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

Title of FAO AMR Reference Centre	**UK FAO Reference Centre for Antimicrobial Resistance**
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Reporting Period	**January 2022 - December 2022**

Contents

Glossary

Abbreviation	Term
AMR	Antimicrobial Resistance
AMR NAP	Antimicrobial Resistance National Action Plan
AMU	Antimicrobial Usage
APHA	Animal and Plant Health Agency
AST	Antimicrobial Susceptibility Testing
ASEAN	Association of South East Asian Nations
BARA	Bangladesh Antimicrobial Resistance Response Alliance
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CLSI	Clinical and Laboratory Standards Institute
CoP	Community of Practice
CVO	Chief Veterinary Officer
dCVO	Deputy Chief Veterinary Officer
Defra	Department for Environment, Food and Rural Affairs
DHSC	Department for Health and Social Care
DIT	Department for International Trade
ECOFF	Epidemiological Cut Off Value (EUCAST)
ECV	Epidemiological Cut Off Value (CLSI)
EUCAST	The European Committee on Antimicrobial Susceptibility Testing
ESBL	Extended Spectrum Beta Lactamase
FAO	Food and Agriculture Organisation of the United Nations
FAO ECTAD	Emergency Centre for Transboundary Animal Diseases
FCDO	Foreign and Commonwealth Development Office
LMIC	Lower- or Middle-Income Country
MSPP	Multistakeholder Partnership Platform
NAP	National Action Plan
NMIS	Philippines National Meat Inspection Services
ODA	Official Development Assistance
PT Scheme	Proficiency Testing Scheme
RAP	FAO Regional Office for Asia Pacific
UKHSA	United Kingdom Health Security Agency
VMD	Veterinary Medicines Directorate
WHO	World Health Organisation
WOAH	World Organisation for Animal Health
WOHC	World One Health Congress

Executive Summary

The UK FAO Reference Centre for AMR (Reference Centre) comprises a 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). Over the last year we have delivered to a high standard in all four of our main activity areas.

International Engagement

The Reference Centre has provided **high quality expert advice** to our global partners including international agencies (FAO and WOAH) UK Government (Defra, DHSC, FCDO, and DIT) and funding partners (Fleming Fund and Mott MacDonald). The easing of COVID-19 related travel restrictions has also allowed us to attend and present our work in-person abroad, and network at **international conferences** and workshops in a range of countries including Bangladesh, Ghana, Singapore, South Africa and Zambia. We have also attended, or hosted, numerous meetings virtually with our partners.

Capacity Building

Helping countries build their capacity for long-term sustainability and resilience remains our focus. In particular, we have engaged with Ghana and Bangladesh to support the development and implementation of agri-environmental dimensions of their One Health based National Action Plan for AMR. We have directly supported the delivery of **AMR workshops** in Qatar and Bangladesh to support implementation of One Health-based approaches. We have established an **AMR Community of Practice** (CoP), where over 70 AMR experts from 20 countries are able to share expertise, promote good laboratory practices, and build professional networks. Capacity building has also included continuing our strong support for the Fleming Fund **Fellowship Program**, actively mentoring AMU and AMR fellows from Ghana and Nigeria. We have **hosted international visitors** at our UK facilities from Zimbabwe, India, and Qatar, who came for training, networking, and to strengthen our collaborations.

Surveillance and research

We engage in **collaborative projects** in many of our partner countries, to support **research capacity development**. Highlights included establishing AMU and AMR baselines in West African fish and pig farms, allowing us to identify areas to strengthen good practice in Ghana and Nigeria. We also developed and implemented a pilot wet market **AMR surveillance programme** with our partner CGIAR WorldFish in Bangladesh. A survey we published showed high carriage of Extended Spectrum Beta Lactamase (ESBL), and other important resistance genes, in *Escherichia coli* recovered from the marine environment in a number of Gulf states.

Guidance and standards

Our experts contributed to providing a range of key e-learning resources including the **FAO e-learning Academy course** "*Understanding AMR in food and agriculture*", which was published in April 2022. This was developed in collaboration with our Reference Centre leads and has received high level engagement with learners. Strengthening our e-learning portfolio, we created a course on "*Residues Sampling in Red Meat – Cattle*" to provide learners with practical tools that can be used effectively in the field. We also sat on **expert groups**, such as the WOAH *ad hoc* Group on use of antimicrobials in aquaculture. We also contributed to guidelines development for farmers, such as an expert group recommending treatment guidelines for finfish farmers in Bangladesh. We run antimicrobial susceptibility testing **proficiency testing schemes**, and the third distribution of our *Escherichia coli* scheme was successfully completed in 2022 with 22 laboratories participating from ten countries. Development of **interpretive criteria for susceptibility testing** for surveillance is another activity we have supported, with the Reference Centre leading schemes to develop epidemiological cut off values for a range of key aquatic pathogens with laboratories internationally.

In summary, **we have a strong track record of delivery with FAO and other organisations in a range of countries to tackle antimicrobial resistance**.

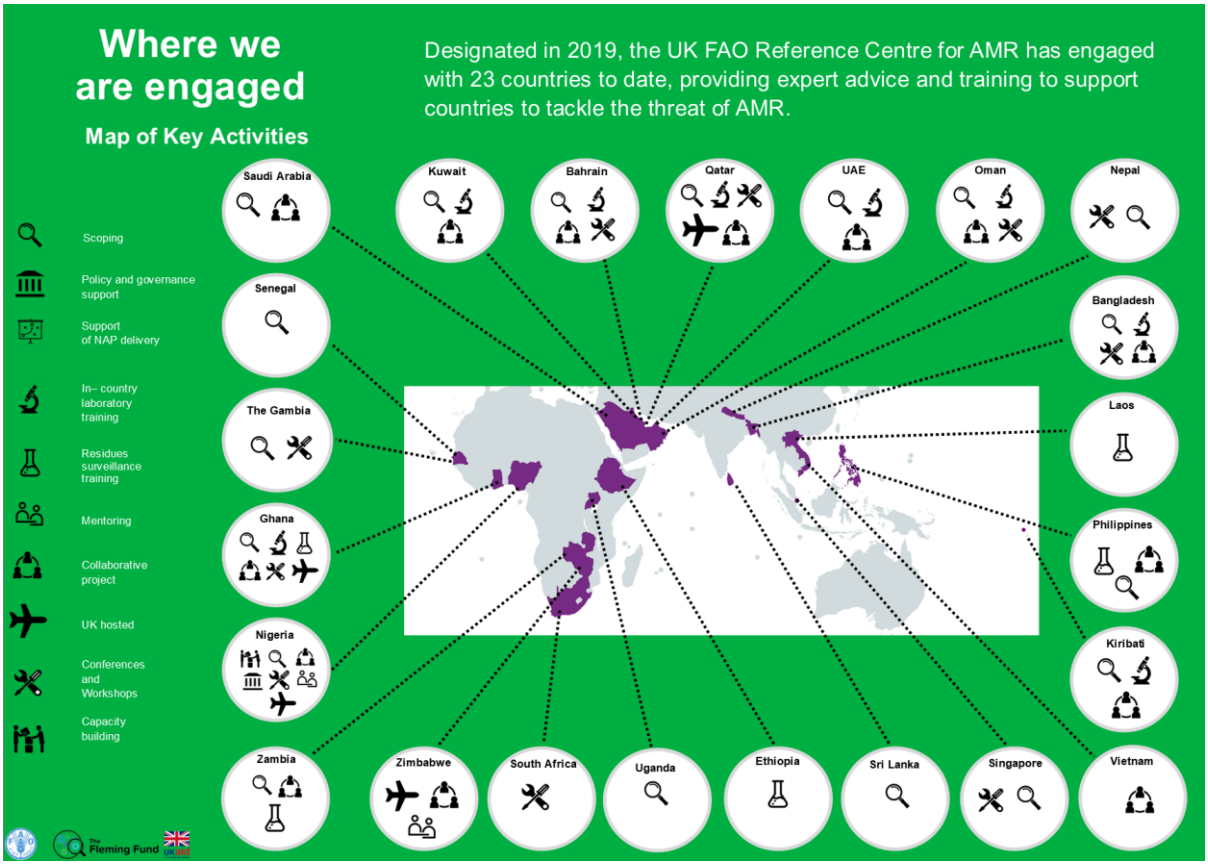


Figure 1. Summary of activities undertaken by the AMR Reference Centre in countries it has supported since its inception up to December 2022

1.0 Introduction

This is the third 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). From its designation in 2019 to the end of 2022, the UK FAO Reference Centre for AMR has a strong track record of delivery for FAO and other organisations in a range of countries to tackle antimicrobial resistance, strengthen surveillance, and build capacity for long-term sustainability and resilience.

The Reference Centre has progressed from initial concept and designation by FAO, through the development of networks and programmes, to its maturation into a high-profile expert team, strongly positioned to support One Health efforts to tackle the scourge of AMR. We engage widely with partners in many countries and, with the generous support of the Fleming Fund and Defra, have been able to deliver significant programmes in several countries. We have sought to develop deep relationships with many of our partners, helping to ensure our work has lasting impact.

In 2022 we have also strengthened our internal governance structure to better support our ambitions to take action on AMR and deliver for our funders and partners. The UK dCVO accepted the role of Senior Strategic Programme Advisor for the Reference Centre in 2022 and provides strategic direction, advice, and oversight.

This report presents the work the Reference Centre undertook in 2022. During this period there was a considerable easing of COVID-19 travel restrictions in many countries, including the UK. This has enabled us to resume international travel, re-engage with partners in-person, and develop new avenues of work. We have also resumed hosting international visitors at our UK facilities.

Looking to the future, we see the achievements of 2022 as a springboard for ongoing delivery and impact in 2023 and beyond. We look forward to continuing our work with our many supportive and engaged partners.

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.

Our Vision

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

Our Mission

To provide leading **scientific and policy expertise** within the global community to tackle antimicrobial resistance in **terrestrial and aquatic animals** and their **environment** in a **One Health** context

Our Objectives

Figure 2. Our objectives

Achieving our Objectives

To achieve our objectives, we seek to complement FAO's programme in supporting member countries in the implementation of national action plans on AMR. Our activities are aligned with both the FAO Action Plan on AMR (2021-2025), the Quadripartite approach to One Health action on AMR, 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.

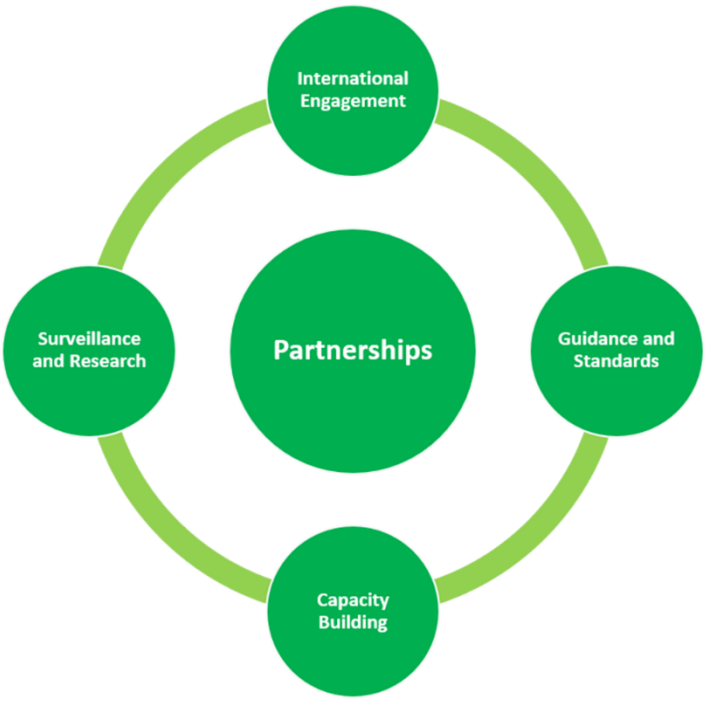


Figure 3. Achieving our objectives

2.0 Acknowledgements and Funding

We would like to thank our partners in the countries and organisations with whom we have worked for their ongoing support and engagement. It has been a great pleasure to meet many of our partners in-person in 2022 at their home institutes and in the UK, following the easing of COVID-19 restrictions.

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 Overseas Development Assistance
- The Fleming Fund, Department of Health and Social Care
- The Fleming Fund Fellowship programme
- The Foreign, Commonwealth and Development Office

3.0 International Engagement

3.1 Engagement with the FAO AMR and the Reference Centre Secretariat

The Reference Centre works closely with the FAO Reference Centre secretariat and AMR focussed FAO staff in the delivery of its programmes. Highlights from 2022 include: the establishment of an AMR Community of Practice; planning and provision of proficiency testing schemes; AMR workshops; and our role in the development of FAO e-learning Academy AMR courses. Each of these activities is described in greater detail within this report.

We participate in bi-monthly FAO AMR Reference Centre meetings, strengthening our collaboration with representatives from the other FAO designated AMR reference centres and sharing knowledge. We are members of the FAO's AMR Subject Matter Experts forum and provide an expert scientific resource for review and consideration of AMR matters for FAO.

We have strengthened engagement and delivery with FAO colleagues at the FAO Regional Office for Asia and the Pacific (FAO RAP). A Reference Centre representative was nominated by the AMR Regional Surveillance Coordinator at FAO RAP to join the Asia-Pacific Community of Practice on antimicrobial treatment guidelines for poultry. This FAO initiative aims to support responsible prescribing, animal health and welfare, and the global public good, by catalysing the development of national antimicrobial treatment guidelines for poultry in South East Asia. We also attended the FAO RAP Regional Consultation and webinar "Advancing regional contributions to global development of veterinary clinical breakpoints". Following introductions made via the Reference Centre, the VMD is now collaborating with FAO RAP to provide technical support for the development of Regional Residues Guideline 6: *"Monitoring and Surveillance of Antimicrobial Residues in Food Animals".* The VMD also provided technical support to the FAO for the development of the *'Multistakeholder Partnership Platform',* convening two expert stakeholder consultations producing potential action groups in anticipation of the platform launch in 2022.

3.2 Provision of Consultancy to Fleming Fund and its Partners

The Fleming Fund is a UK aid investment to tackle antimicrobial resistance in low- and middle-income countries (LMICs) managed by the UK Department of Health and Social Care. The Reference Centre receives funding from the Fleming Fund, and we work closely with the Fleming Fund team and its partners to provide animal health and policy expertise. The Fleming Fund Phase I report was published in April 2022. showcasing the achievements from the first phase of the programme. The report included a section outlining Reference Centre programme delivery undertaken in Nigeria, Ghana, and Bangladesh (pages 37-39). In addition to our country partnerships, we have provided consultancy for the Fleming Fund on ongoing and new initiatives. Examples include contributing to the development of approaches to assess the environmental aspects of AMR.

3.3 Provision of Expertise to UK Government

The Reference Centre supports the UK in its ambition to contain and control antimicrobial resistance (AMR) by 2040, as set out in the UK 20-year vision for antimicrobial resistance and the UK's five-year national action plan for AMR 2019-2024. Through our activities, Reference Centre staff contribute to the delivery of specific national action plan commitments, including working with our global partners to build regulatory capacity in LMICs animal health sectors. Reference Centre agencies also collaborate with global partners to promote, strengthen and integrate AMR and AMU surveillance on common or emerging threats through a One Health approach.

A key element to promoting a One Health approach is our partnership in the UK One Health AMR Reference Centre Cooperative, bringing together public and animal health AMR expertise from three Reference Centre designations based in the UK. Membership comprises the WHO Collaborating Centre for Healthcare Associated Infections and AMR at the UK Health Security Agency (UKHSA); the WOAH Reference Laboratory for AMR at APHA; and the UK FAO Reference Centre for AMR. The Cooperative delivers to an ambition in the UK NAP and provides a forum for members to discuss and coordinate their international work on AMR.

3.4 International Conferences and Meetings

3rd Meeting of the AMR/AMU Technical Advisory Group of South East Asia (20-22 September 2022)

A Reference Centre team member attended the 3rd Meeting of the AMR/AMU Technical Advisory Group (TAG) of South East Asia held virtually and hosted by the FAO RAP office. A total of 75 participants attended the meeting with national representatives from ASEAN countries, FAO Reference Centres for AMR and experts from other international organisations such as CLSI. The meeting provided a platform to update progress on the AMR work collectively achieved in the ASEAN region and reviewed recommendations and cross cutting issues identified in previous TAG meetings.

Third Fleming Fellows' Symposium (12-13 October 2022)

The Third Fleming Fellow Symposium was held virtually in October 2022, with over 70 participants joining from across the Fellowship Scheme. The Symposium addressed sustainability through the three themes of the 'Bigger Picture', 'Communities of Practice' and 'Sharing Best Practice' to frame discussions, draw upon participants' experiences and explore future activities. A Reference Centre team member helped formulate the Symposium theme, content, and programme as a member of the Symposium organising committee. They also chaired the final session of the symposium, presenting insights from the participant survey and moderating the ensuing group discussion.

Philippine Society of Animal Science 59th Scientific Meeting and Annual Convention (19 October 2022)

A Reference Centre team member was an invited speaker at this annual convention, held virtually, presenting on "Antimicrobial Usage (AMU) and Resistance (AMR) and the Use of Non-Antibiotic Alternatives to Reduce AMU and AMR".

*One Health Poultry Hub Third Annual Conference (*25-27 October 2022)

A Reference Centre team member was an invited speaker at this hybrid conference held in Dhaka, Bangladesh, presenting on AMR in animal health and aquaculture sectors.

World One Health Congress (7-11 November 2022)

Reference Centre team members attended the 7th World One Health Congress (WOHC) in Singapore in person and gave oral and poster presentations on their scientific collaborations with partners in LMICs. Additionally, we supported the attendance of a Fleming Fund Fellow Alumnus from the University of Ibadan, Nigeria, at the WOHC, who had two posters accepted for presentation. The team attended a Fleming Fellowship side event, organised by the Fleming Fund management agents Mott MacDonald, and held in the margins of the WOHC. The Fellow is chair of the Fleming Fellowship Alumni Network Steering Committee and gave a well-received overview of the Alumni Network, outlined how Fellows and Alumni could contribute, and answered questions.

Reference Centre staff and Fleming Fund AMR Fellow presenting their joint poster on work undertaken in Nigeria at the World One Health Congress in Singapore, November

A Reference Centre staff member presenting at the Department of International Trade One Health event at WOHC in Singapore, November

The UK Department of International Trade (DIT) organised an evening side event at the WOHC and Reference Centre staff were invited to attend. The event was introduced and chaired by the DIT Chief Scientific Adviser and the UK Trade Commissioner for South East Asia and was attended by approximately 40 people. Speakers from the UK Tech industry and Public Sector Research Establishments gave presentations on the UK's One Health 'offer', including Reference Centre staff who gave a well-received talk on the international One Health work the Defra agencies undertake. This included an overview of our international designations (including AMR Reference centre, as well as our other FAO and WOAH reference centres and collaborating centres), and some examples of large Defra ODA programmes where we deploy this expertise. These included the Defra One Food, Ocean Country Partnership Programme and Animal Health Systems Strengthening projects.

World Aquatic Veterinary Medicines Association World Aquatic Health Conference (4-7 December 2022)

Reference Centre staff attended the WAVMA conference in Pretoria South Africa. Two talks were delivered by Reference Centre staff. One on the UK FAO reference Centre for AMR and another on 'Building partnerships in Africa: One Health approach to improving sustainable aquaculture production'. The conference provided the opportunity to network with African and other international aquatic animal health professionals, including representatives from Mississippi State University, that also deliver aquaculture AMR and biosecurity reference centre functions on behalf of the FAO. The Ghanaian AMU fellow that Cefas are mentoring also attended in person and presented their work investigating antibiotic use in Ghanaian fish farms. They were

also able to review their fellowship programme with their Cefas mentors while attending the WAVMA conference.

Reference Centre staff presenting our work at the WAVMA conference in Pretoria, South Africa in December

FAO Fleming Fund Project 3 Planning Conference (5-9 December 2022)

A FAO planning conference was held in Nairobi, Kenya, bringing together FAO leads from seven countries across Africa region as part of planning activities for the FAO Fleming Fund Project 3. Reference Centre staff attended to provide input and expertise into planning clinics with FAO country leads on technical topics including AMR, AMU and residues surveillance, antimicrobial policies and governance, and substandard and falsified medicines. Additionally, Reference Centre staff presented an overview of the UK FAO Reference Centre, outlining the nature and scope of the support available to countries that could be provided by the Reference Centre. Participation by Reference Centre leads created the opportunity for alignment of activities between the Reference Centre and individual country workplans, in addition to facilitating potential new collaborations on several AMR, AMU and residues surveillance projects with Zambia, Ethiopia, and Ghana. Attendance strengthened relationships with existing partners and represented a significant opportunity to engage with key stakeholders across the region.

Reference Centre staff attending the FAO Fleming Fund Phase 3 Conference from the 5-9th December, Nairobi, Kenya

3.5 Country Engagement

The Kingdom of Bahrain

Reference Centre staff coordinated and led a virtual Joint UK- Bahrain One Health Workshop on Antimicrobial Resistance with stakeholders in the Kingdom of Bahrain in March 2021. Stakeholders representing the Ministry of Health, Supreme Council for the Environment, and Ministry of Municipalities Affairs and Urban Planning spoke together about AMR. Following presentations from Reference Centre staff, the Director of Animal Health (Bahrain) and the Chief of Medical Services (Bahrain), discussions were held as to how the Reference Centre could contribute to the implementation of the agri-environment element of the Bahrain NAP.

The Republic of Ghana

The Reference Centre has continued its programme of active engagement with Ghana in 2022, further deepening the strong links we have made there. This included visits by Reference Centre staff to Ghana in May and July. Highlights from the May visit included productive meetings with key stakeholders including the Ghanaian CVO, the AMR Technical Lead for Animal Health Sector, the FAO AMR Coordinator in Ghana, the Mott MacDonald team, Fleming Fund fellows mentored by APHA & Cefas, and the Ministry of Food and Agriculture's Plant Protection and Regulatory Services. We held meetings with our collaborators at the University of Ghana to discuss our current and future collaborative projects. We have also been providing expert consultancy to our partners. A visit to the FAO Farmer Field School in Kade was undertaken with the FAO AMR Coordinator in Ghana, to meet school instructors and poultry farmers. The insight gained from the visit to Kade has contributed to the design of support that the input Reference Centre can provide to this programme.

Reference centre staff visiting a poultry farm enrolled in the Farmer Field School in Kade, Ghana in May

To support the sharing of expertise and development of regional networks we arranged for our aquaculture Fellow from Nigeria to visit Ghana, while we were in-

country. It was invaluable to meet our Phase II Fellows from Ghana and Nigeria in person for the first time, and it provided the opportunity to obtain and share first-hand knowledge of practices and issues at farm level. The success of this meeting of Fellows and Mentors was featured in an article in the Fleming Fellowship newsletter Petri Dish (May issue).

During the July visit we also accompanied our Aquaculture AMU Fleming fellow to oversee the initial deployment of their survey for AMU in Ghanaian fish farms (detailed in Collaborative Projects). Field and laboratory work was undertaken with our Fellow and alongside colleagues from the Ghanian Veterinary Services Directorate and the Ghanian Fisheries Commission. The laboratory work included bacterial identification and antimicrobial susceptibility testing, using equipment recently provided by Fleming Fund.

Fleming Fellows from Nigeria and Ghana with Reference Centre staff in Accra, Ghana in May

The Reference Centre also supported the team leading the newly implemented Defra Animal Health Systems Strengthening ODA project when they visited Ghana in October. There was strong engagement with FAO (AMR lead; ECTAD lead), the Veterinary Services Directorate (Accra and Kumasi labs), University of Ghana, and

Mott MacDonald (delivery agents for the Fleming Fund), resulting in additional firm opportunities targeted collaboration and support via the Reference Centre.

The in-person re-engagement with Ghanaian colleagues has significantly helped the development of a delivery programme of support that can be provided via the AMR Reference Centre. It also provides valuable insight for other Defra agency ODA programmes in Ghana. We anticipate continuing to provide a range of support to Ghanaian Government and other colleagues in the future.

The Republic of the Philippines

Reference Centre staff visited the National Meat Inspection Services (NMIS), Department of Agriculture, Philippines in June. They met the Director and other executive officers of the NMIS, to obtain an overview of the different activities and

Staff from the NMIS with Reference centre staff, in The Philippines in June

research projects the institute is currently doing. A project planning meeting was held with the Laboratory Head and Laboratory Manager of the NMIS Central Meat Laboratory to define areas for joint work and the input that could be provided by the Reference Centre.

The Republic of Singapore

Meetings were held with the Animal & Veterinary Service, a division of Singapore National Parks, while at the World One Health Conference (WOHC). Opportunities for

joint and collaborative work were identified and have been followed up in calls subsequently.

The United Arab Emirates

Reference Centre staff led an in-country visit to the United Arab Emirates in March 2022. We met with academics from Zayed University, Khalifa University, Ministry of Public Health, Ministry of Climate Change and the Environment (MOCCAE), and the co-chair of the AMR committee. We discussed the results of AMR surveillance in the marine environment project (see below). We also developed a new collaboration involving new methods for AMR surveillance (SmartChip qPCR) and discussed the potential for supporting a multi sector workshop, facilitated by Reference Centre staff, along the lines of the Qatar workshop.

The Republic of Uganda

Reference Centre staff met Ugandan colleagues from Makerere University, both online and at the WAVMA Conference in Pretoria in December (see above). It is anticipated that a trip, originally planned to Uganda immediately prior to the COVID 19 pandemic, will now take place in 2023. This will facilitate collaborative discussion with Ugandan colleagues on implementing improved surveillance for AMR in aquaculture and terrestrial animal production. It will also include developing improved diagnostic capacity for emerging diseases in aquaculture via other aligned designations held by the constituent agencies of the Reference Centre (*e.g.,* the WOAH Collaborating Centre for Emerging Aquatic Animal Diseases).

The Republic of Zambia

We have held UK-Zambia AMR collaboration meetings with representatives from APHA, Cefas, VMD, FAO, and Zambian Veterinary Services held, to discuss and plan collaborative work focused on the Farm Field School programme supported by FAO. Furthermore, Reference Centre staff conducted a scoping visit to the University of Zambia in July 2022 to discuss the proposal of Reference Centre funded post graduate PhD and MSc posts focused on AMR research within the institution. Staff were also able to engage with the Zambian Department of Veterinary Services. Outcomes of this visit was further collaboration to develop this post graduate programme with the

University of Zambia through a workshop in December 2022 (See Section 4.6), and a residues project with the Central Veterinary Research Institute.

4.0 Capacity Building

4.1 AMR Community of practice

In 2022 the Reference Centre established an AMR Community of Practice (CoP) to support the FAO's work to combat AMR across sectors in food and agriculture around the world. The CoP brings together current and prospective laboratory collaborators and other groups or individuals who are involved and interested in topics related to AMR. A main mission of the CoP is to increase awareness and engagement among our partners and other key stakeholders, and to assist in improving laboratory capacity and promote good laboratory practices among its participants. The CoP provides opportunities to share new ideas and to network and collaborate with other participants. Over 70 AMR experts from 20 countries have joined the community to date. The CoP meets virtually once every three months and includes a session called "Meet Your Community" in which community members introduce themselves and present on their institutions and the AMR related work they are currently doing.

4.2 Fleming Fund Professional Fellowship Scheme

The Reference Centre continues to engage strongly with the Fellowship scheme. Our two professional animal health laboratory fellows in Nigeria graduated from the Fellowship programme in December 2021, and they celebrated this success at a graduation ceremony held in January 2022. Significant strengthening of Nigerian staff and institutional capacity has been achieved through this programme, and a One Health collaborative project with human health fellows completed.

We are currently mentor for an aquaculture Fellow in Nigeria, and have helped facilitate their integration into the wider Fellowship network in Nigeria. We also mentor an aquaculture Fellow in Ghana. Further details of our work with the Fellows follows below.

In 2022 the Alumni Network was established to provide support to Fellows after graduation from the programme. A member of Reference Centre team sits on the Alumni Network Steering Committee and one of its sub-committees, contributing to

the preparation of the Network's Terms of Reference, governance structure, and the establishment of activity priorities.

Virtual Fleming Fund Fellows AMR workshop

The Reference Centre hosted a virtual AMR workshop for 15 Fleming Fund Fellows form Kenya, Ghana, and Zimbabwe, in partnership with their mentors at the London School of Hygiene and Tropical Medicine. Fellows introduced their institutes, research interests and Fellowship project. They gained insight into AMR surveillance strategies and research undertaken in animal health at APHA, Cefas and VMD, with contributions from the head of the UK National Reference Laboratory for *Campylobacter* in animals, the head of the APHA Bacteriology Centre of Excellence and leading subject matter experts on disinfectants, disease control, and whole genome sequencing. Discussions included identification of opportunities for future collaborations. This workshop featured in an article in the Fellowship newsletter Petri dish.

CASE STUDY 1: FLEMING FUND FELLOW TRAINING

The agencies of the UK FAO Reference Centre are working closely with the Fleming Fund Fellowship programme, both as host institutions and providing tailored training through in-person placements for Fleming Fund Fellows

“My recent two-week long placement at the Animal and Plant Health Agency (APHA) and the Veterinary Medicines Directorate (VMD) was an eye-opening and life-changing experience in so many ways."

Dr Kudzaishe Vhoko-Tapensana
Zimbabwean Fleming Fund Fellow and Veterinarian

IN-PERSON PLACEMENTS

Dr Kudzaishe Vhoko-Tapensana, Zimbabwean Fleming Fund Fellow (host institution London School of Hygiene and Tropical Medicine) successfully completed a two week training visit to the APHA Bacteriology Department and VMD International Office.

Working closely with bacteriology specialists, Dr Vhoko-Tapensana was trained in **broth microdilution AST and DNA extraction** for **whole genome sequence analysis** using a panel of *E. coli* isolates collected from Zimbabwean poultry farms and transported to the UK to complement the research undertaken during the Fellowship.

Through a combination of virtual and one-to-one sessions with the VMD AMR Surveillance & Evidence team, Dr Vhoko-Tapensana received training and support on approaches to **integrated AMR surveillance** and **reducing antimicrobial usage**. These sessions highlighted parallels between the efforts of the UK and Zimbabwean Governments to control AMR and lessons learned, identifying behavioural science as a take-away point for engagement with stakeholders around AMR.

OUTCOMES

Training in Laboratory Methods

Training in gold standard antimicrobial susceptibility testing methods and WGS analysis can be used to help improve laboratory capacity in Zimbabwe. This training visit has developed into a collaborative project investigating bacterial isolates from poultry in Zimbabwe.

AMR Integrated Surveillance

Training in key topics including harmonised monitoring, clinical surveillance, data management, analysis and effective engagement with stakeholders and can be applied within a Zimbabwean context.

Networking and Collaboration

Dr Vhoko-Tapensana was able to network widely, meeting senior leaders at the VMD, team leaders of the Department of Bacteriology and the Department of Epidemiological Sciences, identifying areas for future collaboration.

4.3 Bangladesh

Bangladesh has remained a priority country for engagement for the Reference Centre in 2022. In March 2022 the Reference Centre, in collaboration with WorldFish, organised and hosted a hybrid meeting with Bangladesh stakeholders. The meeting reviewed current AMR activities, with presentations from Bangladesh colleagues, followed by a discussion and assessment of future collaborative work for the delivery of action on AMR in Bangladesh. In partnership with WorldFish we have also implemented a pilot surveillance programme for AMR in wet markets (see Collaborative Projects below).

In September a team of six visiting experts of UK's FAO Reference Centre for AMR from APHA and Cefas alongside colleagues from FAO Emergency Centre for Transboundary Animal Diseases (ECTAD) and WorldFish co-hosted a two-day AMR workshop, in Dhaka on ''AMR Surveillance in Veterinary and Aquaculture Settings in Bangladesh". A total of 40 experts actively participated in the workshop. Delegates included relevant policy representatives from Bangladesh national government, scientists from Bangladesh research institutes and reference laboratories and academia, members of the Fleming Fund Country Grant Bangladesh, Fleming Fund Fellows, and One Health experts from the International Centre for Diarrhoeal Disease Research, Bangladesh.

Approaches to strengthen surveillance structures and policy frameworks were discussed in participatory break-out sessions. Dhaka, Bangladesh in March

"It is high time to give more focus on aquaculture in light of AMR and AMU. Through this collaboration, both the aquaculture and animal health sector will be benefitted and safe animal protein will be ensured."

Dr. Md. Abu Sufian, Director, Account, Budget and Audit Section, Department of Livestock Services

The workshop brought together the relevant stakeholders to share and review recent insights and achievements, identified approaches to strengthen existing surveillance structures and policy frameworks to produce recommendations for future work in this area in support of the Bangladesh AMR National Action Plan and established a framework for future collaboration.

4.4 The State of Qatar

Reference Centre colleagues participated in a Defra visit to the State of Qatar from the 27th February to 2nd March, holding a two-day One Health AMR workshop "Mapping a pathway to AMR Surveillance in Veterinary and Aquaculture Settings in Qatar". The workshop was hosted by the Ministry of Municipality in collaboration with the Reference Centre and attended by experts from Qatar's National Antibiotic Committee including representatives from the Ministry of Public Health Strategic Planning & Performance Department and Central Food Laboratories, Hamad Medical Corporation, Ministry of Municipality Animal Resource Department and Agriculture Research Department, Qatar University, and the UK Science & Innovation Network. Delegates identified approaches and systems to further strengthen Qatar's One Health approach to tacking AMR through assessment of needs in human, environmental, and animal health. Outputs from the workshop have helped to inform discussions as Qatar prepares its next National Action Plan for AMR.

"Antimicrobial resistance is an important and growing global challenge. It also represents one of the biggest threats to continued progress in global health. I therefore welcome UK/Qatar expert discussions on ways we can cooperate to meet this challenge and protect our peoples' health."

Nick Boucher, Head of the UK Science and Innovation Network (Gulf)

"It was a valuable workshop and has had an opportunity to communicate with scientists from the UK in Qatar in different disciplines. It also gave us a chance to exchange knowledge with them. Furthermore, it clarifies for us the areas for research collaboration between the state of Qatar and the UK in the Agricultural sector."

Dr Mona Albloushi, Biotechnology Consultant, Agricultural Research Department, Ministry of Municipality, Qatar

Workshop in Qatar: Insights and recommendations were shared for discussion in feedback sessions during the AMR workshop

Workshop in Qatar: Group work for landscape mapping of AMR research and surveillance.

To build on the success of the workshop and the opportunities it engendered we have continued to engage with our Qatari colleagues. We hosted a visit at our UK facilities by a Professor of Microbiology from the Biomedical Research Centre at Qatar University in July 2022. A collaborative project has now been initiated with the Biomedical Research Center, which includes a training and capability building component. In September we held a virtual 'Qatar-UK One Health Agri-Environment AMR Collaboration Strategic Planning and Coordination Meeting' to further develop collaborative opportunities to support action on AMR in Qatar.

4.5 One Health AMR Training in Nigeria

The University College Hospital in Ibadan, Nigeria, held a two-day One Health AMR training workshop in November 2022. The course was organised and led by a human health Fleming Fellow Alumni and had 45 participants for theoretical and practical instruction on AMR and susceptibility testing. The Reference Centre supported costs for the workshop and delivered training to participants virtually on topics including:

Veterinary AMR Surveillance and Research at the APHA, Laboratory Health & Safety, reducing antimicrobial usage (UK case study) and Quality Control & Quality Assurance. This training was delivered in partnership with public health colleagues from UKHSA.

4.6 Post Graduate programmes

Continued collaboration with the Brooke, the working equine and livestock charity on shared topics of interest including the role of the agrovet in responsible use of veterinary medicinal products has contributed to the development of research projects for post graduate programmes investigating this area. Collaboration is anticipated to extend throughout 2023.

In partnership with academic institutions in Zambia, the Reference Centre is developing several post-graduate posts (including one PhD and two MSc) to support research on antimicrobial resistance and antimicrobial usage within animal health sectors. Projects will aim to develop in-country research capacity in addition to strengthening understanding of antimicrobial usage at the farm level and at the point of access to promote responsible use. A scoping visit was conducted in July 2022, and a follow up workshop in December 2022; working with academic colleagues and industry representatives to identify knowledge gaps and develop research specifications for the post graduate programme.

4.7 Delivery of e-learning Residues Monitoring and Surveillance Course – Philippines

Reference Centre staff successfully facilitated and delivered workshop sessions of the e-learning course *“Residues of Veterinary Medicines in Foods of Animal Origin”* to a cohort of fifteen learners from across the Philippine government departments, representing different areas of interest including the dairy and aquaculture sectors. Participants completed seven self-directed e-learning modules teaching the principles of veterinary medicines residues surveillance, supported by a series of virtual workshops and expert sessions. Learners were given the opportunity to apply their knowledge and learning from the course in a series of interactive virtual sessions with laboratory experts, pitching their pre-prepared residues surveillance proposals for

assessment. There was a high level of engagement from participants throughout the sessions and positive feedback overall.

Engagement with the International Atomic Energy Agency (IAEA) Food Safety and Control Section has identified synergies and shred goals across the activities of the IAEA and the Reference Centre concerning monitoring of residues of veterinary medicines in foods of animal origin. Outcomes of this collaboration are the sharing of Reference Centre Residues e-learning resources with the IAEA for greater dissemination with member countries to build capacity within national programmes for residues surveillance.

CASE STUDY 2: RESIDUES SAMPLING E-LEARNING

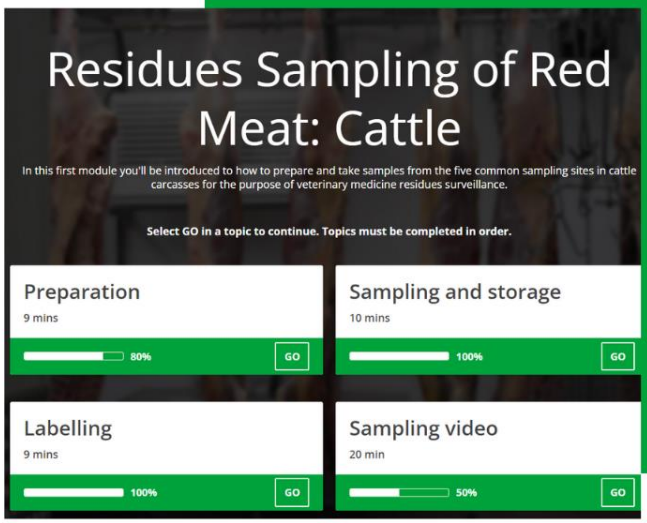
Responding to the need highlighted by stakeholders for a practical course on residues sampling, the UK FAO Reference Centre AMR created a e-learning course providing training on residues sampling in cattle at slaughter

OVERVIEW

Following the successful creation of the e-learning course *"Residues of Veterinary Medicines in Foods of Animal Origin"*, a lack of resource covering the methods for obtaining and transporting residues samples was highlighted as a challenge by stakeholders.

In partnership with residues laboratory consultants, a UK based abattoir and an official veterinarian, Reference Centre staff created a e-learning course to address this gap.

Through a series of self-directed modules, videos outlining the sampling process and subsequent transport and step-by step instruction guides, learners are trained in the process of obtaining samples for residues testing in cattle.



RESOURCE DEVELOPMENT

1. Self Directed Learning:

In collaboration with technical experts, written e-learning modules covering sample collection, packing for transport and receiving the sample at the laboratory were created. Learners complete these modules at their own pace

2. Videos:

Partnering with a UK based abattoir and official veterinarian, Reference Centre staff filmed the step by step process of obtaining samples from the appropriate sites from cattle carcasses at and after slaughter, including:

- Jugular blood sample
- Liver sample
- Kidney sample
- Kidney fat sample
- Urine sample

3. Step by Step Guides:

To complement video resources, written instructions detailing each step of the sampling and packing process were created. This resource can be used in a field or abattoir environment as a practical guide to support residues surveillance in a real life environment

OUTCOMES

Strengthening Residues Surveillance

This course is a useful resource that will support the implementation of the technical aspects of the national residues surveillance programmes

Addressing Need

Field resources within the area of residues surveillance are rare. Digital and downloadable resources such as videos and step by step guides can be used within the field, equipping learners in real life scenarios outside of the classroom

5.0 Surveillance and Research

5.1 Collaborative Projects

We partner with scientists and laboratories in several countries to support their work addressing evidence gaps relevant to AMR and potential risks to veterinary or public health. Through collaborative projects with our partners we provide research capacity development including, confirmatory testing, antimicrobial susceptibility testing, whole genome sequencing and bioinformatics capability. Projects are being undertaken in Bangladesh, Ghana, Nigeria, Philippines, and Vietnam. We work closely with colleagues at APHA's WOAH Collaborating Centre for Risk Analysis & Modelling to provide epidemiological support, including sample size calculations for study design, risk factor analysis, and modelling of results. We also engaged the expertise of staff and other resources from our other complementary WOAH and FAO designations, such as the WOAH Collaborating Centre for Emerging Aquatic Animal Diseases, as needed. To illustrate our collaborative project work, three detailed case studies follow below, as well as some other examples.

CASE STUDY 3: ASSESSING AMR AND AMU ON NIGERIAN PIG FARMS

A Reference Centre funded research project delivered in Nigeria by Fleming Fund Fellows and Alumni examined AMU practices and AMR prevalence within the pig sector.

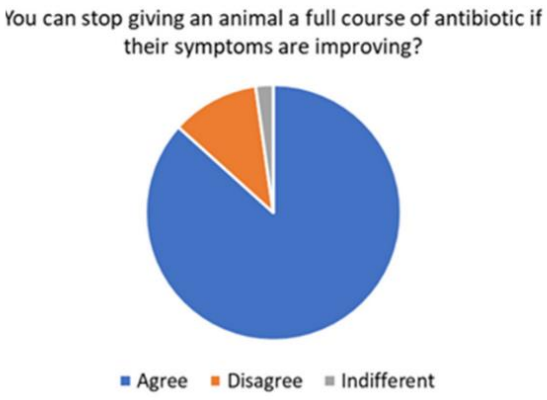
BACKGROUND

TThe Nigerian pig sector plays a vital role within the economy and maintaining food
security.

Currently antimicrobial use (AMU) and AMR remain poorly defined in this sector.

Inappropriate AMU on farms can drive the development of AMR, heightening risk to animal health and the potential for zoonotic spread of AMR bacteria to humans.

This project aimed to address gaps in the evidence and identify areas to strengthen good AMU practice.



A question from the structured questionnaire assessing farmer's knowledge, attitudes and practices in relation to AMU

PROJECT OBJECTIVES

- Gain insight into AMU practices on Nigeria pig farms
- Define the prevalence and AMR profiles of *E. coli* and *Salmonella* from pigs, the farm environment, and in-contact workers

PROJECT METHODS

ASSESSMENT OF AMU::

- A structured questionnaire was used to conduct a study assessing farmer's knowledge, attitude, and practices in relation to AMU.

ASSESSMENT OF AMR:

- Pig and farm worker faecal samples were collected at 25 pig farms in Oyo and Plateau states and processed for isolation of *Salmonella*, commensal *E. coli*, and putative cefotaxime resistant *E. coli* using standard culture methods.
- Environmental samples were collected for testing from Oyo State farms.
- A total of 328 faecal samples were examined and AMR of isolates was determined by disc diffusion and broth microdilution.

RESULTS

ASSESSMENT OF AMU

High AMU at pig farms was reported; tetracycline, penicillin, and sulphonamides were commonly used. There was evidence for poor AMU practices, e.g. some farmers reported using human preparations of gentamicin. Areas for future farmer engagement to improve AMU practices have been highlighted.

ASSESSMENT OF AMR

Salmonella prevalence was 7% in pigs; no *Salmonella* were detected in human samples. *Salmonella* isolates were fully susceptible to 15 different antimicrobials. Tetracycline, ampicillin, and sulfamethoxazole-trimethoprim resistance was common in *E. coli* from pigs, correlating with reported AMU and indicating a potential for selection or maintenance of resistance on-farm.

NEXT STEPS

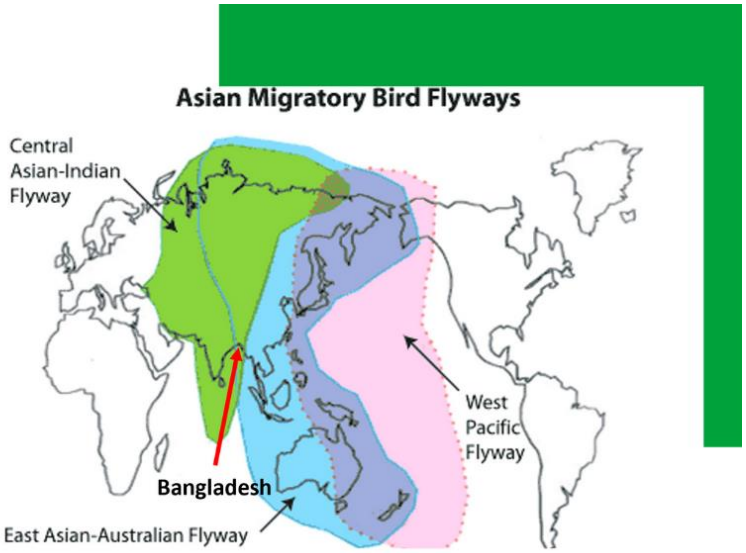
Results are being analysed and whole genome sequencing is being used to assess AMR genotype and phylogenetic relatedness.

CASE STUDY 4: BANGLADESH MIGRATORY BIRDS PROJECT

In partnership with the Bangladesh Livestock Research Institute (BLRI), the Reference Centre completed a study determining the carriage of nontyphoidal Salmonella in migratory birds in Bangladesh to assess the potential for risk to public and animal health

STUDY METHODS

- 451 Cloacal swabs were collected in 2018-2020 from Tanguar and Hakaluki Haors, important wetland ecosystems in North-eastern Bangladesh
- *Salmonella* were isolated according to ISO6579-1:2017 at BLRI and the serovar determined by phenotypic methods at the APHA
- Resistance towards 14 antimicrobials was assessed by broth microdilution and interpreted using EUCAST ECOFF values
- Whole-genome sequencing was used to establish AMR genotype and Sequence Type (ST)



STUDY RESULTS

- The prevalence of Salmonella was 13.5% (61 positive swabs)
- Six serovars were identified: *Salmonella* Perth, Kentucky, Albany, Infantis, Weltevreden, and Brancaster
- *Salmonella* Perth and Weltevreden isolates were fully susceptible and harboured no acquired AMR genes
- All other isolates were multidrug resistant, commonly possessing resistance to the traditional first line antimicrobials ampicillin, chloramphenicol, sulfamethoxazole, and trimethoprim; and ciprofloxacin
- There was excellent correspondence between resistance phenotype and AMR genes. High-level ciprofloxacin resistance correlated with mutations in the chromosomal *gyrB* and/or *parC* genes
- The *Salmonella* Kentucky isolates were ST198, a globally distributed multidrug-resistant lineage reported in humans and animals, and constituting an ongoing risk to public health worldwide

SUMMARY & IMPACT

- The study demonstrated that migratory birds may constitute a reservoir and potential route for dissemination of multidrug resistant (MDR) non-typhoidal *Salmonella* of public health significance
- Bangladesh lies on two migratory flyways indicating that birds have the potential to disseminate *Salmonella* over long distances and between countries
- MDR *Salmonella* are associated with more serious disease in people, and ciprofloxacin resistant *Salmonella* meet WHO criteria for priority pathogens
- The risk to public and animal health can be mitigated by measures including continued surveillance and implementation of good farm biosecurity practices

CASE STUDY 5: ASSESSING AMR AND AMU IN FISH FARMS

Working with Fleming Fund AMR Aquaculture fellows, the UK FAO Reference Centre has supported surveys of antimicrobial use and antibiotic resistance in fish farms in Ghana and Nigeria

GHANA

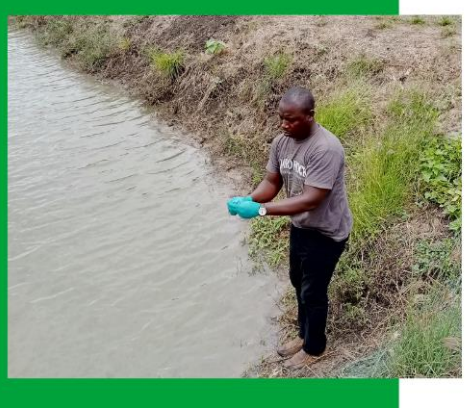
The Ghanian Fleming Fund Aquaculture AMR Fellow, mentored by the Reference Centre and in collaboration with the Ghana Fisheries Commission, conducted a survey of 34 catfish and tilapia farms across the Greater Accra and Eastern regions.

NIGERIA

The Nigerian Aquaculture AMR Fleming Fellow, mentored by the Reference Centre, undertook an AMU and AMR survey of 50 fish farms across four districts in Oyo state.

Samples were taken from tilapia and catfish grown in selected farms in Ghana and Nigeria for bacterial diagnostics and AST of selected aquatic pathogens and other target organisms, including *Aeromonas* spp and *E. coli*.

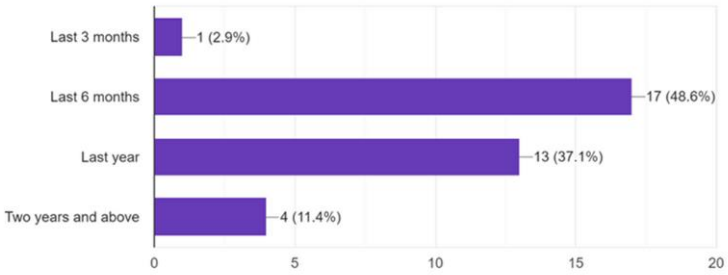
A structured questionnaire was used to conduct a study assessing farmer's knowledge, attitude, and practices in relation to AMU in both countries. The Reference Centre provided laboratory materials and advice on survey design, diagnostics, and antimicrobial susceptibility testing (AST) in both projects.



SURVEY RESULTS

ASSESSMENT OF AMU::

- Over half of farmers reported using antibiotics within the last year to treat and prevent disease (Ghana/Nigeria)
- Use and administration was largely without professional supervision
- Only **16%** (Ghana) and **24%** (Nigeria) of farmers surveyed reported consulting a veterinarian (or paraveterinarian) when sourcing and administering antibiotics
- Antibiotics used were typically supplied by agricultural stores and human pharmacies, rather than via prescription



Reported use of antibiotics by fish farmers surveyed in Nigeria Oyo State (n=50 farmers questioned)

ASSESSMENT OF AMR:

- Results are still being analysed including whole genome sequencing of bacterial isolates

OUTCOMES

- Useful baseline of AMU in aquaculture in Ghana and Nigeria
- Baseline that can be used in future studies to help tailor interventions such as provision of guidance and training, biosecurity improvements and applications of vaccines and monitor the effectiveness and impact on AMR/AMU

5.2 Bangladesh wet market surveillance project

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.

Collecting fish and shrimp samples at Bangladeshi wet markets

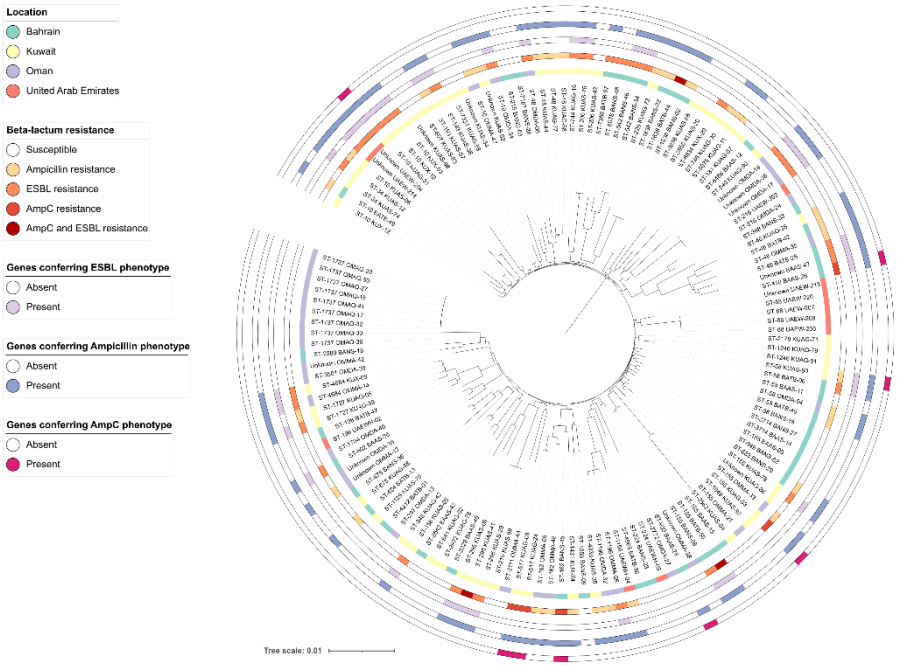
Activity in this reporting period included the development of detailed protocols for the collection, sampling and processing for antibiotic susceptibility testing profiling of fish and shrimp bacterial isolates from wet markets. This work has been carried out in collaboration with partner Bangladesh 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. A report detailing the results of a pilot wet market AMR surveillance project in Bangladesh has been drafted.

Processing the collected samples in the laboratory

5.3 Gulf Region

Collaborative research in the region has included regional and bilateral activities. The Reference Centre led a regional study to trial establishing regionally coordinated sampling of environmental AMR and investigating presence of AMR in coastal waters in collaboration with partners in Bahrain, Kuwait, Oman and the UAE (Light et al. 2022).

560 *E. coli* strains were analysed as part of this monitoring programme between December 2018 and May 2019. Multi-drug resistance (resistance to three or more structural classes of antimicrobials) was observed in 32.5% of tested isolates. High levels of reduced susceptibility to ampicillin (29.6%), nalidixic acid (27.9%), tetracycline (27.5%), sulfamethoxazole (22.5%) and trimethoprim (22.5%) were observed. Reduced susceptibility to the high priority critically important antimicrobials: azithromycin (9.3%), ceftazidime (12.7%), cefotaxime (12.7%), ciprofloxacin (44.6%), gentamicin (2.7%) and tigecycline (0.5%), was also noted. A subset of 173 isolates was whole genome sequenced, and high carriage rates of *qnrS1* (60/173) and *bla*CTX-M-15 (45/173) were observed, correlating with reduced susceptibility to the fluoroquinolones and third generation cephalosporins, respectively. This study is important because of the resistance patterns observed, the demonstrated utility in applying genomic-based approaches to routine microbiological monitoring, and the overall establishment of a transnational AMR surveillance framework focussed on coastal and marine environments.



A phylogenetic tree showing E. coli isolates and their aquired resistance genotypes from Bahrain, Kuwait, Oman, and the United Arab Emirates (Light

Further bilateral research activities have been undertaken exploring the presence of sewage derived AMR in marine environmental samples in Kuwait, Saudi Arabia and the UAE.

A further set of collaborative research projects are currently underway, these include; collaborations with Khalifa University (presence of AMR in wastewater and an evaluation of different screening methods); Zayed University in UAE (comparing the presence of AMR in coastal water in high use recreational beaches and known hot spots for contamination). Saudi Arabia with King Abdullah International Medical Research Center (investigating the presence of AMR in coastal waters off urban areas and aquaculture facilities and comparison with clinical samples); and Kuwait, with Kuwait Institute of Scientific Research and the Environment Public Authority (investigating pathways of exposure to AMR in treated wastewater through irrigation systems and coastal waters and looking at the temporal development of AMR in sediment cores). The Reference Centre is also building a research collaboration

between Khailfa University and UK academic partners to broaden collaboration networks in the region.

6.0 Guidance and standards

6.1 FAO e-learning AMR course

The FAO e-learning Academy published a joint course (found here on the online platform) in March 2022 developed by FAO in close collaboration with agencies of the Reference Centre. The course, that is also certified through the online digital badge system, is now available online, free of charge, as a global public good. As a response to high e-learning user interest, the course has also been translated into Spanish and is available on the FAO E-learning academy website.

The first page of the FAO e-learning course, developing in collaboration with the UK FAO Reference Centre for AMR

"This is again a perfect example of excellent collaboration between a number of partner institutions, and we would like to express our appreciation, for [their] hard work, high level of professionalism and dedication…"

Cristina Petracchi, Lead of the FAO eLearning Academy

6.2 Antimicrobial Usage (AMU) in Finfish guidelines

The FAO Bangladesh Emergency Centre for Transboundary Animal Diseases (ECTAD) team organised a workshop to develop fin fish treatment guidelines with support from the Reference Centre and WorldFish. This builds on the success of the Bangladesh AMR Response Alliance (BARA) group to develop and implement prescribing and treatment guidelines in the human and terrestrial animal (poultry) sectors. A range of international and national experts were gathered to identify the main diseases affecting finfish aquaculture in Bangladesh and recommend methods for their management and control. These included veterinarians, academics and Bangladesh Government officials

Reference centre staff at the Finfish Guidelines workshop hosted by the FAO ECTAD Bangladesh team. Dhaka, Bangladesh in September

The Reference Centre helped facilitate the discussions alongside the FAO ECTAD team, including delivering a presentation on development and implementation of aquaculture production business biosecurity plans. A range of useful information was gathered which will be used to inform the further development of the guidelines. We will continue to support this important activity, including attendance at the planned

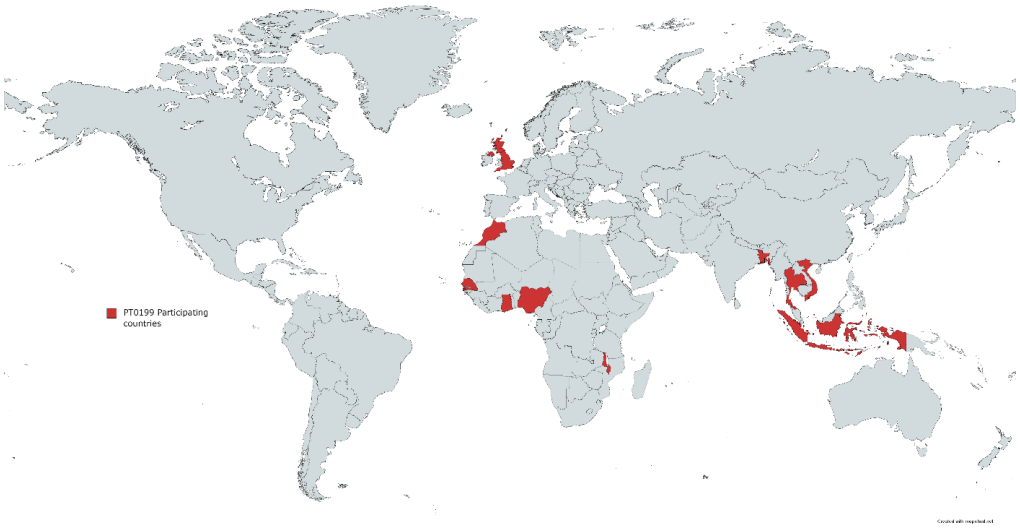
"Development of practical finfish disease management and treatment guidelines for Bangladesh should help improve the health and welfare of farmed fish, improve economic sustainability of farms and help reduce use of antibiotics in this key agricultural sector".

Dr Eric Brum, Country Team Leader, FAO ECTAD Bangladesh

regular virtual meetings organised by FAO to help finalise the guidelines. Reference Centre staff are discussing and assisting FAO and WorldFish in providing training in implementing practical biosecurity measures in Bangladesh aquaculture operations.

6.3 Proficiency Testing Schemes

The Reference Centre supports an annual distribution of a Proficiency Testing (PT) scheme for the susceptibility testing of *Escherichia coli*. This scheme is delivered by VETQAS, APHA's independent and ISO/IEC 17043 accredited PT service. The scheme operates by providing participating laboratories with test samples for analysis. Laboratories analyse the test samples, preferably as part of their normal routine, and report the results to the scheme organisers. They are then provided with a report showing how closely their results agree with the accepted values. Regular participation in PT schemes supports external quality assessment and provides evidence for regulators and accreditation bodies of competent performance.



Schematic map of the 10 countries which participated in the 2022 distribution of the E. coli AST PT scheme. Figure generated using mapchart.net

The report for the PT scheme distribution of 2021 was provided to participants in early 2022. To support laboratories which participated in the 2021 distribution to strengthen their testing capability the Reference Centre held an interactive virtual feedback meeting in May 2022. Twelve laboratories from Africa and Asia joined for feedback on the scheme, common sources of error, and approaches to improve laboratory

performance, including easily implementable quality control steps. An AMR Laboratory specialist from FAO joined the meeting and presented on FAO programmes to improve laboratory testing for AMR surveillance and quality diagnostics to treat bacterial diseases.

The third distribution of the PT scheme was successfully completed in 2022 and results were submitted by 22 laboratories from ten countries. PT scheme performance reports have been provided to all participants, with individual comments noting results which differed from the expected results. There was an increase in the number of laboratories reporting appropriate quality control processes (*e.g.,* use of control strains) and in the number of results that agreed with the accepted values, compared to 2021.

6.4 WOAH *ad hoc* Group on use of antimicrobials in aquaculture

A representative from the Reference Centre team was appointed to the WOAH a*d hoc* group tasked with updating the information on what antimicrobials are authorised for use in aquatic animals farmed for food. After a series of online meetings, the a*d hoc* group met in person in Paris in August to help finalise the list. The list has now been approved by WOAH in the Technical Reference Document of Antimicrobial Agents of Veterinary Importance for Aquatic Animals. The current data provide an overview of the antimicrobial use in various fish sub-categories which will help raise awareness in countries. The group recommended that further differentiation is made to be able to have AMU at species level. The group was thanked for their work by the main WOAH Working Group on Antimicrobial Resistance to bring the list of antimicrobial agents of veterinary importance used in aquaculture up to date. They further noted this provided a useful tool for professionals to refer to, when prescribing and overseeing the use of antimicrobials in aquatic animal species.

WOAH ad hoc Group in Paris discussing use of antimicrobials in aquatic animals. Paris, France in August

6.5 FAO Expert meeting on aquaculture AMR surveillance

Reference Centre microbiologists and epidemiologists are contributing to an initiative by FAO to adapt the published 12-point checklist for active surveillance of aquatic diseases and apply it to surveillance of AMU/AMR. The checklist includes the following: (1) scenario setting; (2) defining surveillance objective; (3) defining the populations; (4) disease clustering; (5) case definition; (6) diagnostic testing; (7) study design and sampling; (8) data collection and management; (9) data analysis; (10) validation and quality assurance; (11) human and financial resources and logistics requirements; and (12) surveillance in the bigger picture. Although AMU surveillance could include different elements compared with disease surveillance, the principles used in developing this checklist could be used to develop a checklist appropriate for AMU surveillance. Reference Centre staff joined the first meeting in December, which was held online with representatives from some of the recently designated FAO aquaculture AMR and biosecurity reference centres and other international experts. Discussions centred around how the existing framework could be adjusted to the specific requirements of aquaculture AMU and AMR surveillance. Further meetings are planned by FAO and Reference Centre staff will continue to provide expert advice for this important initiative.

First meeting of the FAO expert group to develop an aquaculture AMU and AMR surveillance checklist. Hosted by FAO in December

6.6 Setting Susceptibility Testing Standards and Interpretive Criteria

Work has progressed this year to develop epidemiological cut-off (ECOFF/ECV) values for use as standardised interpretive criteria for AST of a range of key aquatic pathogens. ECOFF values distinguish microorganisms without (wild type) and with phenotypically detectable acquired resistance mechanisms (non-wild type) to the agent in question. The Reference Centre has played a key role in facilitating engagement with relevant international bodies, standard setters, and regulators able to help coordinate such activities, including FAO, ASEAN, US FDA, CLSI and EUCAST. We have also helped to establish a strong network of academic and government laboratories across Europe, US, Australia and Asia able to progress the testing required to support this important initiative. We have convened and participated in meetings to agree which pathogens to include, to select isolates to be tested, the methods to be used, and which laboratories to undertake the required testing. We have also been involved with developing and distributing standardised broth microdilution plates for this testing to our partner laboratories. To date, schemes for setting ECOFF/ECV for six aquatic pathogens are under active development, *e.g., Vibrio parahaemolyticus* and *Yersinia ruckeri*.

7.0 Communications and Publications

7.1 FAO UK Case Study on AMR

In partnership with the FAO, the VMD AMR team has written the case study "*Tackling Antimicrobial Resistance in Food Producing Animals",* describing how a reduction of over 50% of the sale of antimicrobials was achieved within the UK livestock industry. The publication highlights the multi-sectoral collaborative approach between the UK's Department for Environment, Food and Rural Affairs and farmers, producers and veterinarians that was key to driving change, and building trusted relationships between all stakeholders. Examples used demonstrate how allowing industry to take ownership of the issue of antimicrobial resistance and supporting its efforts to reduce antimicrobial use has been essential. The case study can be found here on the FAO website.

7.2 FAO Webinar: Addressing AMR in agrifood systems

Reference Centre members delivered presentations as part of a webinar promoting the FAO e-learning course *"Understanding AMR in Food and Agriculture"* (See Section 6.1 for further details), developed in collaboration with Reference Centre technical experts.

7.3 Peer Review Publications

Mohammed A. Samad, Md Shahjalal Sagor, Muhammad Sazzad Hossain, Md Rezaul Karim, Mohammad Asheak Mahmud, Md Samun Sarker, Fahria A. Shownaw, Zakaria Mia, Roderick M. Card, Agnes Agunos & Lindahl Johanna High prevalence of vancomycin non-susceptible and multi-drug resistant enterococci in farmed animals and fresh retail meats in Bangladesh, Vet Res Commun. 2022. DOI: 10.1007/s11259-022-09906-7

Edel Light, Craig Baker-Austin, Roderick M.Card, David Ryder, Mickael Teixeira Alvesa, Hanan A.Al-Sarawi, Khalil Hasan, Abdulla, Henrik Stahl, Aliya Al-Ghabshi, Majed F.Alghoribi, Hanan H.Balkhy, Andrew Joseph, Alexandra Hughes, Will J.F. LeQuesne, David W.Verner-Jeffreys, Brett P. Lyons. Establishing a marine monitoring programme to assess antibiotic resistance: A case study from the Gulf

Cooperation Council (GCC) region. Environmental Advances 9 https://doi.org/10.1016/j.envadv.2022.100268

7.4 Oral Presentations

Key: Reference Centre staff underlined and presenting author indicated with an asterisk *

Roderick M. Card*, Rachel Dalton*, David Verner-Jeffreys*. Introduction to the UK FAO Reference Centre for AMR. LSHTM - Fleming Fund: London Workshop. Virtual Event. 15 February 2022

Roderick M. Card*. An Introduction to Veterinary AMR Surveillance and Research at the APHA. LSHTM - Fleming Fund: London Workshop. Virtual Event. 15 February 2022

Andrew Joseph*. Chemical and Biological Hazards Driving AMR in Aquatic Ecosystems One Health Aquaculture African Workshop. Ocean and Commonwealth Partnership Programme. Virtual Event 16-17 March 2022

David Verner-Jeffreys*. UK FAO Reference Centre for Antimicrobial Resistance One Health Aquaculture African Workshop. Ocean and Commonwealth Partnership Programme. Virtual Event 16-17 March 2022

Roderick M. Card*. An Introduction to Veterinary AMR Surveillance in the UK. Joint UK- Bahrain One Health Workshop on Antimicrobial Resistance. Virtual Event. 21 March 2022

Rachel Dalton*, Fraser Broadfoot*, Junxia Song*; Keith Sumption*; Cristina Petracchi, Alejandro Dorado Garcia. Addressing antimicrobial resistance (AMR) in agrifood systems; a FAO e-learning introductory course on AMR. FAO E-learning International Technical Webinar. Virtual FAO E-Learning Event. 27 April 2022

Athina Popadopoulou*. Finfish biosecurity: UK experiences FAO-ECTAD organised Bangladesh Fin Fish Guidelines Workshop Dhaka, Bangladesh 21-Sep-22

Roderick M. Card*. Survey Results and Group Discussion. Fleming Fellows' Symposium. Virtual Event. 13 October 2022

Ramon Maluping*. Antimicrobial Usage and Resistance and the Use of Non-Antibiotic Alternatives to Reduce AMU and AMR. Philippine Society of Animal Science 59th Scientific Meeting and Annual Convention. Virtual Event. 19-20 October 2022

Roderick M. Card*. AMR in animal health and aquaculture sectors. One Health Poultry Hub Conference. Hybrid Event. 25 October 2022

Roderick M. Card*, Thomas Chisnall, Ruhena Begum, Md Samun Sarker, Muhammad Sazzad Hossain, Md Shahjalal Sagor, Mohammad Asheak Mahmud, Mohammed A. Samad. Migratory Birds in Bangladesh Harbour Multidrug Resistant Non-Typhoidal *Salmonella* of Public Health Significance. 7th World One Health Congress. Sands Expo & Convention Centre, Singapore. 7-11 November 2022

David Verner-Jeffreys* AMR surveillance in aquaculture. 3rd Webinar AQUAE STRENGTH: OIE Cooperation Project 'Strengthening capacity on Aquatic Animal Health and Epidemiological Surveillance'. 10 November 2022

Roderick M. Card*, Rachel Dalton*, Fraser Broadfoot* Introduction to the UK FAO Reference Centre for AMR. FAO Fleming Fund Africa Planning Conference. Nairobi, Kenya. 07 December 2022

Andrew Joseph*. UK FAO Reference Centre for Antimicrobial Resistance: Building Capability in Animal Health to Address AMR and Reduce Antibiotic Usage in Food-Animal Production Systems. World Aquatic Veterinary Medicines Association World Aquatic Health Conference. Pretoria University, South Africa. 4-7 December 2022

David Verner-Jeffreys*, David Bass, Wendy Higman, Rachel Hartnell, Edmund Peeler, Grant Stentiford. Building partnerships in Africa: One Health approach to improving sustainable aquaculture production. World Aquatic Veterinary Medicines Association

World Aquatic Health Conference. Pretoria University, South Africa. 4-7 December 2022

7.5 Poster Presentations

Key: Reference Centre staff underlined and presenting author indicated with an asterisk *

Jerome Delamare-Deboutteville, Roderick Card, Md Habibur, Stephen Hinchliffe, Md. Manik Mia, Mohammad Mahfujul Haque, Shafiq Rheman, Mohammed A. Samad, Charles Tyler, David W. Verner-Jeffreys*. Strengthening antimicrobial surveillance capacity in the aquaculture industry in Bangladesh. 7th World One Health Congress. Sands Expo & Convention Centre, Singapore. 7-11 November 2022

Victoria Adetunji, Idowu Fagbamila, Ini Adebiyi, Eme Ekeng, Suliat Adeleke, Mwapu Ndahi, Rene Hendriksen, Catherine Ryan, Hemanti Patel, Thomas Chisnall, and Roderick M. Card*. Establishing a One Health AMR Community of Practice in Nigeria. 7th World One Health Congress. Sands Expo & Convention Centre, Singapore. 7-11 November 2022

Idowu Fagbamila, Thomas Chisnall*, Carmen Losasso, Lisa Barco, Roderick M. Card. Multidrug-Resistant *Salmonella* Enterica Serotype Kentucky ST198 is Widely Distributed Across Poultry Farms in Nigeria. 7th World One Health Congress. Sands Expo & Convention Centre, Singapore. 7-11 November 2022

7.6 Blogs and other online reports

VMD Blog | July 2022 | Guest edited by Dr Vhoko-Tapensana. My placement experience working with the VMD's AMR Surveillance Team. https://vmd.blog.gov.uk/2022/07/28/my-placement-experience-working-with-the-vmds-amr-surveillance-team/

APHA Science Blog for World Antimicrobial Awareness Week. Working internationally to support local action. https://aphascience.blog.gov.uk/2022/11/24/world-antimicrobial-awareness-week-2022/

Cefas WAAW Marine Science blog for World Antimicrobial Awareness Week. https://marinescience.blog.gov.uk/2022/11/24/antimicrobial-resistance-working-internationally-to-support-local-action/

The Petri Dish | May 2022 | Issue 39. Aquaculture AMU and AMR Fleming Fellows from Nigeria and Ghana mentored by Reference Centre highlighted. https://www.flemingfund.org/publications/petri-dish-bulletin-issue-39/

Appendix One:

Summary of the three Defra agencies which together hold the UK FAO Reference Centre for AMR 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 (WOAH) 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.

APHA website:

Animal and Plant Health Agency - GOV.UK (www.gov.uk)

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.

Cefas website

https://www.cefas.co.uk/

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.

VMD website:

Veterinary Medicines Directorate - GOV.UK (www.gov.uk)