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ANTIMICROBIAL RESISTANCE (AMR) IN AQUACULTURE

Executive Summary

Antimicrobial resistance (AMR) occurs when microorganisms – bacteria, fungi, viruses and parasites – fail to respond to antimicrobial substances, like antibiotics. The use of antimicrobials have benefitted aquaculture through improved on-farm biosecurity and husbandry and treatment of chronic and epizootic diseases. Vaccines are recognized as important tools for the prevention of diseases in fish and a measure for reducing the unregulated use of antimicrobials in aquaculture. However, there are concerns on threats posed by abuse, overuse, misuse of antimicrobials, human and animal health issues, environmental and ecological issues, antimicrobial residues and AMR. The last two were identified by the 2006 Joint FAO/OIE/WHO Expert Meeting on Antimicrobial Use and Antimicrobial Resistance in Aquaculture as two important hazards. The FAO Action Plan on Antimicrobial Resistance 2016–2020 supports the implementation of Resolution 4/2015. It addresses four major Focus areas:

- Awareness: improve awareness on AMR and related threats
- Evidence: develop capacity for surveillance and monitoring of AMR and AMU (antimicrobial use) in food and agriculture
- Governance: strengthen governance related to AMU and AMR in food and agriculture
- Best practices: promote good practices in food and agricultural systems and the prudent use of antimicrobials

Enhanced efforts are now underway to support FAO members in the development and implementation of the food and agriculture components of the National Action Plans on AMR.

This is a Session Background Document[1] prepared for the COFI Sub-Committee on Aquaculture 9th Session, Rome, Italy, 24–27 October 2017.

As in other food production systems, disease represents an important impediment that must be dealt with in the aquatic sector. The situation in aquaculture has become increasingly complicated due to the burgeoning number of species being cultured (more than 500 species of finfish, molluscs, crustaceans, amphibians, and aquatic plants), the culture environment, the systems and types of management and scale of operation. Fish is also the most traded food commodity and this globalization associated with the culture of new species, the international movement of aquatic organisms and the general trend towards intensification of production methods and sectoral industrialization, while creating new market opportunities for farmed aquatic animals have, in the absence of appropriate biosecurity, also simultaneously facilitated the spread of pathogens and diseases. Thus we have seen increased reliance on veterinary medicines to ensure successful production through prevention and treatment of diseases, assuring healthy stocks and maximizing production.

Veterinary medicines are used for disease prevention (vaccines), as therapeutants (antimicrobials) and for husbandry purposes (anaesthetics for handling, hormones to enhance reproduction and production, and disinfectants). Antimicrobials (antibacterial or antibiotics, antifungal, antiparasitic, antiviral agents) play a critical role in the treatment of diseases of food producing animals (aquatic and terrestrial) and plants and help assure food safety and quality. As in other veterinary applications, antimicrobial agents in use in aquaculture are also used in human medicine. There are no antimicrobial agents that have been specifically developed for aquaculture use, and simple economic considerations suggest that this may remain the case.

Antimicrobial resistance (AMR) occurs when microorganisms – bacteria, fungi, viruses and parasites – fail to respond to antimicrobial substances, like antibiotics. This can occur naturally through adaption to the environment[2].

I. Benefits of the use of antimicrobials in aquaculture

The primary benefits of the use of veterinary medicines including antimicrobials can be seen in various situations through: (i) improved on-farm biosecurity and husbandry (e.g. use of vaccines and disinfectants); (ii) treatment of chronic diseases that cause reduced growth, low food conversion rate and poor survival thus leading to reduced production; and (iii) treatment of epizootic diseases that can cause mass mortalities. Vaccines, for instance, are recognized as important tools for the prevention of diseases in fish and a measure for reducing the unregulated use of antimicrobials in aquaculture.

The use of antimicrobials in aquaculture have proved useful in the following situations:

- **New species culture development**: when developing culture techniques for new species there is often a lag phase between the identification and characterization of pathogens and the development of disease control procedures. In such cases, the use of veterinary medicines may be necessary to ensure viability of the new species until alternative control methods can be incorporated into production and health management programmes.

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[1] The document was jointly prepared by Dr Melba Reantaso, Aquaculture Officer (FIAA), Dr Iddya Karunasagar, FAO retiree and Dr Victoria Alday, FAO Consultant, based on draft CCRF Technical Guidelines on Prudent and Responsible Use of Veterinary Medicines and a draft chapter of a book in preparation – Responsible Management of Bacterial Diseases in Aquaculture.

[2] www.fao.org/antimicrobial-resistance/background/what-is-it/en/

- **Failure of preventive therapy**: The use of preventive measures such as good husbandry and vaccination does not always ensure the success of an aquaculture enterprise. Cultured aquatic animals subjected to stresses above what they are capable of enduring may develop depressed immune systems and compromised nonspecific barriers (e.g. skin), enhancing susceptibility to infections by pathogens that can only be resolved by the use of antimicrobials.
- **Emerging and re-emerging infectious disease**: The number and occurrence of transboundary aquatic animal diseases have increased and the use of veterinary medicines to treat such infections supports other biosecurity measures to restrict the geographical spread of infections.
- **Developing culture technologies**: Use of recirculation technologies, elevated growing temperatures, higher densities, chronic antimicrobial usage to control diseases and higher concentration of farms in limited geographical areas - may all change the manner in which pathogens and cultured species interact. In such instances, diseases may manifest themselves in novel ways, requiring rapid diagnosis and treatment with antimicrobials.

II. Issues pertaining to the use of antimicrobials

There are a number of concerns and issues regarding the use of antimicrobials related to: (1) threats posed by abuse, overuse and misuse; (2) human and animal health issues; (3) environmental and ecological issues; (4) antimicrobial residues; and (5) antimicrobial resistance (AMR).

Threats posed by abuse, overuse, misuse. Imprudent use of antimicrobials in aquaculture is a contributing factor in the development of antimicrobial resistance (AMR). For example, antibiotics should only be used in a confirmed bacterial infection case. They should not be used in diseases caused by viral infection. The use of antimicrobials should be based on correct diagnosis. Only antimicrobials that are labelled to treat the condition diagnosed and licensed for use of the species affected should be used. Such drugs should also be properly handled (and disposed), stored and expiry dates should be closely monitored; and they should be administered by a recognized and/or licenced aquatic animal health professional.

Human and animal health issues. For animal health, the main issue is treatment failure due to increase in resistance. For human health, the main concern is adverse health effects associated with the presence of residues in the food produced or resistance in bacteria associated with human disease. Resistance in bacteria causing human disease may arise either directly via enrichment of these bacteria in the aquaculture environment or indirectly via enrichment of the genes that encode such resistance and which may subsequently be transferred to bacteria associated with human disease.

Environmental and ecological issues. The release of the medicines into the aquatic environment through leaching from unconsumed feeds, intentional or unintentional release of effluent water from aquaculture facilities and presence of residues in faecal materials are some of the environmental issues. The impacts on local ecosystem are, in general, poorly studied. The ecological concerns include accumulation of residues in the sediments, impacts of drugs and chemicals on natural biota, and possible development of antimicrobial resistance in aquatic bacteria.

Antimicrobial residues. The Joint FAO/OIE/WHO Expert Meeting on Antimicrobial Use and Antimicrobial Resistance in Aquaculture identified that the two hazards to be considered are antimicrobial residues and development and spread of antimicrobial resistant bacteria[3]. While residues found in animal tissues may be directly related to the use of antimicrobials in the respective sector, the issue with AMR is more complicated in the case of aquaculture. This is because the aquatic environment receives effluents from hospitals, animal farms and agricultural fields. Hence, bacteria carrying AMR

[3] ftp://ftp.fao.org/ag/agn/food/aquaculture_rep_13_16june2006.pdf

determinants that are selected in other sectors find their way into the aquatic environment and may eventually reach aquaculture systems. Further antimicrobial resistance genes (ARGs) respect neither phylogenetic nor geographical borders; hence ARG selected in one sector may impact another.

Antimicrobial usage in aquaculture for the treatment of microbial diseases can result in antimicrobial residues in food products, especially in cases when these have not always been used in a responsible manner. Detection of residues of antimicrobials, e.g. chloramphenicol, nitrofurans and malachite green, in internationally-traded shrimp has caused much concern. This resulted in reductions in imports, causing economic losses among concerned producers and governments. Antibiotic residues accounted for 28 percent of EU rejections and 20 percent of US rejections of aquaculture imports[4]. However, this has also led to tightened national regulations on the use of antibiotics and implementation of national residue control programme in many countries. As a result, the number of cases of rejections/ alerts related to seafood due to residues of antimicrobials has come down drastically in recent years, though some cases of alerts/rejections still occur with respect to some exporting countries. At international level, the Maximum Residue Limit (MRL) that is acceptable aquatic food products is set by the Codex Alimentarius Commission based on the scientific evaluation of the drugs by the Joint FAO/WHO Expert Committee on Food Additives (JECFA). But currently, there are MRLs for only a limited number of antimicrobials in Codex5, although there are additional national/regional MRLs in seafood importing countries, which may not be harmonised. Hence, there is a need to have Codex MRLs for antimicrobials that are approved for use in aquaculture. There is also a need for appropriate design of antimicrobial susceptibility testing programmes relevant to aquaculture and aquaculture products.

III. Antimicrobial resistance

It is now well accepted that antibiotic resistance genes (ARGs) are of ancient origin and can be found in bacteria from pre-antibiotic era. Viable multidrug-resistant bacteria have been cultured from the Lechuguilla Cave in New Mexico, totally isolated for >4 million years (Bhullar *et al.*, 2012). Genes encoding resistance to β-lactam, tetracycline and glycopeptide antibiotics could be found in bacteria from 30,000 year old Beringian permafrost sediments (DeCosta *et al.*, 2011). At least some of the resistance determinants that are presently circulating among human pathogens have been thought to originate from environmental bacteria. For example, qnr genes encoding quinolone resistance and found in plasmids of Escherichia coli and Salmonella might have originated from aquatic organisms like Shewanella or members of aquatic Vibrionaceae, where the qnr (quinolone resistance) gene is found in the chromosome (Poirel *et al.*, 2012). Plasmid-borne extended spectrum beta-lactamase (ESBL) gene of CTX-M group (blaCTX-M) found in E. coli is thought to have originated from environmental organism Kluyvera (Poirel *et al.*, 2012). Thus, many environmental bacteria harbour resistance determinants, which may not be related to exposure to the antibiotics.

Though ARGs have evolved naturally, indiscriminate use of antibiotics in human and animal sectors has led to selection and spread of resistant bacteria. But ARGs found in aquatic systems may be derived from multiple sources. Hospital effluents carry significant pool of ARGs. Using comparative metagenomic approach, Rowe *et al.* (2016) demonstrated that the abundance of ARGs in effluents entering a river catchment area is higher than that in the receiving environment. The possible sources of ARGs entering aquatic environment and eventually aquaculture environment is illustrated in Figure 1 below:

[4] www.fao.org/antimicrobial-resistance/background/what-is-it/en/
[5] see CAC/MRL 2-2017.

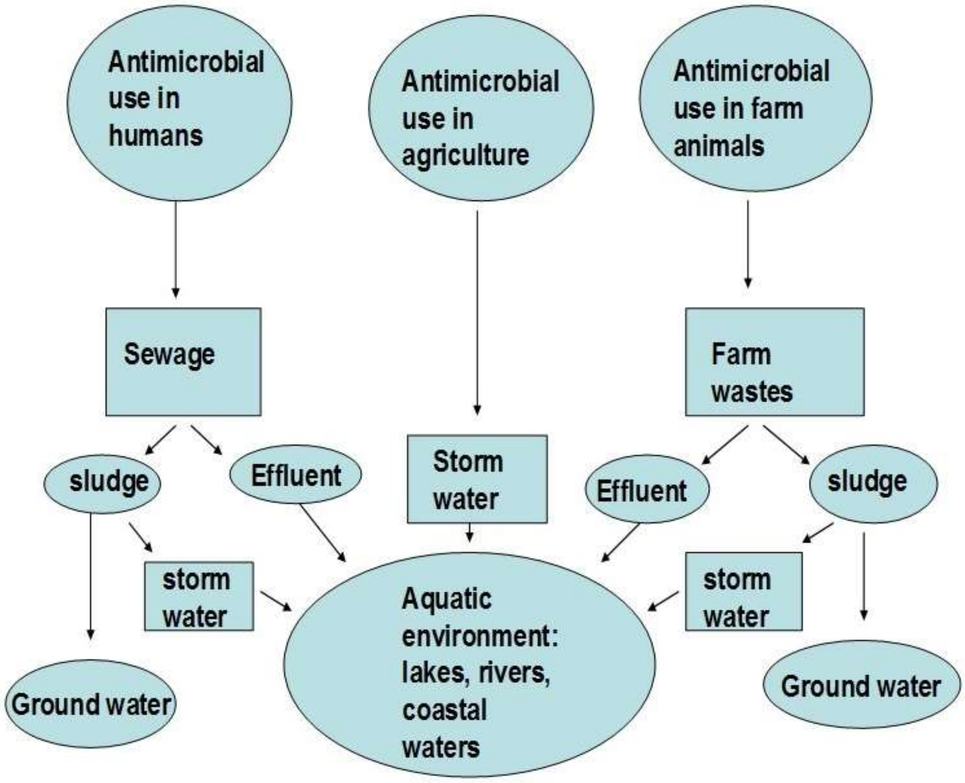

Figure 1. Pathways for the spread of antimicrobial residues and resistant bacteria in the aquatic environment[5].

Innate and acquired resistance of bacteria

The intrinsic resistance of a bacterial species to a particular antibiotic is the ability to resist the action of that antibiotic as a result of inherent structural or functional characteristics (Blair *et al.*, 2015). The intrinsic resistance of some Gram-negative bacteria to many compounds is due to an inability of these agents to cross the outer membrane. For example, the glycopeptide antibiotic vancomycin inhibits peptidoglycan crosslinking by binding to target d-Ala-d-Ala peptides, but in Gram-negative organisms, it cannot cross the outer membrane and access these peptides in the periplasm. Aeromonas spp., commonly found in fresh water aquaculture environments, have been reported to have intrinsic resistance to ampicillin and amoxicillin and poses at least four chromosomally-born beta-lactamase genes. This intrinsic resistance has been the basis for the development of starch ampicillin agar medium for quantitative detections of Aeromonas in foods.

When microorganisms that were once sensitive to an antimicrobial agent become resistant to a particular antibiotic, the resistance is acquired. The acquired resistance could be due to genetic changes such as mutations or acquisition of genes contributing to resistance through horizontal gene transfer. Antibiotic resistance genes may be transferred through mobile genetic elements such as plasmids, transposons, bacteriophages, genomic islands or integrons. Though integrons are not self-mobile, they contain gene cassettes that are mobile.

[5] Karunasagar, I. 2012.Public health and trade impact of antimicrobial use in aquaculture. *In* M.G. Bondad-Reantaso, J.R. Arthur & R.P. Subasinghe, eds. *Improving biosecurity through prudent and responsible use of veterinary medicines in aquatic food production*, pp. 1–9. FAO Fisheries and Aquaculture Technical Paper No. 547. Rome, FAO. 207 pp. (www.fao.org/docrep/016/ba0056e/ba0056e.pdf).

Mechanisms of antimicrobial resistance

Bacteria resist action of antimicrobial agents through different mechanisms (Alekshun and Levy, 2007; Blair *et al.*, 2015). Some of the common ones are:

- *Inactivation of the drug*: Bacteria acquire genes encoding enzymes that inactivate the antibiotic before it can reach the target, e.g. beta-lactamases inactivate beta-lactam antibiotics like penicillins and cephalosporins; carbapenemases that inactivate carbapenems; aminoglycoside modifying enzymes such as N-acetyltransferases, O-adenyltransferases and O-phosphotransferases modify the antibiotics of this class.
- *Prevention of drug access to targets in bacterial cells*: Reduced access can happen due to: (a) *reduced permeability to the drug*; e.g. carbapanem resistance due to reduced or altered porin production by mutations. It has been reported that selective pressure due to carbapenems favour emergence of mutations in porin genes or in genes that regulate porin expression; (b) *increased efflux*: bacterial efflux pumps actively transport antibiotics outside the cell. Some efflux pumps may show narrow substrate specificity, e.g. Tet pumps, but others show broader activity such as multidrug efflux pumps.
- *Modification of drug targets*: Antibiotics act on specific bacterial targets, e.g. ribosomes, and modification of drug targets would render antibiotics ineffective. For instance, the erythromycin ribosome methylase (*erm*) family of proteins methylate 16SrRNA and alter binding targets for macrolide antibiotics. The *qnr* family of genes encode pentapeptide repeat proteins that bind to and protect topoisomerase IV and DNA gyrase from the lethal action of quinolones. Polymyxin antibiotics such as colistin bind to lipopolysaccharides in Gram-negative bacteria and the antibacterial activity is due to the disruption of cell membrane by the hydrophobic chain. Overexpression of putative cytoplasmic membrane protein encoded by pmrC in colistin resistant bacteria leads to addition of phosphoethanolamine to lipid A leading to decreased binding of colistin.
- *Bypass targets*: Methicillin resistance in *Staphylococcus aureus* is due to the acquisition of chromosomal cassette *mec* element. The *mecA* gene responsible for methicillin resistance encodes the β-lactam- insensitive protein PBP2a which enables cell wall biosynthesis to occur despite the native PBP (penicillin-binding protein) being inhibited in the presence of antibiotic. Resistance to sulphonamide and trimethoprims could be due to bypass mechanisms. These drugs interfere in different steps in de novo synthesis of tetrahydrofolic acid, which is an essential precursor for several amino acids and nucleotides. Bacterial resistance could be due to the production of drug resistant dihyrofolate reductase or dihydropteroate synthesis. Plasmid borne sul1 and sul2 genes in sulphonmide resistant bacteria encode drug resistant dihydropteroate synthase.

Genetic mechanisms of AMR

Phenotypic AMR detected could be due to different genetic mechanisms. Tetracycline is commonly used in treatment of diseases in aquatic animals. When resistance to tetracycline is detected, it could be due to: (a) over-production of efflux proteins or (b) production of ribosomal protection proteins or (c) production of tetracycline inactivating proteins (Chopra and Roberts, 2001). Therefore, to understand the emergence and spread of AMR in aquaculture and the relation between antimicrobial use (AMU) and AMR in different sectors, it is important to have information on the genetic determinants related to the resistance.

Studies on epidemiological aspects of the spread of AMR also requires information on the genetic type of resistance determinants. Extended spectrum beta-lactamases could be of different molecular types and the genes encoding these show considerable variations. Four classes (Class A-D) are recognized, based on molecular types. Functionally also, there are different types, some inhibited by clavulanic acid, while others are not. Some are serine-based enzymes, others are metalloenzymes.

IV. AMR and aquaculture

AMR in bacteria associated with aquaculture

Antimicrobial resistance in pathogens of aquatic animals has been reported from different systems. In shrimp hatcheries, mass mortalities due to antibiotic resistant luminous bacteria (*Vibrio spp.*) can be a problem (Karunasagar *et al.*, 1994). Acquired resistance in *Aeromonas salmonicida* causing furunculosis in temperate waters has been reported from a number of countries (FAO/OIE/WHO, 2006). Several mobile genetic elements like plasmids, transposons, integrons carrying AMR genes have been detected in *Aeromonas* spp. from aquaculture sites in different parts of the world (Piotrowska and Popowska, 2015). Over 80 percent of *Vibrio harveyi* from finfish aquaculture systems in Italy showed resistance to amoxicillin, ampicillin and erythromycin, while 76 percent of strains showed resistance to sulphadiazine (Scarano *et al.*, 2014). Thus, AMR in bacterial pathogens of aquatic animals could impact disease management in these systems and the resistance determinants could be transferred to human pathogens from aquatic systems.

Though AMR is observed in aquatic bacteria associated with aquaculture systems, it is difficult to find a direct link between the resistance profile and AMU. Culture-independent studies in the Baltic Sea show presence of resistance genes encoding resistance to sulphonamides, trimethoprim, tetracycline, aminoglycoside, chloramphenicol and also genes encoding multidrug efflux pumps in sediments of fish farms, though some antibiotics like tetracyclines, aminoglycosides and chloramphenicol are not used in this area (Muziasari *et al.*, 2017). Some of these might represent a natural reservoir of resistance genes in the aquatic environment. Antibiotic resistant marine bacteria have been found as far as 522 km offshore and in deep sea at depths of 8 200 m (Aminov, 2011). Therefore, mere detection of AMR in aquaculture systems does not imply misuse of antimicrobials in aquaculture. Source attribution of AMR in aquaculture associated bacteria is very complex and caution needs to be exercised in interpretation of data. AMR may be naturally present in the aquatic environment or derived from AMU in other sectors or derived from AMU in aquaculture.

Public health

From a public health perspective, AMR in aquatic bacteria of zoonotic potential would be significant. Studies done in South Korea show that all *V. parahaemolyticus* isolated from oysters were resistant to ampicillin and vancomycin and half the number of isolates exhibited resistance to cephalothin, rifampin and streptomycin (Kang *et al.*, 2016). However, there was no linkage to use of these antibiotics in aquaculture. There may be geographical variation in the prevalence of resistance. Studies in China with isolates from crustaceans and shellfish showed much higher (over 90 percent) resistance to rifampin and 78 percent resistance to streptomycin (Hu and Chen, 2016). Most *V. vulnificus* strains isolated from Dutch eel farms showed resistance to cefoxitin, though this antibiotic was not used in eel aquaculture (Haenen *et al.*, 2014). Thus, detection of antibiotic resistance in bacteria isolated from aquaculture cannot be directly linked to the use of antimicrobials in aquaculture. Therefore, detection of antibiotic resistance in aquaculture systems needs to be interpreted with caution, considering that resistance determinants are naturally present in these environments and ARGs coming from other sectors. But often, in literature, we can see simplistic linking of any resistance found to AMU in aquaculture, even when there is no use of antimicrobials in that system. For example, Akinbowale *et al.* (2006) attributed resistance found in aquaculture environments in Australia to a significant off-label use. Implementation of an integrated surveillance programme within the framework of One Health, that includes study of AMU and AMGs in different sectors (human, agriculture, veterinary and aquaculture) could improve our understanding of the drivers leading to selection and spread of AMR in the aquatic environment.

AMR in bacteria associated with products of aquaculture in retail markets

When farmed fish are handled and processed, there can be significant changes in the microflora. Therefore, bacteria found in farmed fish at retail level may not represent microflora coming from the aquatic environment. Farmed fish such as Vietnamese catfish and tilapia are filleted before they reach the market, while farmed shrimp are handled and processed (beheading, gutting, peeling) before delivery to export markets. Noor Uddin *et al.* (2016) examined the microflora of raw cultured and wild caught shrimp imported into Denmark and concluded that the flora changed considerably during processing. They suggested that it is not possible to pick up any indicator bacteria that represents aquaculture environment at this stage. This calls for caution in the interpretation of AMR found in fish and shrimp at retail level or at import control points and linking resistance found in bacteria at this stage and AMU in aquaculture. Data from aquatic products at primary production stage is essential to understand any linkage between AMU and AMR in aquaculture.

V. Current initiatives

The Global Plan of Action on AMR (with contributions from FAO and the OIE) was adopted during the 68th World Health Assembly in May 2015[6]. The World Assembly of the OIE delegates in May 2015 adopted the action plan and the 39th FAO Conference (June 2015), adopted Resolution 4/2015. A political declaration was made during a high-level meeting on AMR at the 71st UN General Assembly (UNGA, September 2016). The UNGA called upon the Tripartite (i.e. FAO as global leader for food and agriculture, the OIE as global leader for animal health and welfare and the WHO as global leader for human health) and other intergovernmental organizations to support the development and implementation of national action plans and AMR activities at the national, regional and global levels under the One Health platform.

FAO Action Plan on AMR 2016-2020[7]

Antimicrobials are important tools to the overall implementation of effective biosecurity. However, they need to be used more carefully. This can be tackled (1) through effective policies, e.g. better regulations and enforcement; (2) though improving the knowledge base (e.g. on areas such as disease diagnosis, surveillance, risk analysis and disease prevention, control and management); (3) through capacity building at all levels of the aquaculture production chain, e.g. (i) improving extension that promotes responsible use of antimicrobials; (ii) good aquaculture and biosecurity practices and effective diagnostics that prevent disease occurrence or outbreaks in the first place. All critical as they can reduce the need for use of antimicrobials.

Countries need to have in place appropriate and well-conceived legislation and regulations concerning the prudent and responsible use of antimicrobials in aquaculture including aspects for registration of antimicrobials, licencing of aquatic animal health professionals and others. Countries must also have trained manpower and infrastructure to enforce legislation and regulations with appropriate penalties for violation. Public-private sector partnership should be promoted because dealing with diseases is a shared responsibility among all players in the aquaculture value chain.

The FAO Action Plan on Antimicrobial Resistance 2016–2020 supports the implementation of Resolution 4/2015. It addresses four major Focus areas:

- **Awareness**: improve awareness on AMR and related threats
- **Evidence**: develop capacity for surveillance and monitoring of AMR and AMU (antimicrobial use) in food and agriculture
- **Governance**: strengthen governance related to AMU and AMR in food and agriculture
- **Best practices**: promote good practices in food and agricultural systems and the prudent use of antimicrobials

[6] http://apps.who.int/iris/bitstream/10665/193736/1/9789241509763_eng.pdf?ua=1
[7] www.fao.org/3/a-i5996e.pdf

Enhanced efforts are now underway to support FAO members in the development and implementation of the food and agriculture components of the National Action Plans on AMR.

The Department of Fisheries and Aquaculture of FAO is finalising the FAO Code of Conduct for Responsible Fisheries or CCRF – Technical Guidelines on the Prudent and Responsible Use of Veterinary Medicines in Aquaculture. It provides information on the global challenges, the benefits of their use and salient issues concerning their use and a number of recommendations to governments and to the private sector, including small-scale aquafarmers and to aquatic animal health professionals. A publication "Responsible Management of Bacterial Diseases in Aquaculture" is also underway. The Department is also implementing the project FMM/RAS/298: "Strengthening capacities, policies and national action plans on prudent and responsible use of antimicrobials in fisheries". The project, being implemented until end of 2017, will contribute to achieving UN Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development, supports SO4 (Enable more inclusive and efficient agricultural and food systems at local, national and regional levels) and the One Health and Blue Growth initiatives. The objective is to enhance knowledge, skills and capacity, as well as implementation of policies and national action plans on prudent and responsible use of antimicrobials of competent authorities on fisheries and aquaculture. The project has two components, namely: (1) Aquaculture (includes China, Malaysia, the Philippines and Viet Nam as participants); and (2) Fish Product Safety and Quality (participants Bangladesh, the Philippines, Thailand and Viet Nam). Other ongoing projects that have aquaculture components include that of FAO Project OSRO/RAS/502/USA "Addressing Antimicrobial Usage in Asia's Livestock Production Industry" and FMM/RLA/215/MUL "Support for the development of national action plans on antimicrobial resistance in Latin America and the Caribbean".

During the 8th Session of the FAO Committee on Fisheries Sub-Committee on Aquaculture (COFI/SCA 8) held in Brazil in 2015, biosecurity was identified as one of the priority areas of the work of the SCA and the session highlighted the importance of AMR. Antimicrobial resistance is now a new area of emphasis and high work priority of FAO's Department of Fisheries and Aquaculture.

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