Animal & Plant Health Agency | Veterinary Medicines Directorate | Centre for Environment Fisheries and Aquaculture Science

Title of Reference Centre	**UK FAO Reference Centre for Antimicrobial Resistance**
Name of the institution and contact details	Veterinary Medicines Directorate Department of Environment, Food and Rural Affairs (Defra) Woodham Lane Addlestone KT15 3LS
Heads of the FAO Reference Centre	**David Verner-Jeffreys**, Centre for Environment, Fisheries and Aquaculture Science, Defra **Niloy Acharyya, Rachel Dalton** Veterinary Medicines Directorate, Defra **Roderick M. Card**, Animal and Plant Health Agency, Defra
Reporting Period	**May 2020 - December 2021**

1.0 Introduction

This is the second report covering our Reference Centre activities in support of the Food and Agriculture Organisation of the United Nations (FAO) programme to tackle antimicrobial resistance (AMR). Through this reporting period we have built on existing relationships and developed new partnerships to continue our efforts supporting international action on tackling AMR.

This report encompasses the period in which COVID-19 become a global pandemic and consequently the profound impacts it had on us all. The pandemic dramatically changed the way we all work and collaborate, and this is reflected in activities described in the annual report. Staff in the UK and partner countries were redeployed to support efforts in mounting their national responses to COVID-19. However, despite these challenges we were able to pivot the Reference Centre activities and continue to support global efforts to tackle the threat of AMR and provide capacity development support to our partners.

Reference Centre activity highlights include:

- Maintaining and developing **international engagement** via FAO, Fleming Fund, and 'on-stage' presence at international conferences
- Expanding our own offering of **e-learning tools**, as well as supporting the FAO in the development of their AMR e-learning provision
- Maintaining and expanding **capacity development** support through collaborative research projects
- Increasing delivery within the **Fleming Fund Fellowship** programme to support the development of expertise
- Continuing to support external **laboratory quality assurance** through provision of Proficiency Testing schemes

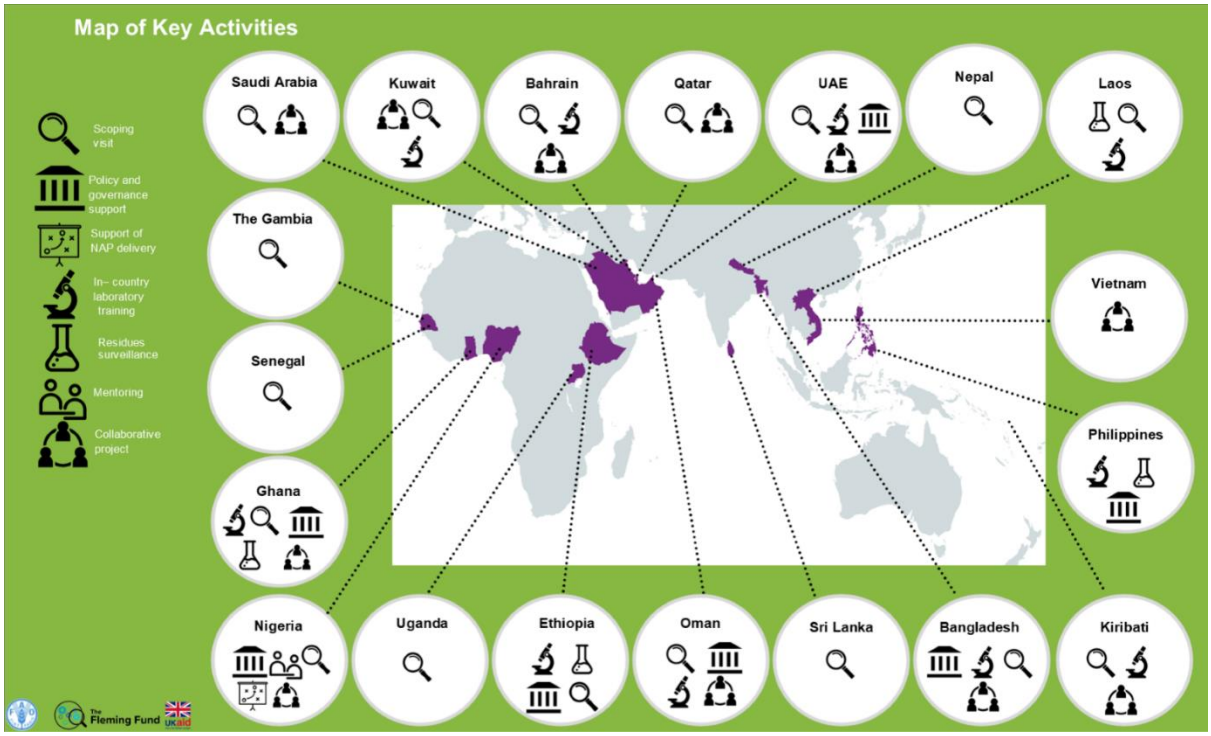

Figure 1. Summary of activities undertaken by the AMR Reference Centre in countries it has supported since its inception up to December 2021.

1.1 Who we are?

The FAO designation recognises the broad range of AMR expertise across three agencies of the UK's Department of Environment, Food and Rural Affairs (Defra): Animal and Plant Health Agency (APHA); Centre for Environment, Fisheries and Aquaculture Science (Cefas); and the Veterinary Medicines Directorate (VMD). Further information about each agency can be found in Appendix One.

1.1.1 Our Vision

To safeguard animal and human health from the threat of antimicrobial resistance.

1.1.2 Our Mission

To provide high quality scientific and policy expertise to help the global community to tackle antimicrobial resistance in terrestrial and aquatic animals and their environments.

1.1.3 Our Objectives

Figure 2. Our objectives

1.2 Achieving our Objectives

To achieve our objectives, we seek to complement FAO's programme in supporting member states in the implementation of national action plans on AMR. Our activities are aligned with both the FAO Action Plan on AMR (2021-2025) and the UK's AMR national action plan (2019 – 2024)

We place partnership at the core of our approach and seek to engage with a wide range of partners to deliver our activities under four broad categories international engagement, surveillance and research, capacity building, and guidance and standards. Activities are underpinned by management and communication functions.

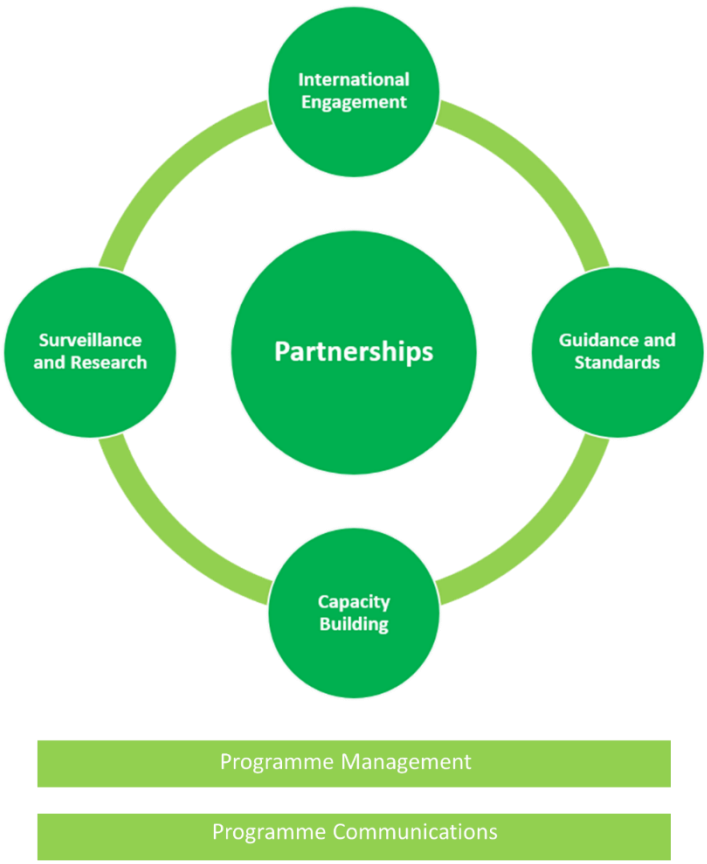

Figure 3. Achieving our objectives

1.3 Acknowledgements

We would like to thank our partners in the countries and institutions with which we have worked for their continued support and for being such engaging and welcoming hosts "on the screen". We also wish to thank the FAO, its AMR Reference Centre secretariat, and the FAO staff and teams with whom we have worked for their continual support and collaborative approach.

We gratefully acknowledge our funding partners for their ongoing support:

- The Department for Environment, Food and Rural Affairs (Defra)
- The Fleming Fund (Department of Health and Social Care, DHSC)
- The Fleming Fund fellowship programme
- The Foreign, Commonwealth and Development Office

2.0 Summary of Activity Undertaken between May 2020 and December 2021 by main activity area

2.1 Activity Area One: International Engagement

2.1.1 Engagement with the FAO AMR and the Reference Centre Secretariat

We have continued to develop our relationship with FAO's Reference Centre secretariat and the AMR focussed FAO staff. We participate in the regular sessions with counterpart Reference Centres and provided input on the format of the inaugural session. Through the FAO's matrix approach, we have identified possible areas of collaboration aligned to the delivery of FAO's action plan commitments. We are members of the FAO's AMR Subject Matter Experts forum and provide a resource for review and consideration of AMR matters for FAO.

We participated in the **FAO AMR Behaviour Change Community of Practice** initiative joining the inception meeting and behavioural insights online co-learning event on 16th September 2020 and followed up by providing contributions to the FAO community of practice discussions on SparkBlue platform.

2.1.2 Provision of Consultancy to Fleming Fund and its partners

The Fleming Fund is a major UK aid Official Development Assistance (ODA) programme of activity managed by the UK Department of Health and Social Care to support up to 24 low- and middle- income countries across Africa and Asia to tackle antimicrobial resistance. We work closely with the Fleming Fund team and its partners to provide animal health and policy expertise. As well as the more detailed country partnerships, we provide consultancy on ongoing initiatives. Examples have included: assisting with Fleming's deep dive on reporting of AMR and AMU in the animal sector; supporting the development of future Fleming Fund phases; participating in the development of their theory of change and contributing to their

future business case; reviewing Fleming Fund's monitoring and evaluation plan for its next phase of work and providing indicators that can be assessed by its independent auditor.

2.1.3 International Conferences

2.1.3.1 Fleming Fund Delivery Partners Event (12-18 October 2020)

Our team participated in the virtual Fleming Fund Delivery Partners Event, presenting on our capacity development support for residues testing in Laos as part of the 'Journey through the Theory of Change' Session. In the 'Country Perspective' Session on Day 3 an Animal Health laboratory professional Fellow, mentored though the Reference Centre, gave a presentation on innovations to simplify collection and analysis of on-farm antimicrobial use and epidemiological data. On the final day, a team member was one of two moderators for the Animal Health Breakout Group sessions addressing the 'Demand for Data' and 'What does success look like?" and afterwards provided feedback to the wider meeting.

2.1.3.2 First Fleming Fellows' Symposium 2020 (28-29 October 2020)

This online Symposium had over 100 attendees on both days and provided an opportunity for participants to meet with Fellows and Host Institution teams from across the Fellowship Scheme. A member of the Reference Centre staff sat on the organising committee for this symposium, helping to formulate the symposium's aims & programme, including thematic panel sessions, an opening address from the DHSC, speed presentations, and breakout discussions. They also co-chaired the 'Sharing best practice' session of presentations by fellows and the ensuing panel discussion.

2.1.3.3 Second Fleming Fellows' Symposium 2021 (10-11 November 2021)

As a member of organising committee for the second Fellows' Symposium we contributed to the Symposium format including themes, content, and programme for a successful two-day event with over 80 participants. We presented the final session of the symposium themed on

sustainability, summarised insights from a participant survey, and moderated the ensuing group discussion.

2.1.3.4 World One Health Congress (30 October - 3 November 2020)

We delivered a presentation titled "*The UK FAO Reference Centre for Antimicrobial Resistance: delivering capacity building support to low- and middle-income countries*" during the Capacity Building session of the Antimicrobial Agents and Resistance track. The talk outlined the role and impact of the Reference Centre, giving examples of the capacity development support work with partners in Africa and Asia.

Additionally, a PhD student from Ebonyi State University (Nigeria) who has been working with APHA and the Royal Veterinary College gave a presentation titled "*Predominance of CTX-M-15 in Cefotaxime-Resistant* Escherichia coli *isolates from Food Animals and in-contact Humans in Southeast Nigeria*". The student had received support from the Reference Centre and gave their talk in the Transmission human, animal, environment session of the Antimicrobial Agents and Resistance track.

2.1.3.5 8th International Conference on Spirochaetal Infections in Animals and Humans (01-03 September 2021)

We delivered a keynote presentation titled "Working group for standardization of MIC testing of *Brachyspira* spp.", outlining international efforts towards standardisation of antimicrobial susceptibility testing and current insights into the molecular genetics of resistance in these important veterinary bacterial pathogens.

2.1.4 Regional Engagements

2.1.4.1 The Gulf Region

As interest in tackling AMR in the Gulf states continues to rise, we have supported Kuwait, United Arab Emirates, Qatar, Bahrain, and Oman in establishing marine AMR surveillance

systems. Activities have included holding initial scoping workshops on veterinary AMR surveillance and integration into One Health AMR approaches.

In March 2021 we participated in a Joint UK- Bahrain One Health Workshop on Antimicrobial Resistance (AMR). The workshop focused on developing a framework under which the Reference Centre team and Bahrain's Ministry of Health can develop a programme of work to better understand the environmental aspects of AMR, supporting the implementation of a holistic One Health focused NAP. Likewise, we participated in a similar joint event with **Qatar** to initiate scoping for future support.

2.1.4.2 Bangladesh

The Reference Centre is a standing invitee to the Bangladesh coordination meeting of Fleming Fund grantees and partners, chaired by the country grant lead. We provide updates on our activities in Bangladesh and ensure these align with other activities in a coordinated manner to realise maximum impact. Our activities in Bangladesh are outlined later in the report.

2.1.4.3 Uganda

To help develop approaches to integrate AMR in aquaculture (and other veterinary settings) into a One Health approach, in the second half of 2020 we met with representatives from Uganda's National Agricultural Research Organisation (NARO). This proved helpful in networking and continuation of dialogue around AMR and antibiotic usage in aquaculture and the livestock sector in Uganda which enabled our colleagues to get a general sense of the type of support that may be required, laying the foundations for future activity. A follow up meeting in February 2021 was held with the Ugandan Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) and Makerere University which helped to further define how may specifically help them implement more One Health based cross-sectoral AMR and AMU surveillance activities in Uganda. Proposals for joint research projects in these and related areas were also developed.

2.1.4.4 Nepal

Preliminary meetings were held with country and regional leads for implementation of the Fleming Fund country grant in Nepal, to discuss areas in which the Reference Centre could offer support. A “Workshop on Animal Health AMR and AMU surveillance in Nepal and the UK” was held with Nepalese stakeholders in June 2021 to build relationships, share expertise, and identify future opportunities.

We were able to provide training to national personnel on surveillance of veterinary medicines residues in products of animal origin as described in section 2.2.5.2.

2.2 Activity Area Two: Capacity Building

2.2.1 Fleming Fund Professional Fellowship Scheme

The Fleming Fund Fellowship Scheme aims to support the professional development of practitioners and influencers to boost AMR workforce capacity. The Scheme encourages peer-to-peer learning, strong One Health communities of practice and communication within the highest levels of government to influence AMR policies. Fellows are primarily chosen from within public government institutions to directly build national capacity to respond to AMR. By providing animal and aquaculture expertise, the Reference Centre contributes to the success of this important scheme. Over the reporting period, we have worked with fellows in Nigeria and Bangladesh.

2.2.2 Fleming Fund Fellows, Nigeria

The Reference Centre, through APHA as the Host Institution, mentored two Nigerian animal health professional Fleming Fellows. This was done in close collaboration with the other Host Institutions for Nigeria: Public Health England (PHE) (renamed the UK Health Security Agency, UKHSA, in October 2020) and the Technical University of Denmark (DTU).

The Fellows successfully completed their Fellowship programme in December 2021 and celebrated their success at a graduation ceremony held in Abuja on 12th January 2022.

Significant improvements in Nigerian staff and institutional capacity have been achieved in this programme. For example, at the initiation of the fellowship the animal health fellows undertook a gap analysis of their home laboratory procedures and systems (such as standard operating procedures, quality management, health & safety, and staff training). This was used to inform the content of their Fellowship programmes and the training provided during their visit to our UK facilities in December 2019. Fellows focussed on addressing these gaps during their fellowship, with support from their mentor and the AMR Reference Centre. At the end of their fellowship the fellows undertook an assessment to demonstrate the impact of their work improving home laboratory systems and how the changes made can be sustained beyond the Fellowship.

Another significant achievement has been the successful completion of a collaborative One Health project involving five fellows and their three mentor institutions. This project involved harmonised approaches to examine the AMR and antimicrobial use (AMU) in poultry farms, farm workers, and hospital submissions. The fellows have presented this work at international conferences and meetings and are currently writing it up for publication. Through these activities we have helped establish a community of practice between fellows and mentors, and meet regularly to coordinate activity, share developments, and identify new opportunities.

Case Study: Laboratory training of Nigerian scientific staff

In October 2021 the APHA and UKHSA fellows organised and delivered One Health AMR 'Step down' antimicrobial susceptibility testing training courses at their home institutes in Nigeria: National Veterinary Research Institute (Jos), University of Ibadan (Ibadan), Nigerian Centre for Disease Control (Abuja), and University College Hospital (Ibadan). A total of 132 participants from government, academic, or private laboratories received training through this programme.

Figure 4. Fleming Fund animal health Fellow leading the laboratory training session at the National Veterinary Research Institute in Vom. [Photo credit: National Veterinary Research Institute]

The two-to-three-day courses comprised a thoughtful balance of lecture room teaching and hands-on sessions in the laboratory. This gave the participants practical experience handling and testing bacterial cultures, as well as background and wider context for their AMR work. The courses were held on different days, enabling fellows to contribute remotely to each other's training programmes. Additionally, the DTU mentored fellow specialising in veterinary antimicrobial use taught at each course. Subject matter experts from the AMR Reference Centre and UKHSA gave presentations via video link on a range of topics including veterinary medicines regulation and policy, AMR susceptibility testing methods, AMR surveillance, AMR in aquaculture, quality control, and health and safety.

Figure 5. Fleming Fund animal health Fellow demonstrating the streaking of bacteria onto a culture plate during a laboratory training session at the University of Ibadan. [Photo credit: University of Ibadan]

Post-course feedback from participants was very positive and praised course quality and content. Participants expressed a strong desire to implement the new learning in their home laboratories, to improve the quality and value of AMR data they generate.

This training strengthened Nigerian institutional capacities through up-skilling of laboratory staff and enhancing their capacity to produce high-quality microbiological data. This all helps to help build a One Health AMR surveillance system and support implementation of Nigeria's national action plan for AMR.

This work also highlighted the value of our 'train-the-trainer' approach, in which fellows received instruction in the UK and then disseminated this learning to colleagues in their home institutions.

The training course was the subject of an APHA science blog published for WAAW 2021 (see below).

2.2.3 Virtual training on regulation of Veterinary Medicines

In February and March 2021, we hosted a virtual visit for Nigeria's animal health Fleming Fund Fellows. Training was provided on a broad range of the regulatory aspects of veterinary medicines and antimicrobial resistance from both the UK and Nigerian perspectives. This was delivered through a pack of narrated presentations and follow-up in depth set of discussions with VMD subject matter experts. The topics covered were pharmacovigilance; veterinary medicines legislation; surveillance of residues of veterinary medicines; authorisation of veterinary medicines; surveillance of AMR and AMU usage, stewardship, and stakeholder engagement. Additionally, colleagues from APHA and Cefas were able to present on how activity across Defra fits into the UK's AMR landscape. In addition to technical experts, there was also an opportunity for the fellows to engage with the head of the UK Responsible Use of Medicines in Agriculture alliance which has coordinated efforts within the livestock sectors to reduce antimicrobial usage. Live sessions with subject matter experts on AMR surveillance and research in aquaculture and terrestrial veterinary settings were also held.

2.2.4 Fleming Fund Fellows, Bangladesh

Building on our previous engagement in 2019 (See previous report), we are working with CGIAR WorldFish and the Fleming Aquaculture Fellows to support the implementation of the Fellow's workplans. CGIAR is a global partnership that unites international organisations engaged in food security. This work dovetails with the wet market surveillance we are supporting in Bangladesh in partnership with WorldFish (see section 2.3.4).

2.2.5 E-Learning development

E-learning provides accessible training to a wider audience and can be useful combined with other training techniques to suit different needs of participants.

2.2.5.1 FAO e-learning

Following discussion for a module on "Understanding AMR in the Aquatic Environment and its Resource" the need for a broader FAO AMR e-learning module was identified. This module of five lessons will provide an accessible introduction to AMR in food and agriculture for a broad range of audience. We were please to contribute to the technical content of the course, which will be launched in April 2022, hosted on the publicly available FAO e-learning platform.

2.2.5.2 Antimicrobial Residues e-learning

Our previous report highlighted the development of a blended course on surveillance on veterinary medicines residues in products of animal origin. This course has now been delivered to national personnel in Ethiopia and Ghana, with plans now in place to continue its roll out to Philippines and Nepal.

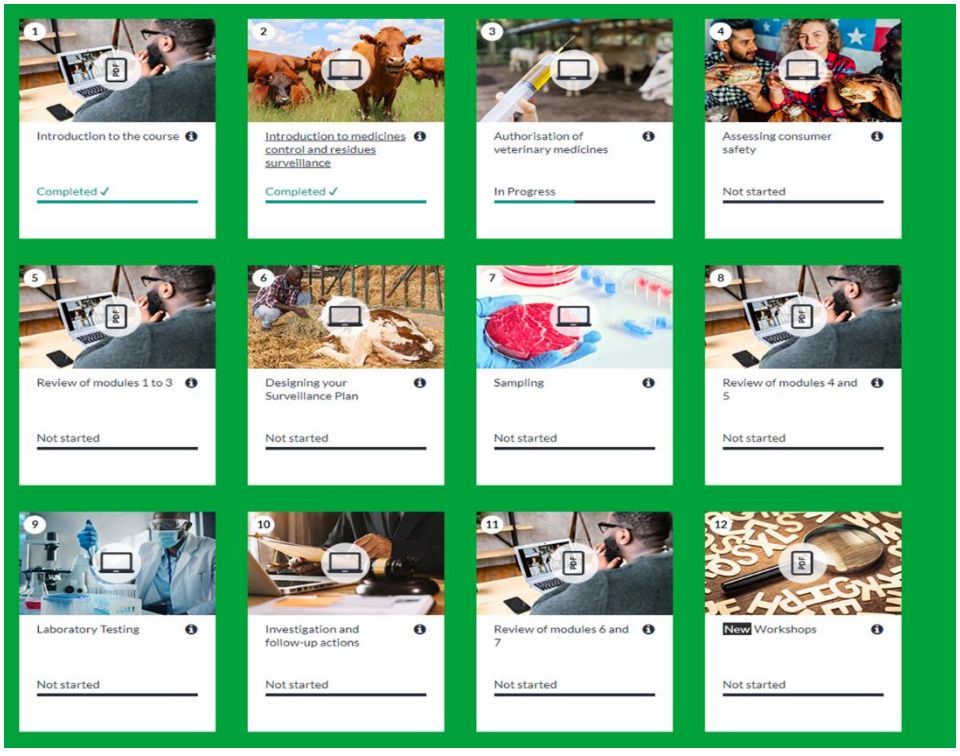

Figure 6. Modules page for the Antimicrobial Residues e-learning course [Image credit: VMD]

2.3 Activity Area Three: Surveillance and Research

2.3.1 Collaborative Projects

Prior to the COVID-19 pandemic, we had established good working relationships with partners at government and academic laboratories in several countries, whilst undertaking country visits (see Annual Report 2019-2020). Discussions with many partners had identified AMR focussed research areas that would benefit from the support that we could provide.

In the absence of international travel in 2020 and 2021, the Reference Centre was able to pivot and focus increased effort on undertaking these collaborative research projects, thereby providing research capacity development, confirmatory testing, antimicrobial susceptibility testing, and whole genome sequencing. Importantly, cargo flights were less impacted by the travel restrictions and bacterial isolates could be sent from many countries for receipt and testing at our UK laboratories.

Collaborative projects with partners in Bangladesh, Ghana, Nigeria, and Vietnam have been established in this manner. The projects specifically address important evidence gaps pertaining to AMR and potential risks to veterinary or public health. The projects seek to provide insight that can help inform the design of future surveillance or research protocols, and contribute towards assessment of risk to humans via, for example, the food chain. Material Transfer Agreements have been signed with the laboratories providing isolates and projects are in differing stages of progress.

2.3.2 Kiribati

AMR and water quality are of concern to the Pacific Island states. In Kiribati, the Reference Centre the Reference Centre was able to add value to data obtained as part of a project delivered through the UK's Commonwealth Marine Economies Programme, in collaboration

with the Environment and Conservation Division of the Kiribati Government's Ministry of Environment, Lands and Agriculture Development (MELAD-ECD). A publication includes preliminary investigations of resistant bacteria released from hospitals and other sources into the environment and the impact on human health (https://doi.org/10.1016/j.marpolbul.2020.111951). In addition, we have been asked by MELAD-ECD to determine how our Reference Centre can best support the inclusion of environmental AMR considerations into Kiribati's NAP.

2.3.3 Philippines

We are working with the FAO and three government laboratories to strengthen laboratory capacity in establishing confirmatory methods, validation of protocols and troubleshooting of instrumentation and methods. Priorities in tackling the pandemic have meant that progress on this work has been limited, however some online support has been provided with a view to progressing as the Covid-19 situation eases.

2.3.4 Bangladesh

We have engaged with CGIAR WorldFish in Bangladesh to develop and pilot a surveillance programme for AMR in wet markets. Meetings were held with the Fleming Fund Country grant holders to ensure the work complemented their wider activities to implement improved AMR surveillance activities across the human health and agricultural sectors in Bangladesh. Activity in this reporting period included the development of detailed protocols for the collection, sampling, and processing for antibiotic susceptibility testing (AST) profiling of fish and shrimp bacterial isolates from wet markets. This work has been carried out in collaboration with partner Bangladesh Government laboratories, including the Bangladesh Livestock Research Institute. Fish and shrimp from four wet markets have been processed and targeted bacterial isolates preserved for confirmatory identification and AST. Supply and procurement of laboratory chemicals, kits, and consumables from Cefas in the UK and local suppliers in Bangladesh was completed and training materials developed and published, including a rapid

AST protocol and PowerPoint presentation, for the training of staff from participating institutions.

Figure 7. Collecting fish and shrimp samples at Bangladeshi wet markets [Photo Credit: WorldFish/CGIAR]

Reference Centre staff also helped organise and deliver a two-day online One Health workshop in March 2021, a component of which was AMR: 'Embedding One Health to support aquatic food production during Covid-19' with CGIAR WorldFish. The main objective of this workshop was to formally introduce the concept of One Health Aquaculture to the authorities and national stakeholders responsible for policies in Bangladesh. Through a combination of plenary talks, presentations, and activities, the workshop focused on future collaborations/directions, building a One Health network and the One Health Aquaculture approach in Bangladesh, and included participants from WorldFish, Cefas (UK), the University of Exeter (UK), Government officials, private sectors, non-governmental organisations, academics, and researchers from Bangladesh.

Figure 8. Processing the collected samples in the laboratory [Photo Credit: WorldFish/CGIAR]

2.4 Activity Area Four: Guidance and standards

2.4.1 Antimicrobial Usage (AMU) in Finfish guidelines

Bangladesh AMR Response Alliance (BARA) members have previously developed a set of AMU Guidelines, following WHO AWaRe categorization, for poultry and human treatment. At the request of the FAO Emergency Centre for Transboundary Animal Diseases (ECTAD) team in Bangladesh a group was convened to discuss the production of a set of similar guidelines to determine AMU in Finfish, to help finfish farmers in countries like Bangladesh. A stakeholder group consisting of members of BARA (including WorldFish and the OIE focal point for AMR and Aquatic Animals in the Department of Fisheries), FAO, OIE and the Reference Centre have been meeting online to discuss technical support that can be offered.

2.4.2 Proficiency Testing Schemes

In 2019 the AMR Reference Centre developed an *Escherichia coli* antimicrobial susceptibility testing Proficiency Testing (PT) scheme. The first distribution of this scheme, in 2020, was undertaken by VetQAS (APHA's independent, ISO/IEC 17043 accredited, proficiency testing service). VetQAS is recognised by national accreditation bodies and is a well-established provider in the provision of PT schemes for veterinary laboratories.

Fourteen laboratories from seven countries participated in 2020, having returned their results by the closing date. The AMR Reference Centre analysed the submitted results to assess laboratory performance against recognised benchmarks and provided a report to all participants summarising the findings. When warranted, participants were provided with additional confidential notes to offer comment and support on possible sources of error. Participating laboratories are evaluated preserving confidentiality, as each is identified by a code known only by the corresponding laboratory, VETQAS, and the UK FAO Reference Centre for AMR.

In Autumn 2021 a second distribution of the *Escherichia coli* antimicrobial susceptibility testing PT scheme was successfully completed. Twenty-six laboratories from 12 countries returned results for this PT distribution. The data was analysed to assess laboratory performance and the PT scheme report will be provided to all participants in early 2022.

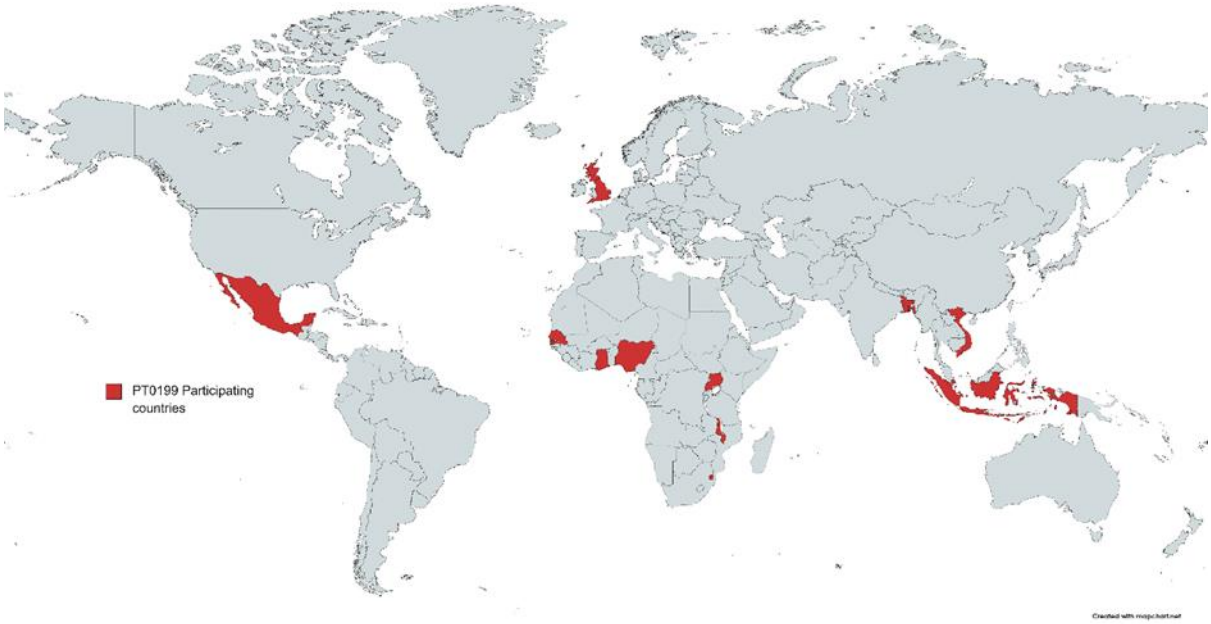

Figure 9. Countries in which participating laboratories were located for the 2021 Escherichia coli *PT AST scheme (generated using mapchart.net).*

2.4.3 Setting Susceptibility Testing Standards and Interpretive Criteria

A portfolio of work has been undertaken during the reporting year to help establish epidemiological cut off values (ECOFF) for priority aquaculture pathogens. In the absence of clinical breakpoints, there is a strong need for internationally agreed ECOFFs for use in developing and reporting aquaculture AMR surveillance programmes. These have included helping to design and test a broth microdilution susceptibility plate for establishing ECOFFs for the important pathogen *Vibrio anguillarum* with partner laboratories from across Europe. Results were shared with the CLSI at an aquaculture working group meeting in September 2019 to consider for inclusion in the next updates of their standards for testing aquatic pathogens. Efforts are also ongoing to establish ECOFFs for other Gram-negative pathogens, including *Yersinia ruckeri*, *Aeromonas salmonicida* and *Vibrio parahaemolyticus*. Discussion with researchers from the University of Queensland Australia is also ongoing to develop additional ECOFF values for the Gram-positive pathogens *Streptococcus agalactiae* and *Streptococcus iniae*. This work has been done in collaboration with a range of European and other international partners, including another FAO AMR Reference laboratory, The French Agency for Food, Environmental and Occupational Health & Safety (ANSES), the US Food and Drug Administration, and representatives from FAO-RAP.

2.4.4 Communications

In addition to the awareness raising and engagement activities outlined in this report, the AMR Reference Centre has had an active communication strategy aimed at reaching a wider audience.

For World Antimicrobial Awareness Week (WAAW) 2020 the Reference Centre published an APHA science blog summarising its One Health AMR work in Nigeria and its close collaboration with Public Health England's WHO Collaborating Centre for AMR and Healthcare Associated Infections. This blog included links to the WAAW 2020 activities being undertaken by the Nigerian Professional Fellows with whom we work.

Cefas published a blog providing a review of activities in different countries.

The UK CVO also published a blog for WAAW 2020 and included mention of the work done by the Reference Centre.

APHA blogs and social media were used to promote APHA involvement in the World One Health Congress 2020 and World One Health Day (link), including mention of the Reference Centre.

For World Antimicrobial Awareness Week (WAAW) 2021, an APHA Science blog was published for WAAW 2021 describing the laboratory training of Nigerian scientific staff described in Activity Area 2. Additionally, for WAAW, we delivered a presentation at the FAO webinar on the use of antimicrobials in the food and agriculture sector.

3.0 Looking to the future

We look forward to continuing our work with so many supportive and engaging partners. Furthermore, we are developing plans for supporting FAO in its ambitions supporting the food and agriculture sectors in Sub-Saharan Africa, South- and South-East Asia in improving their AMR and residues capacity, further embedding laboratory standards through PT schemes, and support research initiatives such as Farmer Field Schools. We look forward to including updates on these in our next report.

4.0 Publications by Reference Centre staff

1. Retrospective analysis of necrotizing typhlitis cases associated with *Brachyspira* spp. in British rheas. McFadzean H, Schock A, Stubberfield E, **Card RM**, Thomson J, Rohde J, Murray L, Velo-Rego E, Ainsworth H, Barlow AM, Welchman D. Avian Pathol. 2021 Apr 21:1-11. https://doi.org/10.1080/03079457.2021.1907305; PMID: 33779433.

2. Reduction in antimicrobial resistance prevalence in *Escherichia coli* from a pig farm following withdrawal of group antibiotic treatment. De Lucia, **Card RM**, Duggett N, Smith RP,

Davies R, Cawthraw SA, Anjum MF, Rambaldi M, Ostanello F, Martelli F. Veterinary Microbiology Volume 258, 109125 https://doi.org/10.1016/j.vetmic.2021.109125

3. Marine water quality of a densely populated Pacific atoll (Tarawa, Kiribati): Cumulative pressures and resulting impacts on ecosystem and human health. Graves CA, Powell A, **Stone M**, Redfern F, Biko T, Devlin M Marine Pollution Bulletin 163 https://doi.org/10.1016/j.marpolbul.2020.111951

4. Whole-Genome Sequencing of *Brachyspira hyodysenteriae* Isolates from England and Wales Reveals Similarities to European Isolates and Mutations Associated with Reduced Sensitivity to Antimicrobials. Emma Stubberfield, Jonathan Sheldon, **Roderick M Card**, Manal AbuOun, Jon Rogers, Susanna Williamson, Gemma L Kay, Mark J Pallen, Muna F Anjum. Front Microbiol. 2021 Aug 31;12:713233. https://doi.org/10.3389/fmicb.2021.713233.

Appendix One

Summary of the three Defra agencies which together hold the UK FAO AMR Reference Centre designation.

Animal and Plant Health Agency (APHA)

APHA works to safeguard animal and plant health for the benefit of people, the environment, and the economy. Its responsibilities include identifying and controlling endemic and exotic diseases and pests in animals, plants, and bees; surveillance of new and emerging pests and diseases; scientific research in areas such as bacterial, viral, prion and parasitic diseases and vaccines, and food safety; and to act as an international reference laboratory for many farm animal diseases.

APHA is globally recognised for its AMR expertise, has been a reference laboratory on AMR for the World Organisation for Animal Health (OIE) since 2003, and is the UK's national reference laboratory for AMR in veterinary bacteria. The APHA undertakes passive and active AMR surveillance in UK livestock and food sectors and provides AMR data and expert analysis

for the annual report on sales of antibiotics and surveillance of AMR published by the VMD. It has significant laboratory capability in its network of diagnostic laboratories and at its central facility at Weybridge, Surrey. APHA's capability includes development of phenotypic and genotypic diagnostic tests; molecular typing utilising dedicated sequencing units (e.g., whole genome sequencing); research with extensive collaborative networks and complex modelling techniques.

Centre for Environment, Fisheries and Aquaculture Science (Cefas)

Cefas is the UK government's marine and freshwater science agency, working for healthy and productive oceans, seas and rivers and safe and sustainable seafood. Innovative, world-class science is central to the mission, working to safeguard human and animal health, enable food security and support marine economies. Cefas is a global leader in aquatic animal health and is positioned to provide services in identifying AMR risks to aquatic animals and to help develop and assess the effectiveness of alternatives to use of antibiotics for control of diseases of farmed aquatic animals (particularly in finfish and shrimp).

For this Cefas can draw on its extensive expertise in disease investigation, diagnosis, and control, including experience of AMR characterisation of aquatic pathogens. As well as state of the art equipment for measuring AMR, it also has access to a range of advanced pathology and molecular technologies, including high throughput sequencing for pathogen genomics. Cefas epidemiology and risk teams also have experience in designing and interpreting surveys to help quantify and reduce antibiotic usage on farms.

Veterinary Medicines Directorate (VMD)

The Veterinary Medicines Directorate (VMD)[1] is the UK regulator of veterinary medicines. VMD facilitates the availability of safe and effective veterinary medicines for prevention and treatment of disease and to protect animal health and welfare, human health, and the environment. We have built a reputation as a leading centre for regulation, encompassing all

aspects of VMP authorisation and post authorisation management, including legislation, scientific data assessment, pharmacovigilance, antimicrobial use, resistance and residues surveillance, and compliance with good manufacturing and distribution practices.

The VMD is the UK policy lead on AMR in regard to animal health and we are responsible for overseeing implementation of the animal health aspects of the UK 5 Year AMR national action plan[2] and 20-year vision[3], working closely with human health colleagues, and taking a One Health approach. We publish an annual report on sales of antibiotics and surveillance of AMR (UK Veterinary Antimicrobial Resistance and Sales Surveillance) and chair Defra's cross-government AMR Coordination group which brings together expertise from across the UK government and devolved administrations to review and respond to emerging AMR threats.

We work with low- and middle- income countries to provide technical and policy expertise across all aspects of veterinary medicines regulation. We are a member of VICH, participate in expert advisory groups for the British Pharmacopoeia and the European Pharmacopoeia, are Committee members for the Pharmaceutical Inspection Co-operation Scheme (PICs) and provide subject specific expertise on aspects of veterinary medicines to Codex Alimentarius, FAO and OIE.

[1] VMD website: Veterinary Medicines Directorate - GOV.UK (www.gov.uk)
[2] HM government: Tackling Antimicrobial Resistance 2029 – 2024: The UK's five-year national action plan
[3] HM government: Contained and Controlled: The UK's 20-year vision for antimicrobial resistance