



# PACCARB

PRESIDENTIAL ADVISORY COUNCIL ON COMBATING ANTIBIOTIC-RESISTANT BACTERIA

## **Meeting Summary**

### **25<sup>th</sup> Public Meeting of the Presidential Advisory Council on Combating Antibiotic-Resistant Bacteria**

**May 21–22, 2024**

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# Meeting Proceedings

## Day 1

### Welcome, Overview, and Roll Call

*Paul Plummer, D.V.M., Ph.D., DACVIM, DECSRHM, Council Chair; Jason Newland, M.D., M.Ed., Vice Chair; and Jomana F. Musmar, M.S., Ph.D., Designated Federal Official, Advisory Council Committee Manager, Office of the Assistant Secretary for Health, U.S. Department of Health and Human Services (HHS)*

Dr. Plummer welcomed participants to the meeting of the Presidential Advisory Council on Combating Antibiotic-Resistant Bacteria (PACCARB) at 9:00 a.m. ET. He summarized the agenda and explained that the Council would review and vote on accepting PACCARB's report to the HHS Secretary on how the United States can lead the global response to antimicrobial resistance (AMR). (See the Secretary's task [letter](#) to the PACCARB.) Dr. Plummer and Dr. Newland thanked the working group that developed the report, the HHS staff who coordinated the process, and the presenters and stakeholders whose insights informed the content.

Dr. Musmar described the Council's establishment and charter and summarized the rules governing the Council under the Federal Advisory Committee Act and conflict-of-interest guidelines. She then called the roll. (See the appendix for the list of Council members and staff.)

### Opening Remarks: Global AMR Working Group Report

*Loyce Pace, M.P.H., Office of Global Affairs, HHS*

Ms. Pace noted that AMR is an urgent, global threat that demands political visibility and strategies for coordinated action at all levels with a One Health approach. The United States is a global leader with a track record of progress in protecting people, animals, and the environment from the threat of AMR. Later this month, HHS Secretary Xavier Becerra will lead a delegation to the World Health Assembly in Geneva, which will consider a resolution to advance AMR efforts. Sec. Becerra and others understand that challenges remain and more can be done against AMR, especially after the setbacks caused by COVID-19.

Ms. Pace recognized that the PACCARB is a valuable mechanism for monitoring progress, assessing gaps, and recommending solutions that inform U.S. government (USG) policy generally and the National Action Plan (NAP) on Combating Antibiotic-Resistant Bacteria (CARB) specifically. The PACCARB report and recommendations on global AMR will offer advice on how U.S. agencies can lead global AMR efforts for sustained action domestically and internationally. In addition to focusing on the upcoming World Health Assembly, the USG is preparing to negotiate a political declaration at the second United Nations General Assembly (UNGA) High-Level Meeting (HLM) on AMR and anticipating the fourth Global High-Level Ministerial Meeting on AMR in November. Ms. Pace underscored that these international convenings are critical for drawing attention to AMR, generating commitments, and setting ambitious, actionable targets that are rooted in science. Such efforts can galvanize more effective, coordinated, and sustained multinational efforts. These convenings also offer an opportunity to highlight the critical linkage between AMR and other global health challenges, such as tuberculosis and access to clean water and sanitation.

Antimicrobial-resistant pathogens know no borders and pose significant threats to global health security, economies, and our way of life, said Ms. Pace. Therefore, the response must be comprehensive and inclusive. The PACCARB working group's report outlines concrete actions for USG agencies to leverage their resources, expertise, and influence in advancing the global fight against AMR. Notably, AMR is a key priority for the Biden-Harris Administration, and the United States is committed to maintaining the momentum for action. The USG must commit to feasible actions and work with countries and international organizations to ensure implementation of sustainable solutions. In conclusion, Ms. Pace thanked Council members for their dedication, expertise, and unwavering commitment to this vital cause. She called for seizing this opportunity to chart a course toward a future where AMR is effectively mitigated.

### **Patient Story: Maddie's Transplant**

*Michael Graziano, small-r Films*

Dr. Musmar introduced a short documentary film by Mr. Graziano that features the harrowing tale of a young woman and her mother confronting what happens when the human immune system becomes compromised and necessary drugs stop working. Mr. Graziano explained that the film is part of the Holobiome project, a multipart film series that encompasses multiple, overlapping stories related to antimicrobials (<http://www.small-r.com/holobiome>). The project aims to help people better understand AMR and improve health and science literacy, with the ultimate goal of compelling more judicious use of antimicrobials. The film was supported and presented by the NovoNordisk Foundation. Dr. Musmar noted that the film will be screened on Capitol Hill later in the week, with remarks from congressional leaders.

### **Discussion**

Dr. Plummer observed that the Council has frequently stressed the need for better communication about AMR and the role of narratives and storytelling. He asked how the arts, such as film, can raise awareness among patients, providers, and others about the complexity of AMR and drive action. Mr. Graziano responded that narrative is how humans make sense of the world. He has considered bringing the Holobiome films to medical students to help them develop a narrative framework for talking with patients about AMR. Mr. Graziano added that the Holobiome project emphasizes interconnectedness across the One Health spectrum. He said his team has ideas for transforming the films into a more immersive experience through virtual reality and other advanced technology.

### **Global AMR Working Group Report: A United Front: Collaborative Global Leadership to Combat Antimicrobial Resistance**

*Paul Plummer, D.V.M., Ph.D., DACVIM, DECSRHM, Council Chair, and Jason Newland, M.D., M.Ed., Vice Chair*

Dr. Newland reiterated the task from Sec. Becerra to provide recommendations on USG leadership in preparation for the UNGA HLM in September and updating the NAP CARB. The PACCARB's working group met monthly from January through May to develop the report, with input from stakeholders and the public. Dr. Plummer added that the report was also informed by input from the December 2023 and February 2024 public PACCARB meetings.

The report and recommendations are organized into four main priorities for global action:

- Preventing infections
- Improving global awareness of AMR
- Globally responsive development of AMR products
- Equitable access to antimicrobials, vaccines, and diagnostics

Because the recommendations within these priorities do not fully address all the current gaps in the global fight against AMR, the working group outlined several foundational concepts that should be incorporated in all domestic and international AMR policy:

- Clearly defining AMR
- Using the principles of plain language
- Developing science-based metrics and monitoring activities
- Keeping the focus of AMR activities on local needs
- Taking a leadership position in promoting global targets

The Global AMR working group also reinforced recommendations from the 2019 PACCARB report, *Priorities for the National Action Plan on Combating Antibiotic-Resistant Bacteria, 2020–2025*. Specifically, the working group’s report calls for sustained funding at the executive level for addressing AMR and for naming an ambassador who can be the face of AMR in all U.S.-related activities. The PACCARB believes that an ambassador can advocate for consistent funding of CARB-related activities and coordinate a truly One Health message for clear communication. Notably, the report recognizes the importance of identifying an ambassador with expertise across all the areas of One Health.

Dr. Plummer and Dr. Newland reviewed the recommendations in the report. The recommendations are intended to offer guidance to the USG to ensure continued leadership at the international level in the fight against AMR. The report also describes U.S.-specific actions that federal agencies can take to further the global priorities and inform the next iteration of the NAP CARB.

## **Discussion**

Council members discussed the importance of emphasizing that preventing infection removes the need to use antibiotics, which prevents the development of resistance. Council members agreed on revised language to better frame the concept.

The draft report describes challenges to the uptake of animal vaccines, including the low efficacy of some vaccines—an issue raised in the context of animal food production in low- and middle-income countries (LMICs). It was noted that economic and other factors also pose disincentives to using animal vaccines. Ultimately, Council members agreed to revise language to reflect that the variable efficacy of some veterinary vaccines, economic drivers, and a lack of incentives to use vaccines make vaccine prophylaxis less desirable than antimicrobial treatment in some cases.

Lucas Pantaleon, D.V.M., M.S., M.B.A., DACVIM, advised that the World Health Organization (WHO) recently published its updated list of priority pathogens, so the report should reference the updated list. Timothy Jinks, Ph.D., noted that the United Nations Interagency Coordinating Group on AMR and the Global AMR Leaders Group support the concept that AMR targets

should be crafted with input from an advisory panel that focuses on the science behind the metrics. Council members agreed that the corresponding recommendation in the report should reflect the support of those global entities. Other minor edits were suggested to ensure consistency throughout the report.

**Vote:** Council members unanimously approved [the report](#), as amended, for submission to the HHS Secretary.

## **Follow Up on PACCARB Pandemic Preparedness Report: Workforce**

*Amanda Jezek, Infectious Diseases Society of America (IDSA)*

In its March 2023 report, *Preparing for the Next Pandemic in the Era of AMR*, the PACCARB recommended that the USG bolster the workforce by expanding recruitment and support of public health professionals, infection preventionists, and infectious disease (ID) specialists and engaging a broader set of providers. Specifically, the report suggested that adequate funding be provided for loan forgiveness or repayment programs, as included in the bipartisan Bio-Preparedness Workforce Pilot Program authorized by Congress in 2023.

Ms. Jezek described the current shortage of ID professionals and noted that the situation is worsening, as few medical students and residents opt to pursue an ID career. From interviews, IDSA has determined that trainees frequently demonstrate great interest in the field but cannot justify specializing in ID because of the high cost of education and the comparatively low pay for ID specialists compared with other specialties. Ms. Jezek said the health care system does not value ID expertise or its impact on patient outcomes. Among the proposed solutions to the workforce shortage are the loan repayment program authorized by Congress but not yet funded and significant investments in training already being made by the National Institute of Allergy and Infectious Diseases (NIAID). Increased reimbursement for care provided by ID specialists is also needed.

Following consultation with the Centers for Medicare & Medicaid Services (CMS), IDSA proposed two code descriptors for inclusion in CMS's Physician Fee Schedule, which influences public and private health system reimbursement: complex medication management and complex inpatient care management. Ms. Jezek noted that the PACCARB was instrumental in convincing CMS to require that facilities create antibiotic stewardship programs. She asked that the PACCARB communicate with CMS and the Office of Management and Budget about the importance of adequate reimbursement for ID services and with the Health Resources and Services Administration about including funds in their fiscal year 2026 budget to support the pilot loan repayment program for ID providers.

## **Panel 1: Advocacy, the Voice of the Patient to Drive Change**

### **Challenges When Communicating About AMR**

*Vanessa Carter, WHO Task Force of AMR Survivors*

Ms. Carter described the results of a car accident in her mid-20s in South Africa. Among numerous other injuries, she lost vision in one eye and suffered extensive damage to her face that required multiple surgeries, including prosthetic implants that led to a drug-resistant infection. Ms. Carter saw several medical specialists, all of whom performed procedures and prescribed

different antibiotics. She requested a copy of her diagnostic test results and only then began to understand the nature of the infection. Via the internet, Ms. Carter connected with a U.S. craniofacial surgeon who determined an effective method to reconstruct her face. Still, she contracted another infection of the bone and skin and developed an allergy to the bacterial ointment used. After months of rotating advanced antibiotics, Ms. Carter said, she finally recovered to a point where she felt comfortable showing her face in public.

The ordeal revealed the many gaps in communication between providers and patients and among providers, as well as the lack of attention to the principles of antibiotic stewardship. Ms. Carter said that patients need clear instructions about how and when to take antibiotics, how to spot signs of drug resistance, how to keep a surgical site clean, and how to prevent infection at home and in the hospital. Patients also benefit from effective coordination of care among providers, even if it is as simple as telling patients to inform other providers that they are under another provider's care and taking medications.

Borrowing from her former career in marketing, Ms. Carter suggested that public health efforts look for ways to reach people directly with clear messages about AMR and antibiotic stewardship. A patient-centered approach considers the individual's circumstances, such as being bedridden in the intensive care unit or having limited capacity to delve into complex scientific literature. Airlines educate passengers about safety with videos and pamphlets delivered to the individual's seat; hospitals could take the same approach. Websites designed for the public should contain videos and information presented in lay language.

Ms. Carter emphasized the importance of involving all stakeholders to develop and disseminate messaging around AMR. The United Kingdom's INVOLVE project engages patients, caregivers, researchers, medical providers, educators, and policymakers in a holistic approach to health care. The Imperial College of London launched the Fleming Initiative to develop real-world solutions to AMR; it includes the public and patients in all aspects—even its website logo and design. Finally, Ms. Carter emphasized that effective communication considers cultural, educational, and linguistic differences across settings, and especially in LMICs.

### **Driving Innovation for Antifungal Development**

*Robert Purdie, Mycology Advocacy, Research, and Education (MyCARE)*

Mr. Purdie described the long journey that eventually led to a diagnosis of coccidioidal meningitis, a result of Valley fever. Throughout the course of his disease, he tried and failed a host of antibiotics, one of which was used at too high a dose and caused squamous cell skin carcinoma. Mr. Purdie pointed out that the dosages for triazoles approved by the Food and Drug Administration (FDA) are lower than what is prescribed to treat Valley fever, and the drugs can suppress but not cure the disease. At the high doses used for Valley fever patients, the drugs are associated with a host of side effects that patients with severe infection must endure.

People with Valley fever and other fungal infections face significant direct costs related to hospitalization, procedures, testing, and treatment. Other costs are harder to quantify, such as deterioration of personal relationships, missed work and lost income, and financial hardship. Mr. Purdie said that one third of people with chronic illness report suffering from depression, but he believes that figure underestimates the real prevalence.



Valley fever is both rare and epidemic, Mr. Purdie explained. Out of about 150,000 infections per year, 60 percent are asymptomatic; 10 percent are diagnosed, and 1 percent are disseminated, resulting in chronic infection. There is little recognition and understanding of fungal infections compared with bacterial and viral infections. Fungi kill more than 1.6 million people each year. Since 2000, Valley fever has increased fivefold in the United States. Fungal pathogens are a threat to human health, biosecurity, and ecosystems, making it a One Health priority, but there is insufficient surveillance and funding to identify and address the threat. Mr. Purdie pointed out that his condition was diagnosed with 70-year-old test and treated with 60-year-old drug. The United States is perceived as having state-of-the-art health care, yet the approach to fungal infection is archaic.

Mr. Purdie insisted that AMR is not difficult to explain—it is just not easy. A multilayered communication approach is needed to reach people, including policymakers, with clear explanations of AMR and its impact. HIV/AIDS activists transformed the inclusion of patients and the public in research and development (R&D), and FDA responded by changing its approach to drug approval, paving the way for effective treatment. Mr. Purdie said FDA could use the same response to address AMR, especially in the context of rare conditions. He recommended the following approaches to advance AMR R&D:

- Substantially increase funding for federal public health agencies to increase surveillance, develop diagnostics, conduct preclinical research, and advance potential therapeutics—while including the patient perspective.
- Advance push and pull incentives for private R&D and ensure that the various incentive mechanisms work together, especially at the global level.
- Incorporate fungal infections into the mission of existing USG efforts, such as the Biomedical Advanced Research and Development Authority, the Combating Antibiotic-Resistant Bacteria Biopharmaceutical Accelerator (CARB-X), the Advanced Research Projects Agency for Health, and the Patient-Centered Outcomes Research Institute—and increase funding to support the expansion.
- Create and expand public–private partnerships to address AMR and fungal infections.

### **The Realities of Accessing Care and Education as a Refugee**

*Louange Koffi, RN, Amahoro Coalition Fellow*

Ms. Koffi explained that she grew up in a refugee camp in Ghana; as a nurse, she focuses on health promotion among displaced communities. Refugees around the world face similar challenges to health care—primarily lack of access to health care facilities and lack of clean water and proper sanitation. Ms. Koffi described walking miles to get care at a community hospital, where providers had no diagnostic tests and so prescribed medication using a trial-and-error approach. She raised money to seek care for a skin issue that required repeated hospital visits and various courses of different drugs. Like many in her family and community, she was not counseled about the need to take the full course of antibiotics. Ms. Koffi noted that abuse of over-the-counter antibiotics is common because individuals lack the money to seek health care and when they do, the care is not always effective because of the lack of diagnostic tools.

Ms. Koffi identified several areas for improving care and minimizing AMR among refugees:

- Develop basic health care facilities within refugee camps to provide first aid and facilitate transportation to local community health care facilities when needed.
- Ensure that hospitals have access to diagnostic tools and appropriate antibiotics.
- Educate health care providers to identify the bacteria causing disease and prescribe the right medications for them.
- Ensure that camps have access to clean water for refugees and for the animals they raise for food.
- Promote health education in refugee camps, including antibiotic stewardship principles, for camp residents and health care providers.
- Apply the concepts of human-centered design, engaging individuals and communities in solving their own problems.
- Invest in more training for health care workers in and outside of refugee camps and promote collaboration among providers and across settings.

The public health challenges seen in refugee camps are exacerbated by violent conflicts, and left unaddressed, the situation will deteriorate, said Ms. Koffi. Governments, nongovernmental organizations, laboratories, providers, individuals, and others must work together to address conflict, provide education, and invest resources to stop AMR in refugee camps and conflict zones, she concluded.

### **Recognizing the Crucial Role Antibiotics Play in Our Lives: The Importance of Sharing Our Experiences with Infection**

*Rachel Freeman, Ph.D., IQVIA*

Dr. Freeman said her career as a microbiologist was driven by a desire to tackle drug-resistant infections and provided her with various perspectives on AMR in different settings. She relayed her own experience of a complicated miscarriage in March 2020, just as COVID-19 was spreading rapidly around the world. Despite severe blood loss and fever that persisted, Dr. Freeman described multiple instances in which she had to advocate for treatment and care. Throughout the ordeal, Dr. Freeman's suspicions were confirmed; ultimately, a provider recognized the seriousness of the issue and expedited treatment. She was given antibiotics for septic miscarriage and discharged the day after surgery because of concerns about the rising COVID-19 infections in the hospital.

Dr. Freeman considered herself fortunate: she had access to the care she needed, had the knowledge and confidence to challenge providers, and was prescribed the right antibiotic to address her condition. Still, she later read about increasing rates of resistance to that antibiotic. The incident highlighted that without the right antibiotic at the right time, her miscarriage could have been fatal.

AMR is escalating faster than the pace of discovery, and treatment options are diminishing. Data are not enough. Dr. Freeman said individuals should share their experiences and talk openly about the impact of infections on their lives to raise awareness. Despite the availability of diagnostics, data, and technology, people are still receiving antibiotics they do not need. Society in general must acknowledge the importance of antibiotics and demand action from all sectors to counter the immediate threat of AMR and prevent death from AMR.

## **Discussion**

Dr. Newland appreciated the presenters taking time to share their stories, noting that all four described the effect of delayed diagnosis. He suggested the PACCARB elevate the role that delayed diagnosis plays in AMR. Mr. Purdie suggested increasing funding for diagnostics. He pointed out that urgent care centers, where many U.S. people seek primary care, lack point-of-care diagnostics, and thus prescribe drugs empirically, contributing to antibiotic overuse. Dr. Freeman agreed that even a simple diagnostic that distinguishes between bacterial, viral, and fungal infections would be an important step to mitigate misuse. She added that a lot of data are already available to help identify which patients merit extra precautions in prescribing.

Ms. Carter said that having the diagnostic report in hand and educating herself on what was happening changed the trajectory of her experience. There are mechanisms for speeding up diagnosis, but they lack funding, especially in LMICs. Policymakers must be better educated about the indiscriminate use of antibiotics that is costing lives.

Several Council members applauded the presenters for their advocacy efforts, noting that the discussion highlights clear solutions: raising awareness and increasing resources for AMR. Lynn Marks, M.D., noted that the R&D portfolio must be broader to support the need for multiple treatment options. He said Dr. Freeman's experience highlighted the overlap between AMR and sepsis, and there are opportunities for stakeholders in both arenas to collaborate on raising awareness. Dennis M. Dixon, Ph.D., said NIAID has been investing in diagnostics for a decade but has not yet seen results. He added that the USG relies on private companies to advance products from clinical trials to the market, but there was little interest in an antifungal that was poised to address *Aspergillus*. Robin Patel, M.D., DABMM, FIDSA, FACP, FAAM, suggested building on advances that led to rapid development of COVID-19 diagnostic tests for home use.

Armando Nahum thanked the presenters and noted that WHO has designated September 17 as World Patient Safety Day. Dr. Musmar expressed the need to understand how to quantify the burden of AMR beyond mortality. She noted that Valley fever and other fungal infections demonstrate the intersection of AMR and climate change, adding that human interventions are accelerating the rate of AMR.

## **Panel 2: Companion Animals and Drug Resistance**

### **Companion Animals: Understanding Their Unique Regulatory Position**

*Scott Weese, D.V.M., D.V.Sc., University of Guelph*

Dr. Weese pointed out that AMR efforts and antimicrobial stewardship in animals primarily focus on food animals. Companion animals pose a risk for zoonotic disease, but the lack of surveillance and understanding of the issue result in less motivation to address concerns than in the food animal production sector. Pathogen transfer is also a risk with hybrid food/companion animals, such as backyard chickens, and working animals, such as horses. Treating animals requires thinking broadly about their interactions with vulnerable people in various settings.

The proportion of antimicrobials used in companion animal medicine is substantially less than in food animal medicine—yet the amount is very large given the number of companion animals. AMR is common and transfers between humans and animals in both directions. Many regulatory

and advocacy issues apply to both food and companion animals, such as the need for a robust health system that prioritizes prevention and animal welfare, a focus on responsible use, and integrated, standardized, and comparable surveillance that can be communicated easily. In companion animals, unlike in food animals, drugs may be used off-label to treat a wide range of IDs. Companion animal medicine uses a wider range of drug classes, including some new to human medicine and some banned from food animal use.

Veterinarians face unique pressures and restrictions around drug prescription for companion animals. Dogs and cats have longer lifespans than food animals, and owners increasingly urge veterinarians to take any steps necessary for treatment, regardless of cost. Owners of racehorses will invest a great deal of money in treatment, because such horses have particularly high monetary value. Contact between humans and nonfood animals tends to be of high duration and frequency (e.g., sleeping with a dog). Moreover, efforts to restrict antimicrobial use in animals, as in Europe, can have unintended consequences for companion animal medicine, such as driving unnecessary use of higher-tier medications rather than allowing off-label use of a lower-tier drug. In food production, there is a lot of confusion around the appropriate use of antimicrobials for prophylaxis. Dr. Weese emphasized that companion animal medicine faces a host of issues around overuse and misuse of antimicrobials alongside these pressures, all of which are contributing to an increase in multidrug-resistant infections in companion animals.

### **The Emergence of Carbapenemase-Producing Organisms (CPOs) in Pets**

*Stephen Cole, V.M.D., M.S., University of Pennsylvania*

Dr. Cole described a recent increase of CPOs in companion animals—in some cases, with the same strain as in humans. In 2018, Dr. Cole and colleagues traced the spread of resistant *Escherichia coli* through two animal hospitals that had robust infection prevention practices. Ultimately, transmission was linked to reuse of endotracheal tubes, a common money-saving practice. The Veterinary Laboratory Investigation and Response Network, which includes U.S. and Canadian practices, played a key role in detecting the mechanisms and patterns of concern. Dr. Cole recommended more federal funding to bolster veterinary laboratory surveillance capacity. In a partnership with the Philadelphia, PA, Department of Public Health, Dr. Cole and colleagues identified numerous companion animals with CPOs. Federal assistance could enhance the capacity of health departments to partner with veterinary laboratories to detect and prevent the spread of disease among animals and between animals and humans.

A pilot study in Philadelphia found that more than a third of animal hospitals had circulating CPOs, and most of those had the same strain. CPOs can be endemic and disseminated easily around the country. In collaborations with state health departments in New Jersey and Massachusetts, Dr. Cole and colleagues identified concerning strains of CPOs and alerted veterinarians about them. More than 1 million dogs and cats are imported into the United States annually. Dr. Cole said the federal government could increase monitoring of animal importation to detect potential AMR.

Dr. Cole called on PACCARB to advocate for increased funding for companion animal research and expanded surveillance. Providing veterinarians access to federal programs to support education would increase the workforce. There is a dire need for more veterinarians who specialize in clinical microbiology or ID. Such specialists can interact with public health

agencies, consult with laboratories about antimicrobial stewardship, and increase capacity for surveillance and response. Moreover, veterinary medicine needs more funding specifically for antimicrobial susceptibility testing (AST) and resistance monitoring, which are key to public health. Dr. Cole concluded that companion animal care is a large and growing field, thanks in part to the strong bond between humans and animals. It is critical to prevent AMR in companion animals and avoid the spread of AMR to the people who love and care for them.

### **Detection and Surveillance of Carbapenem-Resistant Organisms (CROs) in Companion Animals**

*Karen Alroy, D.V.M., M.P.H., New York City Department of Health & Mental Hygiene*

Dr. Alroy explained that CPOs are a subset of CROs. She offered four key ways to improve the detection of CROs and reduce the spread of AMR among companion animals:

**Support AST in companion animals, rather than put the costs entirely on owners.**

Dr. Alroy described the many steps involved from the first recognition of symptoms in an animal to diagnostic testing to reporting the results to a public health entity, all of which pose barriers. New York City established a legal framework for clinicians and laboratories to report findings at the time of diagnosis.

**Make phenotypic and molecular testing more accessible by strengthening existing programs, such as those within the Centers for Disease Control and Prevention (CDC) and FDA.**

Few laboratories offer such testing outside of research and public health settings. New York City plans to ask laboratories to send leftover isolates to laboratories that have capacity for phenotypic and molecular testing in an effort to capture data prospectively. Currently, New York City gathers retrospective data to get a sense of the context in which CROs occur, but those data do not advance public health investigations.

**Improve information reporting to support timely public health action.** The best data come from automated reporting systems using standardized approaches, yet veterinarians use manual reporting that lacks standardization. There are neither incentives for reporting nor repercussions for not reporting. Dr. Alroy said New York City is initiating new requests for veterinarian laboratory reporting.

**Strengthen veterinary disease prevention using basic principles for reducing disease transmission.** Zoonotic disease transmission is prevalent among veterinary staff; few organizations have written infection prevention and control policies, but most staff say they want more information available online for staff and pet owners about zoonotic disease and how to implement tried-and-true prevention methods.

In general, Dr. Alroy concluded, animal medicine would benefit from more guidelines, training, and information dissemination on AMR.

### **Public Health Response to a One Health Outbreak**

*Melissa Cummings, M.S., Massachusetts Department of Public Health*

Ms. Cummings said the Massachusetts Department of Public Health conducts onsite infection control and response interventions to address outbreaks in high-risk settings. The state public health laboratory conducts whole genome sequencing for CPOs and pan-resistant organisms to

identify novel gene targets and relatedness; all data are reported to the National Center for Biotechnology Information in real time. Thanks to a longstanding relationship, a veterinary referral hospital asked for help managing an ongoing CPO outbreak—specifically, seven cases of New Delhi metallo-beta-lactamase-positive (NDM+) *E. coli*. The Department of Public Health and a state veterinarian worked with the veterinary hospital to create a response plan that relied on collaboration and standardized tools to find opportunities for improvement. The effort revealed that a lot of basic infection prevention steps were overlooked or improperly implemented, such as appropriate hand hygiene and glove use, appropriate application of cleaning products, and prevention of contamination of supplies.

Ms. Cummings noted that the Department investigated three cases of NDM+ *E. coli* in humans around the same time as the veterinary hospital's outbreak, but it found no epidemiological link between the human and animal cases. However, all three humans lived in the same county, and further investigation identified that all three had companion animals that they took to the same veterinary referral hospital. The evidence suggested the animal hospital exposure caused the human infections. Ms. Cummings said it is not surprising that ID transmission goes in both directions between animals and humans; these cases highlighted the need to change how the Department of Public Health approaches zoonotic infection, especially when there is no clear link to the source.

Veterinary health providers need more awareness and education about management and control of infection in animals; to do so, they need more funding and access to expertise and resources (including whole genome sequencing). Many common prevention strategies apply across human and animal health settings. Interdisciplinary collaboration and coordination among veterinary providers and state and local public health entities is vital. Sharing information with public health laboratories opens paths for better and earlier communication about issues of concern. States would benefit from more guidelines and tools to assess zoonotic infections.

## **Discussion**

Dr. Plummer pointed out that many animals carrying CPOs or CROs are not clinically affected and show no symptoms, which complicates detection, and ASTs are far more expensive than empirical treatment of antibiotics. Dr. Cole agreed that the cost of diagnostic testing is a huge barrier to surveillance, but as AMR increases, failing to detect emerging pathogens in companion animals increases the risk to public health broadly. Dr. Jinks echoed the need for better access to diagnostics and clinical expertise to stem AMR in veterinary medicine.

Virginia R. Fajt, D.V.M., Ph.D., DACVCP, noted that antimicrobial stewardship relies on access to data and capacity to analyze and interpret data. She asked how to engage laboratories with limited resources and experience and no access to a microbiologist in public health efforts to gather more data. Dr. Alroy responded that public health entities must provide incentives or funding to private-sector veterinary diagnostic laboratories. Dr. Weese agreed that such laboratories are rightfully concerned about profits, but he also noted that more education is needed about the appropriate use of available products and the risk of AMR. Dr. Cole suggested raising awareness about the role of veterinary microbiologists and offering more online education options. He added that he has seen some success developing networks between veterinarians and local public health entities.

Elizabeth Dodds Ashley, Pharm.D., M.H.S., FCCP, BCPS, observed that increasing public health resources and capacity for surveillance has helped human health. She suggested PACCARB support more veterinary antimicrobial stewardship, such as embedding ID specialists in veterinary hospitals. She also recommended promoting partnerships between veterinary microbiologists and human health ID clinicians. Dr. Cole cited partnerships formed with the Minnesota Department of Health and efforts by the Association for Professionals in Infection Control and Epidemiology to create a workgroup on human and animal infection prevention and control. He stressed that such partnerships must avoid assigning blame for the spread of disease.

Julia E. Szymczak, Ph.D., appreciated the effectiveness of capitalizing on existing relationships but noted that relying on such networks results in a lot of missed opportunities. She asked what levers exist to support a more coordinated approach to antimicrobial stewardship. Dr. Alroy said no regulatory bodies oversee veterinary facilities and no financial incentives promote stewardship. Dr. Weese added that preventing infection in animals is critical. He called for improving access to care and infection prevention and control measures in animal medicine.

Joni Scheftel, D.V.M., M.P.H., DACVPM, pointed out that, like other clinicians, veterinarians must keep information private and only share data designated as reportable for public health purposes. Veterinarians report findings to a state board of animal health, which coordinates with the state department of health. To overcome barriers, some states have created policies that provide more leeway for reporting. Dr. Cole said Pennsylvania developed a policy that allows for more reporting on clusters or outbreaks in animals. Dr. Alroy noted that many veterinary diagnostic laboratories are confused about what they are required to report, which motivated New York to clarify its own requirements. Dr. Cole added that public health departments might not know how to handle animal infection results and when to report them to a national entity, so there is confusion on both sides.

## **Public Comment**

**John Alter of the AMR Action Fund** noted that at least 110 armed conflicts are ongoing at this moment. The causes of AMR in conflict settings include international transport of soldiers who sustain catastrophic injuries and ad hoc clinics that are overburdened and lack basic supplies and infection control capacity. Civilians are displaced and may be relocated to refugee camps, and damaged infrastructure leads to poor sanitary conditions. The danger of the conflict itself is paramount, but the impact of uncontrollable infections is deadly, too. The AMR Action Fund is committed to enabling the launch of up to four new antimicrobials by 2030. However, longer-term policy changes are necessary to make the innovation ecosystem sustainable, reinvigorate the antibiotic and antifungal pipelines, and support enhanced defense and surveillance measures. The AMR Action Fund offers the following policy recommendations.

First, the USG should invest in targeted antimicrobials to overcome rising biosecurity threats identified in the recently updated USG policy for oversight of dual-use research of concern and pathogens with enhanced pandemic potential. The select agents and toxins subject to the policy include several bacterial pathogens that pose a significant threat to biosecurity. Although the Strategic National Stockpile serves as a repository for antibiotics and medical material for use in an outbreak, they are often broad-spectrum products, and the market for R&D continues to

decline. As these pathogens evolve, the USG should replace volume-based procurement with a subscription model for critical-need antibiotics via multiyear contracts to ensure adequate solutions for rising biosecurity threats.

Second, the AMR Action Fund urges sustained funding for CDC detection and surveillance to better monitor and track priority bacterial and fungal pathogens in accordance with the 2024 National Blueprint for Biodefense recommendations. Third, federal agency, university, and professional society partners should increase collaboration to incentivize research and training programs in areas that intersect with AMR, similar to suggestions made by IDSA earlier. Next, the USG should develop institutional federal research mechanisms that allow ID trainees to easily identify and meaningfully interact with qualified potential mentors at the federal and institutional levels. Finally, the USG should appoint a federal champion for AMR to represent U.S. policy positions on the global stage.

**Sameer Kadri, M.D., M.S., of the National Institutes of Health Clinical Center** offered suggestions for improving AMR data and metrics. The COVID-19 pandemic showed that gathering and disseminating critical and timely data are essential for action. The United States has a lot of data, but a lot of that data are siloed. Dr. Kadri suggested that the PACCARB recommend removing firewalls so that deidentified data can be accumulated from electronic medical records and used to develop more sensitive metrics. In addition to mortality, data are needed on other outcomes, such as disability, morbidity, readmission, and nursing home stays. These outcomes are important to clinicians and patients with AMR infections. Although it is difficult to attribute the impact of interventions on outcomes, the data might show improved mortality and nonmortality outcomes for patients with resistant infections.

**Tara Burke, Ph.D., of the Advanced Medical Technology Association (AdvaMed)** said in vitro diagnostic tests serve as a cornerstone for combating AMR. The biotechnology industry continues to innovate, developing advanced diagnostic tools that not only provide faster and more accurate results, but also ensure appropriate antibiotic stewardship. These technologies allow for the rapid detection of pathogens and their resistance patterns, enabling targeted treatment that is both effective and economical. To ensure timely access to innovative technologies to mitigate the impact of AMR and support efficiencies in health systems, AdvaMed believes AMR policy should strengthen access to and utilization of diagnostics, including recognition of the critical role they play in AMR stewardship programs and in supporting evidence generation through surveillance. A key driver of adoption of in vitro diagnostic testing is appropriate reimbursement pathways, including policies for Medicare beneficiaries that support the uptake and implementation of such technologies, which will help reduce inappropriate prescribing practices and lead to improvements in patient outcomes. AdvaMed believes the current NAP CARB priority to develop incentives and reimbursement strategies to support uptake of diagnostics is a step in the right direction, but more can be done, particularly through expansion of existing programs within CMS.

**Megan Coffee, M.D., Ph.D., of the International Rescue Committee**, which responds to conflicts and disasters, said that for too long, AMR has not been seen as a primary issue of concern among vulnerable populations. In three countries affected by conflict—Nigeria, Sudan, and Yemen—responders are seeing incredible levels of AMR. The International Rescue



Committee is working with the U.S. Agency for International Development to form a technical advisory group on the humanitarian response to conflicts and vulnerable populations. Increasingly, the combination of climate change, violence, and mobility are creating a perfect storm to generate AMR. For example, malnutrition wards tend to have the most vulnerable children, all in one place, all sick with measles, malaria, and cholera, all having diarrhea and needing antibiotics, resulting in AMR. In addition, areas of conflict often have no running water and no supplies for protecting against the spread of infection. It would take a change in culture to ensure that care providers are doing no harm.

People in conflict zones rely on themselves and their communities. In such areas, four out of five people interviewed reported taking an antibiotic before they sought care in a clinic, including most of the youngest children. Only 5 percent of children had not had an antibiotic. It is important to understand how communities are using antibiotics, how they understand infections, whether they think they need to take an antibiotic to prevent a cold or diarrhea, and how COVID-19 has affected vaccine hesitancy.

**Dave Gross of Arkstone Medical** said his company offers precise ID treatment guidance, ensuring that physicians are empowered with the knowledge they need to make informed prescription decisions. Arkstone software integrates directly with diagnostic laboratories to provide ID treatment guidance to physicians at the moment they receive laboratory results, ensuring that the right antibiotic is chosen for the right infection at the right time. In many situations, the guidance recommends the use of no antibiotics at all. Arkstone technology gives physicians instant access to ID expertise, regardless of the size or staff of the laboratory. Any laboratory anywhere in the world can use Arkstone, which also takes into consideration the resources available to the region.

Despite critical advances, antimicrobial stewardship remains relatively obscure. Laboratories routinely test the sensitivities for dozens of drugs, many of which are not relevant to the specific infection being treated, which often leads to misguided prescription practices and contributes to the rise of antibiotic resistance. Molecular testing unlocked the potential for identifying resistance genes, but many doctors did not understand the results and overprescribed antibiotics because of them. In response, CMS and some private insurance companies cut reimbursement for some types of testing and discouraged their use. Mr. Gross said solutions like Arkstone's can make the data valuable and usable, helping doctors prescribe responsibly and leading to proactive antimicrobial stewardship and improved patient outcomes. Insurance companies and government agencies hold significant power to mandate reimbursement and push for the adoption of technologies that facilitate real antimicrobial stewardship. Incentivizing clinicians and health care institutions to participate in stewardship can drastically reduce the number of prescriptions written empirically. Mr. Gross implored those in positions of influence to embrace new technologies and incentivize the use of services like Arkstone that provide antimicrobial stewardship.

## **Innovation Spotlight**

The Innovation Spotlight is an opportunity for public comment open to all individuals with relevant new and emerging technologies they wish to present to the Council. The Council does not endorse or sponsor any of the companies or products described.

**Annie Bell of Lumos Diagnostics** described FebriDx<sup>®</sup>, a simple, all-in-one, point-of-care assay that can be used at the bedside by clinicians to determine whether a patient with signs and symptoms of acute respiratory infection has a bacterial or nonbacterial infection. FDA has approved FebriDx for use in urgent care settings and emergency departments. FebriDx has a high negative predictive value for bacterial infection, so it identifies those patients who may not benefit from antibiotics and helps protect them from the associated negative sequelae.

The test works by using two host response biomarkers: C-reactive protein and myxovirus resistance protein A. Independently, neither biomarker is sensitive or specific enough to detect or rule out bacterial infection, but when paired together, they have a high sensitivity, specificity, and negative predictive value for detecting and ruling out bacterial infection. The test is simple to use in the clinician's office or at the bedside. It includes a built-in lancet for collecting a small amount of blood from a finger and a mechanism for transferring blood into a tube for testing. Results are available in about 10 minutes.

A multicenter, prospective U.S. trial compared FebriDx results with those of standard tests and subjected them to expert adjudication. FebriDx was determined to be very sensitive and specific for detecting and ruling out bacterial infection. It can give clinicians the confidence to identify a true bacterial infection and prescribe antibiotics appropriately in support of antimicrobial stewardship. It offers tangible results to help patients understand when they do not need antibiotics. Ms. Bell noted that FebriDx is also a very affordable test.

**Arup Roy-Burman MD of Elemeno** described the difficulty of keeping clinical staff up to date with constantly changing information, especially with frequent staff turnover. Disseminating critical information to support antimicrobial stewardship is challenging, and so is making that information stick. The best type of information is the kind one gets in context, in small chunks, when dealing with a specific issue. Attention spans are getting shorter and shorter. With a brief window for learning, information must be presented quickly and in a multimedia format. Elemeno is a just-in-time microlearning application customized for front-line health care teams. The goal of clinical education on the job is to train and orient staff, with minimal variation, to improve standardization, predictability, and safety of care, while also attending to local concerns. Faced with national guidelines, front-line staff want to know how to apply them in their own settings, with the available resources and formulary, to their patients.

The front-line experience of providing health care is chaotic. Providers get operational information from management, training from different specialists and educators, system-wide standards, and unit-specific information, much of it in binders, flyers, or shared online spaces that are not easily located when needed. Elemeno creates a one-stop-shop geared to the organization and customized to the individual care unit. The application transforms knowledge, making it accessible and digestible, just in time, to overcome the cognitive overload. Health care systems around the country using Elemeno have seen substantial reductions in central-line-associated bloodstream infections, *Clostridioides difficile* infections, and serious patient harm. Elemeno adapts national guidelines to the needs of the facility and its staff so that the guidance is personal and relevant. Using the application, management gets feedback on what works and what does not that can be used to inform future iterations.

## **Closing Remarks and Recess for the Day**

*Paul Plummer, D.V.M., Ph.D., DACVIM, DECSRHM, Council Chair, and Jason Newland, M.D., M.Ed., Vice Chair*

Dr. Newland and Dr. Plummer appreciated the hard work of the Council and PACCARB staff to finalize the report, *A United Front: Collaborative Global Leadership to Combat Antimicrobial Resistance*. Dr. Plummer added that the panels and public comments so far have been profoundly interesting and provide much-needed context for the Council's work. The meeting recessed at 3:45 p.m.

## **Day 2**

### **Welcome and Roll Call**

*Paul Plummer, D.V.M., Ph.D., DACVIM, DECSRHM, Council Chair; Jason Newland, M.D., M.Ed., Vice Chair; and Jomana F. Musmar, M.S., Ph. D., Designated Federal Official, Advisory Council Committee Manager, Office of the Assistant Secretary for Health, HHS*

Dr. Plummer welcomed the participants at 9 a.m. Dr. Newland reminded participants that the Council's report, *A United Front: Collaborative Global Leadership to Combat Antimicrobial Resistance*, described the need to highlight the link between AMR and other large societal issues, some of which would be addressed by the day's panels. Dr. Musmar reiterated the rules governing the Council under the Federal Advisory Committee Act and conflict-of-interest guidelines. She then called the roll.

### **Opening Remarks: Drug Resistance as an Emerging ID Threat**

*Daniel Jernigan, M.D., M.P.H., National Center for Emerging and Zoonotic Infectious Diseases, CDC*

Dr. Jernigan stated that the National Center for Emerging and Zoonotic Infectious Diseases plays an active role in managing all USG domestic and global AMR activities. He described the threat of AMR to human, animal, and environmental health; economic stability; and national security, noting the many factors that drive AMR. CDC focuses on prevention, detection, and response to disease. Domestically and globally, CDC aims to prevent the spread of infection and resistant pathogens by supporting public health laboratory capacity, community health endeavors, and judicious use of antimicrobials in humans, animals, and plants. CDC collaborates with industry, academic, and government partners in the United States and abroad. Dr. Jernigan emphasized that the upcoming UNGA HLM offers a prime opportunity for the United States to demonstrate its leadership by bringing the global community together in making specific and achievable commitments to tackling AMR.

President Biden's proposed fiscal year 2025 budget provides \$10 million for CDC's AMR initiative, which would increase investment in state, local, and territorial capacity to detect and control AMR. It would also strengthen CDC's capacity to identify AMR through the Global Antimicrobial Resistance Laboratory and Response Network (Global AR Lab & Response Network) and other CDC platforms, supporting the goals of the NAP CARB and the National Biodefense Strategy.

Thanks to its investments in domestic and global AMR programs, CDC identified a contaminated artificial tears product from India as the cause of drug-resistant *Pseudomonas aeruginosa* infections in the United States. The complexity of that response highlights the value of coordinating efforts to protect public health. The Global AR Lab & Response Network works in 50 countries; the *P. aeruginosa* outbreak demonstrates the need for continued investment in such infrastructure to prevent similar outbreaks globally and domestically.

CDC's One Health Office works with other federal agencies through the U.S. One Health Coordination Unit to strengthen human, animal, and environmental health. It stands up outbreak response teams for emerging zoonotic diseases, especially in relation to companion animals. CDC is working to better understand and test for *Candida albicans* in response to five outbreaks at animal hospitals and rescue facilities. CDC's zoonotic disease priorities include fungal infections, which have a high mortality rate and for which treatment options are limited. In closing, Dr. Jernigan thanked PACCARB for its leadership, for providing CDC with valuable feedback and recommendations, and for highlighting the need to take advantage of the unique opportunity of the UNGA HLM to spur further action on AMR domestically and globally.

### **Panel 3: Conflict Zones and Drug Resistance**

#### **AMR and Stewardship in Displaced Populations in the Middle East**

*Souha Kanj, M.D., American University of Beirut Medical Center*

Dr. Kanj stated that war shapes the modern Arab world; since 2001, the Middle East has been more affected by war than any other region. As of the end of 2022, the region had 15.7 million displaced people, mostly related to conflicts in Iraq, Libya, Syria, and Yemen. Refugee camps are characterized by overcrowding, inadequate shelter, insufficient nutrition, poor vaccination, and poor sanitation—a recipe for ID. War exacerbates many drivers of AMR: the number and nature of war wounds increases the risk of resistance, which is compounded by the loss of health care providers, use of underresourced field hospitals, increased exposure to pathogens, poor infection control, and lack of aseptic techniques during surgery. An analysis of AMR in European migrants found that large numbers came from Middle Eastern countries affected by war. Even Middle Eastern countries not experiencing conflict, such as Lebanon, have high rates of AMR, in part because AMR is imported into the country by foreign patients.

Syria has been experiencing conflict since 2011, and the effects are broad. Despite sparse data, the country has evidence of multidrug-resistant organisms, particularly among injured people. Even before the war, Syria had poor surveillance, few microbiology laboratories, and little quality control. In addition, fake antibiotics smuggled into the country also drive Syria's widespread AMR. Many Syrian refugees fled to Turkey and Lebanon. Lebanon has good laboratory capacity, yet even its state-of-the-art hospital struggles to manage high AMR rates. In that Lebanese hospital, refugees with war-related wounds were more likely than other patients to have carbapenem-resistant bacterial strains. Lebanon's current economic crisis has led to increased poverty and high costs of health care. Refugees in Lebanon face higher mortality rates from ID, and rates were exacerbated by the COVID-19 pandemic.

Gaza faced high levels of poverty and unemployment before the war with Israel began, along with high levels of multidrug-resistant pathogens. One report suggested that 34 percent of

hospital water could be contaminated with bacteria. Since the war began, one quarter of Gaza's population has been displaced, and most hospitals have been destroyed or rendered nonfunctional. The influx of injured people, breakdown of water and sewage systems, shortage of drugs, and other factors will fuel increased AMR. These factors will cause disease and AMR for years after the war. Dr. Kanj noted that stakeholders can pursue solutions for antimicrobial stewardship among refugees, such as improving surveillance, building capacity of health care workers, increasing availability of rapid diagnostics and point-of-care testing, and enhancing quality control, although these require urgent collaboration. She emphasized that AMR recognizes no borders.

### **War and Antimicrobial Resistance: A Surgeon's View**

*Ghassan Abu-Sittah, M.B.Ch.B., University of Glasgow*

Dr. Abu-Sittah described his experience as a surgeon in multiple war zones in the Middle East. He pointed out that blast wounds are often unclosed or reconstructed, making them an ideal host for bacteria growth. Underresourced care facilities in conflict zones often have open wards, where family members are usually on hand, creating opportunities for bacteria spread in all directions. The use of antibiotics in times of conflict depends on what is available at the time of treatment and what patients obtain in the open market, and many drugs are counterfeit or substandard. Dr. Abu-Sittah said humanitarian efforts during conflict sometimes result in "antibiotic dumping," in which a pharmaceutical manufacturer sends a large shipment of a single antibiotic that is nearing expiration (so that the company can write off the donation). That practice contributes to selection pressure.

War destroys health care systems, leaving most patients to receive care in field hospitals or in damaged hospitals that lack facilities such as running water. Moreover, destruction of infrastructure results in exposure to heavy metals in the built environment. The cobalt found in large ammunition co-selects for antibiotic resistance, as do cement, copper, and other building materials. Heavy metals leach into the soil and water, resulting in high toxicity. During conflicts, hospital waste is not distinguished from other garbage. Notably, estimates suggest that about 10,000 bodies remain buried in the rubble of Gaza, which will lead to another environmental catastrophe that spreads AMR throughout the region. Dr. Abu-Sittah emphasized that conflicts are a force-multiplier for AMR.

### **Rising Rates and Increased Geographic Spread of Resistant Infections from the War in Ukraine**

*Joanna Gaines, Ph.D., Ukraine Global Health Security Program, CDC*

Dr. Gaines explained that CDC set up a regional office in Ukraine before the February 2022 invasion by Russia that has since destroyed critical infrastructure throughout Ukraine and accelerated AMR. About a month after the war began, recognizing the consequences of migration and medical evacuation to other countries, the European Centre for Disease Prevention and Control put out guidance about the risk of AMR and multidrug-resistant organisms along with recommendations for boosting capacity to diagnose and manage AMR. European surveillance systems have identified increased colonization and infection with multidrug-resistant bacteria in patients from Ukraine, with related cases showing up as far away as Japan.

War wounds are costly to treat; they require more extensive surgery and longer hospital stays than other wounds, and they are associated with higher rates of amputation and mortality. The Netherlands reported no outbreaks of AMR infections despite treating Ukrainian war-wounded patients, thanks to well-established infection prevention and control policies. In contrast, a German health system identified one Ukrainian soldier carrying six different multidrug-resistant bacteria, an effect of going untreated for a long time.

Ukraine's government asked CDC to help develop a sustainable model for hospital-based AMR detection and response that included linkages to European and U.S. experts. Notably, CDC facilitates collaboration among Ukrainian systems, WHO, the U.S. Department of Defense, clinical providers, and others. Working with regional administrations in three pilot health care facilities in western Ukraine, CDC organizes multidisciplinary teams to address AMR in hospitals, builds data systems to support communication and training on the fundamentals of infection prevention and control, and coordinates efforts from the national to the local level. CDC hopes to expand the regional model if funding is available. Dr. Gaines pointed out that addressing the AMR threat requires complex capacity building, enhanced communication, and improved infection and prevention control practices within and outside of hospital settings. She stressed that misinformation and disinformation pose a significant threat. The public health crisis resulting from Russia's invasion of Ukraine is a unique threat to Ukraine's people and affects its military readiness. Moreover, it threatens Ukraine's allies.

### **Understanding the Health and Drug-Resistance Consequences of the Conflict in Sudan**

*Engy Hamed, WHO*

Ms. Hamed said WHO has considered Sudan fragile since 2000. The country experienced a military coup in 2021 that resulted in sanctions, thus limiting global donations from other countries. The most recent conflict began in April 2023. Ms. Hamed noted that AMR is not on the radar of donors, and she called on the U.S. Agency for International Development and others to better communicate worsening AMR in Sudan.

Before the most recent conflict, Sudan had limited access to health care systems and vaccination; poor water, sanitation, and hygiene systems; high death rates from measles, malaria, and dengue fever; and outbreaks of cholera, tuberculosis, typhoid, and diphtheria. Although lack of access to medications is expected in fragile countries, Sudan is also faced with unregulated access to drugs, because it lacks national regulatory authorities; antibiotics are widely prescribed and used. Microbiology laboratories have testing equipment but, because of sanctions, lack the ability to install the equipment and the supplies needed to use it.

The situation worsened when war broke out in 2023. Observers are anticipating that Sudan will soon face the worst famine in history. Most people lack access to health care. Cases of cholera, measles, malaria, and dengue fever are increasing, and the figures are underreported because providers lack internet and Wi-Fi access. The conflict has driven an increase in poliovirus, meningitis, and typhoid. Laboratories have been destroyed, and government staff have not been paid in more than a year. The war interrupted polio and measles vaccination campaigns and prevented the country from receiving international funds for AMR. Sudan is the largest livestock exporter in the region, but vaccination programs were halted by the war, and livestock have been moved to new territories, increasing the risk of spreading infection.

## Discussion

Dr. Plummer asked for input on how to prioritize health interventions in conflict zones. For example, should the United States increase focus on universal treatment approaches? He also asked for advice on maintaining antimicrobial stewardship in conflict zones. Dr. Kanj pointed out one example of improving diagnostic capacity: Doctors Without Borders' AntibioGo, a mobile application that helps clinicians identify and learn about bacterial infections and resistance at the point of care. Rather than seeking universal therapeutics, Dr. Kanj recommended limiting the availability of certain high-tier drugs to a single hospital in a region that disseminates them appropriately to avoid multidrug resistance. Dr. Abu-Sittah emphasized that, rather than focusing on developing new antibiotics, more alternatives are needed, such as better point-of-care diagnostics and nonsystemic or local solutions, such as topical products.

Ms. Hamed called for continued outreach to health care workers outside of a given country's conflict zone to emphasize prevention and provide guidance on antimicrobial use. Dr. Kanj noted that the train-the-trainer approach for antimicrobial stewardship and infection prevention and control is effective in most settings.

Dr. Newland asked about the impact of AMR on children in conflict zones. Dr. Gaines responded that, in Ukraine, researchers found AMR linked to conflict zones even among people not directly affected, such as those with cancer and pediatric populations who sought care outside of conflict zones. Dr. Kanj added that drug resistance and vaccine-preventable disease infection are common in refugee camps, which often house a lot of children. Dr. Abu-Sittah said the proportion of children affected is high, adding that, according to one surgeon in Gaza, half of amputations occurred in patients already treated because they were unable to prevent postoperative infection.

Dr. Pantaleon noted that many animals are displaced in war zones; he asked whether colonization among abandoned animals noticeably affects AMR. Dr. Kanj offered some examples of multidrug-resistance bacteria in chickens as a result of environmental exposure and feeding practices. Dr. Gaines said patient records often are not transferred in the midst of a conflict, so it is difficult to track whether screening for resistant genes occurred and what might contribute to resistance. At the same time, inappropriate use of antibiotics is hard to control in such settings. Dr. Kanj pointed out that the Global Health Institute and the American University of Beirut created a mobile electronic health record for refugees, which is one example of innovation for managing health in conflict zones.

Dr. Fajt asked how much is known about colonization and AMR in animals in conflict zones, whether in food or companion animals. Ms. Hamed said data were limited before conflicts emerged, but some evidence identifies specific areas of resistance. Access to testing for humans and animals remains a key barrier. Dr. Gaines added that a lot of decisions are made without adequate information about appropriate antimicrobial use or access to diagnostic tests. Dr. Abu-Sittah said migratory birds lend insight into the path of AMR.

Susan Huang, M.D., M.P.H., asked whether high-level technology, such as algorithmic data, could be used to estimate risk and identify risk factors in the absence of laboratory testing

capacity. Dr. Kanj responded that her organization is seeking funding to assess the use of machine learning and artificial intelligence in war settings.

Michael Craig, M.P.P., noted that decolonization agents can be deployed in war settings to mitigate transmission of AMR and improve patient outcomes. Dr. Kanj appreciated the concept but said that her efforts to use chlorhexidine for decolonization were unsuccessful, which suggests that organisms are developing resistance to that product.

Francisco Zagmutt, D.V.M., M.P.V.M., Ph.D., asked panelists to outline key priorities. Dr. Kanj recommended improving vaccine availability, increasing training, and enhancing point-of-care testing to understand the epidemiology of AMR in conflict zones. Dr. Gaines emphasized information sharing, noting that establishing surveillance and networks before conflict emerges paves the way for maintaining surveillance and communication during conflict. She also emphasized the need for more training that is culturally relevant, applicable to the setting, and accessible to those with low education levels. All providers should receive high-quality, evidence-based training on infection prevention and control, said Dr. Gaines.

Ms. Hamed recommended developing simple messages on prevention that can be used by community health workers to reach people on the ground and increasing access to antimicrobials during health emergencies. She also suggested better communicating that AMR is a priority and integrating awareness into vaccination, child health interventions, emergency responses, and other efforts. Dr. Abu-Sittah proposed embracing alternatives such as locally active, topical treatments and point-of-care diagnostics. He echoed the call for education, emphasizing that basic and specialty training should focus more on infection prevention and control as a core component of care and less on very rare abnormalities. Dr. Abu-Sittah said WHO should lead such a change in medical education, especially in LMICs that suffer the most devastating effects of inadequate care.

## **Panel 4: Unequal Exposure, Unequal Risk: Environmental Racism and Drug Resistance**

### **Environmental Racism and Its Impact on Health Disparities**

*Roshanak Mehdipanah, Ph.D., University of Michigan*

The Environmental Protection Agency defines *environmental justice* as the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Dr. Mehdipanah focused on housing, which plays a huge role in health. Housing is a social determinant of health (SDoH), and non-White people are disproportionately affected by housing inequity. In 1934, in an attempt to increase access to home ownership for middle-class people, the Federal Housing Administration developed guidance for housing investments that institutionalized racial segregation and restricted home access for non-White buyers. These policies, known as redlining, led to long-term disinvestment in communities of color, worsening social and economic disparities. Looking at communities in and around Detroit, MI, Dr. Mehdipanah determined that not only were the historically redlined communities more likely to experience negative impacts of SDoH, but the areas designated as good investments accrued more benefits over time than other areas—also known as resource hoarding.



AMR is exacerbated by various factors associated with long-term environmental racism in housing:

- Overcrowding in homes fosters infections.
- Poor hygiene increases the risk of infection. Detroit has seen rising rates of water shutoffs among low-income people since before the COVID-19 pandemic, which limits the ability to wash hands, for example.
- Flint, MI, experienced a crisis of contaminated water, and similar crises are anticipated in other areas of the state.
- People who lack secure housing are more likely to seek care repeatedly in the emergency department, and readmission is associated with increased infections.
- The high cost of housing affects the ability to pay for food and medicine.
- Housing insecurity has a negative effect on medication adherence.

Dr. Mehdipanah emphasized that all of these factors apply to low- and middle-income housed people, not just unhoused people.

### **Role of Race, Ethnicity, and Socioeconomic Status in Colonization and Community-Acquired Infection With Increasingly Drug-Resistant Pathogens**

*Maya Nadimpalli, Ph.D., Emory University*

Dr. Nadimpalli said the COVID-19 pandemic led her to assess whether AMR affects populations equally. Her systematic review of the global literature looked at the relationship between socioeconomic status, race and ethnicity, income, education, and other factors and risk of colonization or infection with selected community-acquired pathogens for which resistance is increasing. She found higher risks associated with lower educational attainment, lower access to health care (in U.S. studies), lower income, more crowded residences, and higher socioeconomic deprivation scores. Dr. Nadimpalli cautioned that most of the studies reviewed did not assess the correlations between socioeconomic factors and colonization or infection, so she could not determine what drives the associations. Also, all the U.S. data came from health records; more data are needed from community surveys or other sources that better represent the population broadly. Few studies were conducted in LMICs, which are facing the greatest AMR burden.

Regarding race and ethnicity specifically, Dr. Nadimpalli said data came from only five countries. She underscored that there is no biological reason for higher risk of AMR linked to skin color or ethnic group, but racial and ethnic minoritization is a SDoH because of structural racism. The literature review found that in the United States, Black people are at higher risk than White people for colonization or infection with methicillin-resistant *Staphylococcus aureus* (MRSA, but not *S. aureus*), and Hispanic people are at higher risk for antimicrobial-resistant Enterobacterales infection and colonization. In Israel, Bedouins are at higher risk than Jewish people for MRSA and antimicrobial-resistant urinary tract infections. In Australia and New Zealand, Aboriginal, Maori, and Pacific Islanders are at higher risk MRSA and *S. aureus*. One major limitation of the research is that studies did not clarify whether racial and ethnic categories were assigned or self-identified. Future research must report how such data are collected.

Dr. Nadimpalli concluded that race is a social construct, but historically marginalized populations everywhere are at higher risk for colonization and infection with resistant pathogens

as a result of the intersection of SDoH. More research is needed to identify the underlying disparities and to determine which SDoH have the most impact. She called for more efforts to equitably prevent, diagnose, and treat AMR infections by taking SDoH into account.

### **Exploring the Intersection of Racism, Drug Resistance, and Vaccine Equity**

*Jacinda Abdul-Mutakabbir, Pharm.D., M.P.H., University of California San Diego*

Dr. Abdul-Mutakabbir explained that in Southern California's Inland Empire, racially and ethnically minoritized people are more likely to reside in areas that house factories; the resulting pollution and emissions are linked to higher rates of acute and chronic respiratory illnesses. Dr. Abdul-Mutakabbir's research on AMR and antimicrobial stewardship found that racially and ethnically minoritized hospital patients were more likely to have candidemia, were younger and sicker at presentation, and had more comorbidities, among other factors increasing the likelihood of AMR. Even more significantly, the research found these patients were more likely to have azole-resistant *Candida* species, revealing disparities in AMR. The findings highlight how disparities build on each other. Dr. Abdul-Mutakabbir said the results drove her to develop an intervention to prevent disease through vaccination.

Drawing insights from the response to COVID-19 vaccines, Dr. Abdul-Mutakabbir's program took a tiered approach to reach the local Black community around San Bernardino County. In collaboration with faith-based organizations (FBOs), the program offered education first, then vaccination. Dr. Abdul-Mutakabbir emphasized that education contributes to agency, which historically has been denied to marginalized communities. The effort resulted in much higher vaccination rates for Black and African American people in the community than achieved by the mass COVID-19 vaccination clinics set up by Loma Linda University. The program has since expanded to include influenza vaccination. Surveys conducted before and after the education component confirm that participants' perceptions of risk and knowledge about vaccines changed, and their intention to receive vaccines increased. Vaccines are offered through community health fairs, where participants can also get basic health screening and education—a useful benefit for those with less access to health care.

Data from other communities indicate that most people did not know they needed an influenza vaccine as well as a COVID-19 vaccine. However, her community has been receiving education about vaccines for the past 3 years and were more likely to be aware of the need and express intent to be vaccinated. Dr. Abdul-Mutakabbir plans to use the same model to address AMR and other IDs. The program demonstrates that with sustained commitment, there are opportunities for effective education and increased vaccine uptake.

### **Antimicrobial Prescribing Disparities and the Pursuit of Pharmacoequity**

*Jasmine Marcelin, M.D., University of Nebraska Medical Center*

Dr. Marcelin underscored that AMR threatens the quality of care and patient safety. *Pharmacoequity* refers to ensuring that all individuals have access to the highest quality medications to manage their health needs. Many areas lack antimicrobial stewardship, and more work is needed to reduce inappropriate prescribing at the individual level.

To improve outcomes related to antibiotics, Dr. Marcelin proposed funding development of new medications, increasing participant diversity in clinical trials, better understanding what drives

inequities in prescribing and how to address it at the individual level, and examining access to needed medications. She noted that cystic fibrosis and sickle cell disease are both chronic conditions that affect a small subset of the population; yet, much more research funding has gone to cystic fibrosis, which has a higher incidence in White people than any other group, resulting in numerous drugs, than to sickle cell disease, which has a higher incidence in Black people and those of African ancestry and for which only two drugs are approved.

Historically, racially and ethnically minoritized people have been underrepresented in medical research, and there has not been enough work to include them in clinical trials. They are less likely to be correctly diagnosed with a condition that warrants antibiotic treatment. For example, Black children with ear infections are less likely than others to be diagnosed with otitis media and receive antibiotics. More inappropriate prescribing takes place in the South and rural areas. Access to medications is restricted by lack of pharmacies; non-White neighborhoods are more likely than White neighborhoods to be pharmacy deserts or lack access to care. Recent data demonstrate that Black, Hispanic, and Indigenous people are much less likely than White people to receive monoclonal antibody treatment for COVID-19.

Dr. Marcelin and colleagues created the pharmacoequity framework for integrating equity into antimicrobial stewardship programs. It is a tool to increase health equity by improving medical access, mitigating prescription bias, reducing prescription costs, and enforcing equity as a quality measure. The framework describes recommended actions for individuals, institutions, and public health entities. The first step is collection of data in a standardized, reproducible manner to identify the drivers of inequity; the next is to develop tools for mitigating inequity and leading with pharmacoequity.

## **Discussion**

Dr. Fajt asked whether evidence supports gender as a confounding factor of racism. Dr. Abdul-Mutakabbir said research demonstrates the impact of the intersection of marginalized identities, such as race, ethnicity, and gender. Dr. Nadimpalli added that her study found a lot of disparities in risk factors, such as occupation; women, often racially and ethnically minoritized women, are more likely than other groups to care for patients. Dr. Marcelin noted that physicians were less likely to accept a recommended intervention from a female pharmacist than a male pharmacist.

Dr. Newland acknowledged the impact of environmental racism but asked what strengths racially and ethnically minoritized populations demonstrate. Dr. Abdul-Mutakabbir said the Black faith community is strong, and the role of religion in decision-making is often overlooked. Loma Linda University is a faith-based institution with strong connections to local FBOs. Dr. Abdul-Mutakabbir said relationships with local Black pastors has been key to reaching communities. She works within her own community to translate scientific information, and her partnership with faith leaders helps to build trust with the community.

Dr. Jinks asked what opportunities exist to incorporate an AMR lens into policies around SDoH. Dr. Mehdipanah said public health plays an important role in all policies; she pointed to CDC's moratorium on evictions during the peak of the COVID-19 pandemic as an example. Dr. Nadimpalli called for more data, noting that wastewater surveillance is one way to link AMR with the characteristics of a community. Incorporating SDoH questions into outpatient visits

would also collect useful data. Dr. Marcelin pointed out that there are no standardized, reliable, reproducible methods for collecting or reporting race and ethnicity, which are not biological constructs but are important social constructs. Researchers must try to collect the data, then analyze subgroups to understand AMR in various populations. Dr. Marcelin added that more work is needed to understand unconscious bias in prescribing by individual clinicians.

Christopher Houchens, Ph.D., asked Dr. Abdul-Mutakabbir how to scale up successful community efforts to increase vaccine uptake and minimize drug resistance. Dr. Abdul-Mutakabbir credited her students with helping her expand the reach of her programs by developing their own community interventions. She hoped that training students in this model of community care would empower them, thus organically scaling up the model over time.

Thomas Wittum, Ph.D., asked Dr. Abdul-Mutakabbir to elaborate on her successful work to increase vaccine uptake. Dr. Abdul-Mutakabbir said education was key, but the type and focus of education was not the same across communities. For example, following education in an Hispanic community, demand for COVID-19 vaccine was high. In some predominately Black neighborhoods, when providers switched the type of COVID-19 vaccine available, fewer people sought out vaccination.

Dr. Dixon said the NIAID Antibacterial Resistance Leadership Group published guidelines on how to address bias in trials. Partnering with FBOs was recommended as one way to improve diversity in clinical trials.

## **Council Roundtable**

Dr. Plummer invited Council members to offer their perspectives on the information presented at this meeting, with particular attention to potential policy recommendations for the future. The feedback is summarized here according to broad categories of interest.

### **Consider New Approaches to Diagnosis**

- New approaches to diagnosis should include new diagnostic technology, attention to timely diagnosis, and research on diagnostic stewardship and safety.
- Explore diagnostic equity for AMR—that is, better diagnostic capacity, better allocation of technology, and better implementation science for action following diagnosis.

### **Research, Surveillance, and Data Collection Can Be Enhanced**

- AMR pathogens take advantage of inequities and vulnerabilities, such as conflict and environmental racism, and the data underestimate the impact.
- There is a persistent need to better integrate human and animal surveillance systems to increase efficiency.
- Automated technology can increase understanding of information gathered from human and animal surveillance.
- Consider research to expand the shelf-life of existing drugs.

### **Workforce Issues Remain a Top Concern**

- The definition of the AMR workforce should broaden to capture more stakeholders, such as community leaders, farm workers who contribute to animal health, and others not traditionally classified as health care workers.
- From a workforce perspective, ID medicine and antibiotic stewardship are not attractive fields; some effort is needed to get trainees excited about pursuing such careers.

### **The Need for Communication, Education, and Awareness Persists**

- Individual patients' stories are powerful. PACCARB should explore how to amplify patient stories to reach a broader audience and bolster advocacy efforts.
- Progress on educating the public, health care workers, health providers, and others about AMR has been insufficient and merits continued attention.
- PACCARB has repeatedly emphasized that communication is key. The proposed AMR ambassador should prioritize communication.
- Patient stories highlight that patients must demonstrate dogged persistence to advocate for themselves; education should include training on how patients can advocate for themselves and play a role in stewardship.

### **Boost the Public Health Response to AMR**

- PACCARB should promote public–private partnerships involving academia and public health to gather and integrate more data.
- PACCARB should advocate for a national vaccine program for adults, similar to the Vaccines for Children program, which could benefit particularly vulnerable populations, such as refugees and people living in shelters.
- More attention is needed on how to support antimicrobial stewardship globally, such as putting infrastructure in place in areas of potential political conflict.
- CDC plays a fundamental role in tackling AMR, yet it is in danger of losing vital resources to maintain its efforts, even as it should be expanding them.
- Existing approaches to public health were insufficient to address COVID-19; new strategies and funding are needed for AMR, especially in war zones and refugee camps.
- Preventive measures may be less effective in certain contexts, such as conflict zones, so expectations of their benefits should be adjusted accordingly.

### **Expand Understanding of the Drivers of AMR**

- Given the many drivers of AMR, focus on adaptability and flexibility in mitigating and preventing AMR in humans and animals.
- There are opportunities to better understand the role of companion animals in transmission and spread of AMR. The next iteration of the NAP CARB should consider creative approaches to the USG role, especially in addressing companion animals.
- The use of counterfeit or diluted drugs may affect expectations and outcomes.

### **Seek Out Experts From Various Fields to Inform AMR Issues**

- The role of pharmacists in controlling antimicrobial access and the calls to include patients as stewards highlight the importance of engagement at the local level, including within the United States.

- The One Health approach would benefit from the expertise of economists who can make a convincing case to policymakers about return on investment for combating AMR.
- PACCARB should keep in mind the effects of social and behavioral interactions on AMR.

### **Broaden the Scope of Understanding AMR**

- The problems are complex but solvable through a systems approach.
- The intense focus on innovation and new products might be diverting attention away from alternatives and infrastructure that would offer a more humane approach to health care, especially animal care.
- The unequal distribution of risk and access to resources stems from social stratification and the concentration of political power. Discussion of solutions should keep in mind the people in power who benefit from the status quo.
- War and conflict zones can provide case studies and offer opportunities to raise awareness about AMR.
- Long-term solutions should center on the need to restore and maintain balance for health, from the microbiome level to the social and ecological systems that trigger a cascade of events.

### **Product Development Remains Stymied**

- The burden of AMR is rising, the product pipeline is inadequate, and talent is leaving the AMR space.
- There is still no economic model to support AMR products once developed. Economic reform is needed that recognizes the value of innovation.

### **Closing Remarks**

*Paul Plummer, D.V.M., Ph.D., DACVIM, DECSRHM, Council Chair, and Jason Newland, M.D., M.Ed., Vice Chair*

Dr. Plummer expressed gratitude for the work of the Council members and staff for completing the report and recommendations to the Secretary. He hoped the recommendations would inform the upcoming UNGA HLM and the next NAP CARB. Dr. Plummer pointed out that every PACCARB meeting brings to light previously unrecognized topics and nuances around AMR, demonstrating the importance of sharing expertise and addressing issues collaboratively. The meeting adjourned at 1:38 p.m.

## **Appendix: Presidential Advisory Council on Combating Antibiotic-Resistant Bacteria (PACCARB) Members**

**May 21–22, 2024**

### **PACCARB Voting Members Present**

Paul Plummer, D.V.M., Ph.D., DACVIM, DECSRHM, Chair

Jason Newland, M.D., M.Ed., Vice Chair

Stephanie Black, M.D., M.Sc.

Claire Burbick, D.V.M., Ph.D., DACVM

Virginia R. Fajt, D.V.M., Ph.D., DACVCP

Susan Huang, M.D., M.P.H.

Jennie H. Kwon, D.O., M.S.C.I., FSHEA, FIDSA

Brian Lubbers, D.V.M., Ph.D., DACVCP

Lynn Marks, M.D.

Armando Nahum

Payal K. Patel, M.D., M.P.H.

Robin Patel, M.D., DABMM, FIDSA, FACP, FAAM

Joni Scheftel, D.V.M., M.P.H., DACVPM

Julia E. Szymczak, Ph.D.

Thomas Wittum, Ph.D.

### **Organizational Liaisons Present**

*Bill & Melinda Gates Foundation*

Padmini Srikantiah, M.D., M.P.H.

*Biotechnology Innovation Organization*

Emily Wheeler (*virtual*)

*EpiX Analytics*

Francisco Zagmutt, D.V.M., M.P.V.M., Ph.D.

*National Institute for Animal Agriculture*

Lucas Pantaleon, D.V.M., M.S., M.B.A., DACVIM

*Society of Infectious Disease Pharmacists*

Elizabeth Dodds Ashley, Pharm.D., M.H.S., FCCP, BCPS

*Wellcome Trust*

Timothy Jinks, Ph.D.

### **Regular Government Employees Present**

*U.S. Department of Health and Human Services*

Christopher Houchens, Ph.D., Biomedical Advanced Research and Development Authority,  
Office of the Assistant Secretary for Preparedness and Response

Michael Craig, M.P.P., Antibiotic Resistance Coordination and Strategy Unit, Centers for  
Disease Control and Prevention (*virtual*)

Ribhi Shawar, Ph.D., (for William Flynn, D.V.M.), Center for Veterinary Medicine, Food and Drug Administration

Patrick McDermott, Ph.D., Office of Global Affairs

Melissa Miller, M.D., M.S., FCCM, Agency for Healthcare Research and Quality

Dennis M. Dixon, Ph.D., National Institute of Allergy and Infectious Diseases, National Institutes of Health

*U.S. Department of Agriculture*

Gamola Fortenberry, Ph.D. M.P.H., REHS/RS, PMP, for Kis Robertson-Hale, D.V.M., M.P.H. RADM, Food Safety and Inspection Service

Chelsey Shivley, D.V.M., Ph.D., DACAW, for Sarah M. Tomlinson, D.V.M., Animal and Plant Health Inspection Service (*virtual*)

*U.S. Department of Defense*

Paige Waterman, M.D., FACP, FIDSA, COL MC, Uniformed Services University

*U.S. Environmental Protection Agency, U.S. Department of the Interior*

Jay Garland, Ph.D., Center for Environmental Solutions and Emergency Response (*virtual*)

**Designated Federal Officials**

Jomana F. Musmar, M.S., Ph.D., Advisory Council Committee Manager, Office of the Assistant Secretary for Health (OASH), Department of Health and Human Services (HHS)

Sarah McClelland, M.P.H., Public Health Advisor, Alternate Designated Federal Officer, OASH, HHS

**Advisory Council Staff**

Zanah Francis, M.S., Ph.D., ORISE Fellow, HHS

Michael Haverkate, D.V.M., Deloitte Consulting

Mark Kazmierczak, Ph.D., Deloitte Consulting

Haley Krem, Committee Management Officer, OASH, HHS

Bryn O'Meara, Deloitte Consulting

Lauren Plaine, M.P.S., RN, CEN, Deloitte Consulting

Jennifer Adona, Rose Li Associates



## Glossary of Abbreviations

AdvaMed	Advanced Medical Technology Association
AMR	antimicrobial resistance
AST	antibiotic susceptibility testing
CARB-X	Combating Antibiotic-Resistant Bacteria Biopharmaceutical Accelerator
CDC	Centers for Disease Control and Prevention
CMS	Centers for Medicare & Medicaid Services
COVID-19	coronavirus disease 2019
CPO	carbapenemase-producing organism
CRO	carbapenem-resistant organism
FBO	faith-based organization
FDA	Food and Drug Administration
Global AR Lab & Response Network	Global Antimicrobial Resistance Laboratory and Response Network
HHS	U.S. Department of Health and Human Services
HLM	High-Level Meeting
ID	infectious disease
IDSA	Infectious Diseases Society of America
LMICs	low- and middle-income countries
MRSA	methicillin-resistant <i>Staphylococcus aureus</i>
NAP CARB	National Action Plan on Combating Antibiotic-Resistant Bacteria
NDM+	New Delhi metallo-beta-lactamase-positive
NIAID	National Institute of Allergy and Infectious Diseases
PACCARB	Presidential Advisory Council on Combating Antibiotic-Resistant Bacteria
R&D	research and development
SDoH	social determinant of health
UNGA	United Nations General Assembly
USG	United States government
WHO	World Health Organization