expects membership to number in the hundreds, and all those with interest in AMR who want to move the efforts forward will be welcome.

The final recommendation from the report is the establishment of an AMR Multi-Partner Trust Fund. "The Tri-partite asked the UN to create the fund to help implement a work plan to assist lower and middle-income countries in building capacity," she explained.

These four groups will work separately. And all of them will be going to the public for comment in the coming years.

Next, Filpi reminded symposium attendees of the goals for the National Strategy for CARB that was released in 2014/2015 and included the following:

Goal 1: Slow the emergence of resistant bacteria and prevent the spread of resistant infections
Goal 2: Strengthen National One Health Surveillance Efforts to Combat Resistance
Goal 3: Advance Development and Use of Rapid and Innovative Diagnostic Tests for Identification and Characterization of Resistant Bacteria
Goal 4: Accelerate Basic and Applied Research and Development for New Antibiotics, Other Therapeutics, and Vaccines
Goal 5: International Collaboration and Capacities for Antibiotic-Resistance Prevention, Surveillance, Control, and Antibiotic Research and Development

"We see progress," Filpi pointed out. "The CDC's 2019 AR Threats Report confirms that prevention works." There have been 18 percent fewer deaths from antibiotic resistance overall and 28 percent fewer deaths from antibiotic resistance in hospitals since the 2013 report.

More US hospitals are also meeting the CDC's Core Elements of Antibiotic Stewardship. In 2017, 85 percent of hospitals met the standards as opposed to only 41 percent in 2014. The standards are both resource and time intensive.

While we have made progress, this remains an ongoing need.

According to the "Antibiotic Resistance Threats in the United States" report from 2019, there are still too many resistant infections (2.8M/year) and too many deaths (over 35K). Some resistant infections are increasing, including community-acquired bacterial infections. New resistant pathogens have emerged during this time, including *Candida auris*. And ongoing challenges remain with developing new antibiotic products, vaccines, diagnostics, and alternative therapies.

"The second CARB National Action Plan for 2020-2025 continues the U.S. government's commitment to continue the fight against antibiotic resistance," she noted. Filpi went on to address where the significant gaps remain, considering recommendations from the international community.

With respect to Goal 5, Improve International Collaboration and capacities for antibiotic-resistance prevention, surveillance control, and antibiotic research and prevention, CARB plans to enhance US leadership in the global fight against antibiotic resistance. "We also plan to promote increased awareness and capacity in countries to address the emergence and slow the spread of antibiotic resistance," she explained.

Furthermore, CARB looks to generate consistent and actionable global data on antibiotic resistance, including extending the CDC's AR Lab Network to global sites to address the identification, emergence, spread, and effects of antibiotic resistance.

Finally, CARB plans to increase international collaborations to facilitate basic, translational, and clinical research to understand the causes of antibiotic resistance and develop countermeasures.

“However, to our surprise, our international partners also felt the US was not doing enough in a leadership role,” Filpi explained. “Therefore, we will be making our extensive international work more public in the coming years along with a policy impact.”

Watch for enhanced US leadership in the global fight against antibiotic resistance in the coming years. “We are examining mechanisms for appointing a US Federal Champion for International CARB, who would support the Secretaries of HHS, USDA, DoS, and the Administrator of USAID,” she shared. “We will be advocating for US policy positions on antibiotic resistance at international fora and organizations using a One Health approach and determining who would report to the CARB Task Force to inform international engagements.”

A target goal is to convene a working group of the CARB Task Force to define interagency needs and develop options for appointing a Federal Champion for International CARB by 2021.

CARB will also be working to enhance US leadership in the global fight against antibiotic resistance. This will include enhanced engagements with multilateral organizations to support progress on US priorities to combat antibiotic resistance.

“The G7 and the G20 both recognize AMR as a priority,” noted Filpi. “While the G20 has traditionally focused on economic issues, they have taken this on and received some key commitments.” One of these is the global AMR R&D Hub that is currently focusing on investments into AMR R&D, antibacterials in clinical development, and incentives for antibiotic R&D. The Hub has determined funding for AMR in human health far exceeds animal health funding, and this is a critical need moving forward.

Another area for global work on AMR is the Transatlantic Taskforce on AMR (TATFAR). TATFAR was created in 2009 to address the urgent threat of antimicrobial resistance (AMR). Their technical experts collaborate and enhance synergy and communications, leading to strengthened domestic and global efforts. Partners include Canada, the European Union, Norway, and the United States. Key focus areas are improving antibiotic use in humans and animals, preventing infections and their spread, and strengthening the drug pipeline.

Strategic objectives for the Global Health Security Agenda AMR Action Package (AP) include supporting the Global Action Plan on AMR and the Tri-partite Plus's associated work on AMR. Additional objectives are supporting AMR efforts in the political space and providing guidance, and sharing best practices to assist Action Package members in developing their capacity to address AMR.

“The U.S. will be the chair for this group in 2021 and plans to re-focus on the International Health Regulations (IHR) and the Joint External Evaluations results,” concluded Filpi. “We also plan to contribute to the WHO benchmarks library for IHR.” Non-government stakeholders are also included in the program.

Filpi is a member of the Federal Taskforce for Combating Antibiotic-Resistant Bacteria (CARB) and the Transatlantic Taskforce on Antimicrobial Resistance. In her current role, she leads in conjunction with USDA and U.S. Department of State the international AMR working group where the CARB Taskforce sets international AMR policy. Filpi represents the US government and HHS as a member of the Global Health Security AMR Action Package, the Global AMR R&D Hub, and the Presidential Advisory Council on Combating Antibiotic-Resistant Bacteria. She has served as a reviewer at the FDA in the Center for Devices and Radiological Health. Filpi started her federal career as a CRTA fellow under Dr. Michael Gottesman's guidance at the National Institutes of Health, where she focused on microRNA regulation of host resistance to drug treatment. She received her PhD in Microbiology and Immunology, and her Master's in Biohazardous Threat Agents and Emerging Infectious Disease from Georgetown University. Filpi is a two-time recipient of the Secretary's Award for Distinguished Service for her antimicrobial resistance work.

Closing Remarks

Eric Moore, DVM, Director of Technical Services, North America, Norbrook, Inc.

"I've been impressed with the quality of people willing to participate in the AMR conversation during this symposium," Dr. Moore shared in closing. "All our sessions have been based on One Health, including the environment, humans, and animal health, from communication through global policy."

Day two of the Symposium focused on animal and human health. This included progress and activities around monitoring and preventative actions, management practices, and stewardship programs. "The theme of continued improvement brought all the stakeholders to the table," he noted.

"The third day's focus on the environment in One Health ranged from watersheds to single plant impacts looking at AMR through the entire ecosystem," he pointed out. "This included both global policies and actions."

"The amount of AMR activity in the past five to six years is overwhelming," said Moore. "The NIAA has been continually raising the bar on this issue. Conversations we started ten years ago have ballooned into something greater to address this worldwide crisis."

The AMR issue has moved forward thanks to our mission at the NIAA, which is as follows:

> *The NIAA is a non-profit, membership-driven organization that unites and advances animal agriculture for the challenges facing animal agriculture industries, including aquatic, beef, dairy, equine, goat, poultry, sheep, and swine. NIAA is dedicated to furthering programs for eradicating diseases that pose a risk to the health of animals, wildlife, and humans; promoting the efficient production of a safe and wholesome food supply for our nation and abroad; and promoting best practices in environmental stewardship and animal health and well-being.*

“I’m proud that we have helped agriculture be a valued part of the AMR discussion,” he said.

“The complexity of this issue is so broad and immense it will be a continued effort,” Moore concluded. “Everyone looks at this issue through their own lens. But this symposium helps people consider the AMR issue through a couple of different lenses, including the policies and issues that drive action plans.”

“We’re all in this with the same goal.”

Eric Moore, DVM, Director of Technical Services, North America, Norbrook, Inc. Dr. Eric Moore received his DVM from Kansas State University College of Veterinary Medicine in 1994. He is a second-generation veterinarian from south-central Nebraska. Moore began his career in rural private practice in western and central Kansas, specializing in cow/calf, stocker, and feedlot operations. In October 2004, he joined Kansas State University as a clinical instructor in agricultural practices. In 2006 he joined Schering-Plough Animal Health as a technical services manager. Moore is currently employed with Norbrook, Inc. as Director of Technical Services, North America. He is a member of AABP, AASV, AVMA, and NIAA. He currently serves AVMA on the Animal Agriculture Liaison Committee. For the National Institute of Animal Agriculture, Moore serves on the executive board and co-chairs the Antibiotics Council and the Antibiotic Stewardship Symposium. He is a long-time member of AVC and has served as a former co-chair and member of the Cattle Health and Well Being committee and member of the Scholarship Committee.