



World Health
Organization

European Region

Prevention and control of antimicrobial resistance in the food chain: guidance for food safety authorities in Europe



Abstract

In 2011, the WHO Regional Office for Europe launched the publication *Tackling antibiotic resistance from a food safety perspective in Europe*. The publication explored the options for prevention and containment of antibiotic resistance in the food chain through national coordination and international cooperation. Over the past decade, significant progress has been made and good achievements have been reached. However, foodborne antimicrobial resistance remains an issue in the WHO European Region. Every year, 23 million people fall ill, nearly 5000 people die from unsafe food, and several foodborne disease hazards are showing increasing levels of resistance to commonly used antimicrobials.

This publication gives an overview of the current context and recent developments regarding foodborne antimicrobial resistance in the Region. It also explores the role of food safety authorities in reducing antimicrobial resistance and provides updated and practical advice on the prevention and control of antimicrobial resistance at the animal–human–environment interface using the One Health approach, including examples of successful interventions and programmes undertaken by Member States in the Region to prevent and contain antimicrobial resistance in foodborne pathogens.

The publication is aimed at policy-makers and food safety authorities working in the public health, agriculture, food production and veterinary sectors in Member States in the Region.

Keywords

ANTIMICROBIAL RESISTANCE
FOOD SAFETY
FOOD SAFETY AUTHORITIES
EUROPEAN REGION

ISBN: 978-92-890-5875-9 (PDF)

ISBN: 978-92-890-5876-6 (print)

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Suggested citation. Prevention and control of antimicrobial resistance in the food chain: guidance for food safety authorities in Europe. Copenhagen: WHO Regional Office for Europe; 2024. Licence: CC BY-NC-SA 3.0 IGO.

Cataloguing-in-Publication (CIP) data. CIP data are available at <http://apps.who.int/iris>.

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Foreword

Antimicrobials, including antibiotics, have revolutionized the treatment of infectious diseases. But their use and misuse have resulted in the development and spread of antibiotic resistance. This is now a significant health problem: over 33 000 people die each year in European Union (EU)/European Economic Area (EEA) countries alone due to an infection caused by bacteria resistant to antibiotics.

Antibiotic resistance is not only a human health threat, but also a food safety issue: antibiotic use in food animals – for treatment, disease prevention or, in some countries outside the EU, growth promotion – allows resistant bacteria and resistance genes to emerge and spread from food animals to humans through the food chain. There is also concern about the spread of resistance from the environment to humans and animals through the feed chain. Where food safety control systems are deficient, residues of antimicrobial agents ingested via food constitute another health concern, as they may cause allergies, alteration of the intestinal flora, and drug resistance.

The *European strategic action plan on antibiotic resistance for the period 2011–2020* has contributed to significant progress in tackling antimicrobial resistance in the WHO European Region over the past decade. However, much remains to be done to safeguard the prevention and treatment of human and animal diseases in the future.

Food safety authorities play a key role in strengthening the legal framework governing antimicrobial residues and microbial contaminant limits in food. They are also responsible for monitoring antimicrobial residues in food and antimicrobial resistance in priority foodborne pathogens. In addition, food safety authorities play an important supporting role in advocating for high-level political attention to antimicrobial resistance, strengthening One Health governance structures and coordinating action across sectors. This includes risk communication, the education of consumers and other stakeholders, and promotion of the prudent use of antimicrobials in human and veterinary medicine.

Acknowledgements

This publication was developed by Peter Sousa Hoejskov, Technical Officer for Food Safety and Zoonotic Diseases at the WHO Regional Office for Europe, and Marina Morach, an independent consultant. It draws on an earlier work, *Tackling antimicrobial resistance from a food safety perspective in Europe*, produced by various experts for the Regional Office, and provides new updates and insights on the prevention and control of antimicrobial resistance in the food chain. Technical review and input were provided by Johanna Takkinen and Dominique Monnet from the European Centre for Disease Prevention and Control (ECDC).

Comments were also received from the European Food Safety Authority (EFSA) Panel on Biological Hazards (BIOHAZ) and Unit on Biological Hazards and Contaminants (BIOCONTAM).

The authors are grateful for valuable comments received from colleagues at the WHO Regional Office for Europe and headquarters, including Danilo Lo Fo Wong, Sarah Paulin-Deschenaux and Anand Balachandran.

Financial support for the publication was provided by the governments of Germany and the Kingdom of the Netherlands.

Abbreviations

AMC	antimicrobial medicines consumption
AMR	antimicrobial resistance
AMU	antimicrobial use
CAC/GL	Codex Alimentarius Commission/Guidelines
CAC/RCP	Codex Alimentarius Commission/Code of Practice
CAESAR	Central Asian and European Surveillance of Antimicrobial Resistance
EARS-Net	European Antimicrobial Resistance Surveillance Network
ECDC	European Centre for Disease Prevention and Control
EEA	European Economic Area
EFSA	European Food Safety Authority
EMA	European Medicines Agency
ESAC-Net	European Surveillance of Antimicrobial Consumption Network
ESVAC	European Surveillance of Veterinary Antimicrobial Consumption
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GLASS	Global Antimicrobial Resistance and Use Surveillance System
IACG	Interagency Coordination Group on Antimicrobial Resistance
IHR	International Health Regulations (2005)
NAP	national action plan on antimicrobial resistance
UN	United Nations
WOAH	World Organisation for Animal Health

Glossary

The following definitions are included to establish a common understanding of the terms used in this document.

Antimicrobial agent

Any substance of natural, semisynthetic or synthetic origin that at in vivo concentrations kills or inhibits the growth of microorganisms by interacting with a specific target.

AMR

AMR occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines, making infections harder to treat and increasing the risk of disease spread, severe illness and death. As a result, the medicines become ineffective and infections persist in the body, increasing the risk of spread to others.

Antimicrobial stewardship

Interventions designed to promote the optimal use of antibiotic agents, including drug choice, dosing, route and duration of administration.

Food and Agriculture Organization of the United Nations

The Food and Agriculture Organization of the United Nations (FAO) is the leading organization within the United Nations system in the field of food and agriculture. Major areas of focus of its global mandate include improving nutrition, increasing agricultural productivity, raising the standard of living in rural populations and contributing to global economic growth worldwide.

Foodborne pathogen

Any disease-causing microorganism, such as a bacterium, virus or parasite, that is transmitted to people via food.

Food-producing animals

Animals raised for the purpose of providing food for humans.

Integrated surveillance

Integrated surveillance of AMR in foodborne bacteria is the collection, validation, analysis and reporting of relevant microbiological and epidemiological data on AMR in foodborne bacteria from humans, animals and food, and on relevant antimicrobial use (AMU) in human and animals. This includes data from relevant food chain sectors – including animals, food and humans – and

data on both AMR and AMU. Integrated surveillance of AMR in foodborne bacteria expands on traditional public health surveillance to cover multiple elements of the food chain and to include AMU data, with a view to better understanding sources of infection and transmission routes.

Maximum residue limits – Pesticides

A maximum residue limit is the highest level of a pesticide residue that is legally tolerated in or on food or feed when pesticides are applied correctly in accordance with good agricultural practices.

Maximum residue limits – Veterinary drugs

The maximum residue limit is the maximum concentration of residue legally tolerated in a food product obtained from an animal that has received a veterinary medicine or that has been exposed to a biocidal product for use in animal husbandry (1).

One Health

One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems.

It recognizes that the health of humans, domestic and wild animals, plants and the wider environment, including ecosystems, are closely linked and interdependent.

The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, and action on climate change, and contributing to sustainable development (2).

Residue limits

The traces that pesticides leave in treated products or those left by veterinary drugs in animals are called residues.

United Nations Environment Programme

The United Nations Environment Programme (UNEP) is the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system, and serves as an authoritative advocate for the global environment.

World Organisation for Animal Health

The World Organisation for Animal Health (WOAH) is the intergovernmental organization responsible for, inter alia, developing international standards on animal health, veterinary public health, zoonoses and animal welfare; ensuring the transparent dissemination of official information on animal health status; and strengthening veterinary services.

Executive summary

This publication takes stock of developments in combating antimicrobial resistance (AMR) from a food safety perspective and provides guidance to food safety authorities on their role in addressing the issue of AMR in the food chain using the One Health approach.

AMR threatens historic achievements in modern medicine and public health as well as broader development. Antimicrobial agents, such as antibiotics, are essential to treat some human and animal diseases. Overuse and misuse of antimicrobials in food-producing animals has contributed to an increasing challenge of antimicrobial-resistant pathogens being passed on to people through the food chain and the environment. Residues of antimicrobial agents in food of animal origin are another health concern as they can cause allergies, alterations in the intestinal flora and bacterial resistance. Every year in the WHO European Region, thousands of people get sick and die from foodborne diseases. Many foodborne diseases are caused by bacteria, which are showing increasing levels of resistance to commonly used antimicrobials – calling for action to improve food safety.

Over the past ten years, significant progress on addressing the issue of AMR has taken place at the global, regional and country levels. The Food and Agriculture Organization of the United Nations (FAO), UN Environment Programme (UNEP), World Organisation for Animal Health (WOAH) and WHO have enhanced their collaboration through the establishment of Quadripartite coordination and funding mechanisms. The overall awareness of the issue of AMR has improved and technical guidance to support country efforts in combating AMR has been developed and used. To guide efforts at the country level, many countries have developed national action plans (NAPs) on AMR using the One Health approach.

AMR is a public health challenge that requires collaboration across sectors, groups of stakeholders and countries – using the One Health approach. Food safety authorities play a key role in contributing to combat AMR. This includes strengthening the legal framework for antimicrobial residues and microbial contaminant limits in food. They are also responsible for monitoring antimicrobial residues in food and AMR in priority foodborne bacteria and in promoting good food hygiene practices. In addition, the food safety authorities play an important supportive role in advocating for high-level political attention to AMR, strengthening One Health governance structures and coordinating action across sectors. This includes risk communication, the education of consumers, and promotion of the prudent use of antimicrobials.



Introduction

Antimicrobial resistance (AMR) is a major global threat of increasing concern for human, animal and environmental health. Alarming levels of resistance to common community-acquired pathogens have been reported across the world. The overuse and misuse of antimicrobials in food-producing animals has contributed to the growing challenge of antimicrobial-resistant pathogens being passed on to people through the food chain and the environment. Residues of antimicrobial agents ingested via food of animal origin constitute another health concern, as they may cause allergies, alteration of the intestinal flora, and drug resistance.

In 2011, the WHO Regional Office for Europe launched the publication *Tackling antibiotic resistance from a food safety perspective in Europe* (3), with the aim of supporting Member States' efforts to prevent and contain antibiotic resistance by focusing on its spread through the food chain. The publication raised awareness of the importance of antibiotic resistance as a food safety issue and the responsibilities of all players along the food chain to prevent and control its spread. Together with the *European strategic action plan on antibiotic resistance for the period 2011–2020* (4), *A European One Health Action Plan against Antimicrobial Resistance (AMR)*, and other EU strategies on AMR, the publication also supported governments to develop and implement policies to contain AMR and protect human health.

Over the past decade, the context of AMR has become increasingly complex, creating a need to shift the focus from antibiotic resistance to AMR. Indeed, growing resistance is being observed in foodborne pathogens, not only to the most commonly used antimicrobials, but also to last-resort antimicrobials. International trade and travel have also undergone significant expansion, leading to an increased risk of rapid spread of antimicrobial-resistant bacteria in food.

At the same time, there have been noteworthy advances in research and development on detection, diagnosis, investigation and response in the context of AMR-related public health incidents, while new technologies – such as next-generation sequencing – have been introduced and their cost of use in routine work has been significantly reduced. The revision of existing guidelines and the development of new guidance documents, particularly those of the Ad Hoc Codex Intergovernmental Task Force on Antimicrobial Resistance, provide references for minimizing and containing AMR, and strengthening integrated monitoring and surveillance of foodborne AMR. Awareness of AMR among the general public and policy-makers has also increased, which puts pressure on governments, businesses, international agencies and civil society to coordinate and scale up action in a timely manner.

Objective and scope

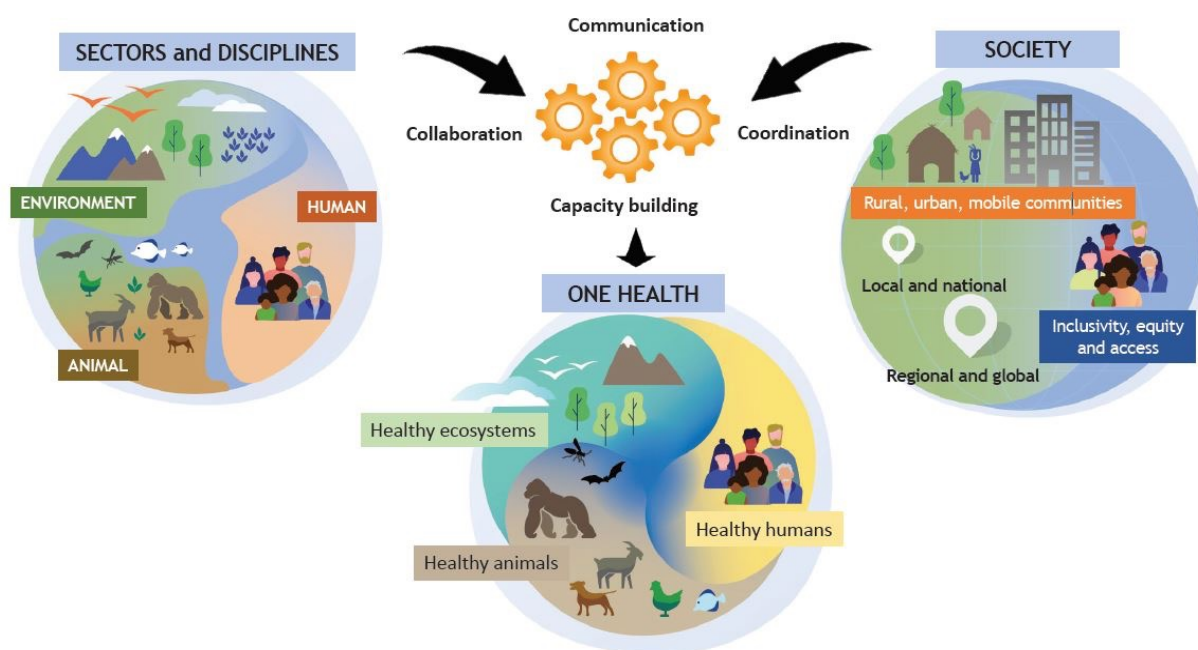
This document is intended to give an overview of the current context and recent developments regarding foodborne AMR in the WHO European Region and explore the role of food safety authorities in reducing AMR. It also provides updated and practical advice on the prevention and control of AMR at the animal–human interface through the One Health approach, including non-exhaustive examples of successful interventions and programmes undertaken by Member States in the Region to prevent and contain AMR in foodborne bacteria in general.

Developments in combating foodborne AMR over the past decade

One Health

One Health is not a new concept, but it has received renewed attention and evolved over the past decade because of the increased frequency and severity of threats linking the health of humans, animals, plants and the environment. One Health calls for a holistic and systems-based approach that recognizes the interconnection between the health of humans, animals, plants and the environment. The One Health approach is illustrated in Fig. 1.

Fig. 1. The One Health approach



Source: (2)

One Health is an important tool for tackling AMR and therefore requires international recognition, involvement and partnership that can guide and support national initiatives. However, the One Health approach is equally important for addressing other health issues originating in the animal–human–environment interface, including food safety, the control of zoonotic diseases and neglected tropical diseases, environmental health and emergency preparedness, and implementation of the International Health Regulations (IHR) (2005). These are complex topics that require close collaboration across sectors, stakeholders and countries. Within the scope of this guidance, the focus is on One Health as a holistic and multifaceted tool that allows an intersectoral, interdisciplinary and transdisciplinary approach to tackling AMR in the food chain.

Global level

Global action plan on AMR

Tackling AMR as it relates to food safety requires international recognition, involvement and partnership that can guide and support national initiatives. For a long time, WHO, the FAO and WOAHA have recognized the importance of AMR. This has resulted in international commitment to dealing with the problem and developing guidance to support action. In particular, World Health Assembly resolution WHA51.17 (5) urges Member States to encourage the reduced and rational use of antimicrobials in food animals. This resulted in the further development of the *WHO Global Principles for the Containment of Antimicrobial Resistance in Animals Intended for Food* (6), which were developed with the participation of FAO and WOAHA and included in the *WHO Global Strategy for Containment of Antimicrobial Resistance* (7). This collaboration to combat health risks at the animal–human–environment interface, including AMR, was first formalized through a tripartite concept note in April 2010, followed by a memorandum of understanding. In 2022, an updated memorandum of understanding to strengthen cooperation to sustainably balance and optimize the health of humans, animals, plants and the environment was signed by FAO, UNEP, WHO, and the WOAHA (collectively referred to as the “Quadripartite”). The new agreement provides a legal and formal framework for the four organizations to tackle the challenges at the human, animal, plant and environment interface using a more integrated and coordinated approach.

In May 2015, the World Health Assembly adopted a *Global action plan on antimicrobial resistance* (8). The plan outlines five key objectives:

- improve awareness and understanding of AMR through effective communication, education and training;
- strengthen the knowledge and evidence base through surveillance and research;
- reduce the incidence of infection through effective sanitation, hygiene and infection prevention measures;
- optimize the use of antimicrobial medicines in human and animal health; and
- develop the economic case for sustainable investment that takes account of the needs of all countries and increase investment in new medicines, diagnostic tools, vaccines and other interventions.

With this approach, the main goal of ensuring that infectious diseases can be treated and prevented using quality-assured, safe and effective medicines is achievable.

Road maps for improving collaboration on the animal–human interface

The IHR require WHO Member States to develop, strengthen and maintain minimum national core public health capacities to detect, assess, notify and respond to public health threats. WHO has developed various assessment and monitoring tools for this purpose, such as the IHR Monitoring and Evaluation Framework. For its part, WOAHA has developed the Performance of Veterinary Services (PVS) Pathway, which is composed of different tools to assist countries to objectively assess and address the main weaknesses of their veterinary services.

IHR-PVS national bridging workshops are three-day events facilitated by WHO and WOAHA, bringing together between 50 and 80 participants from public health and animal health services. The objective of the IHR-PVS national bridging workshops is to analyse and improve collaboration between the two sectors in the prevention and detection of and response to zoonotic diseases and other health events at the animal–human interface.

The output of the workshops includes a joint road map for the improvement of collaboration between the public health and animal health sectors to better address health threats at the animal–human interface, including AMR (9).

Quadripartite collaboration

In 2022, the Quadripartite launched the One Health Quadripartite Joint Plan of Action (2022–2026). The Plan, which was welcomed by the Seventy-fifth World Health Assembly, will guide the work of the Quadripartite to operationalize the One Health approach at the global, regional and country levels.

The development of the One Health Quadripartite Joint Plan of Action was guided by the multidisciplinary One Health High-Level Expert Panel, made up of experts representing a broad spectrum of disciplines relevant to One Health. In addition to the development of the Joint Plan of Action, the Panel also provides:

1. policy-relevant scientific assessments on the emergence of health crises arising from the animal–human–environment interface, and research gaps; and
2. guidance on the development of a long-term strategic approach to reducing the risk of zoonotic pandemics, with an associated monitoring and early warning framework, and the synergies needed to institutionalize and implement the One Health approach, including in areas that drive pandemic risk.

The Panel's advice contributes to enhancing strategic orientations and coordination, and to providing high political visibility on the subject of One Health. The Panel also performs the following functions:

- provide advice on the analysis of scientific evidence on the links between animals, humans and environmental health, and contribute to foresight on emerging threats to health;
- provide advice on better understanding the impacts of food systems – including agriculture, livestock farming and trade, wildlife hunting and trade, aquaculture, animal product processing, handling, distribution and consumer practices – and ecological and environmental factors that may be contributing to zoonotic disease emergence/re-emergence and spillover events;

- contribute to setting the One Health research agenda and propose, advise on and review approaches and specific studies relevant to the development of a global approach to reduce the risk of zoonotic pandemics;
- provide advice, by invitation, on the One Health policy response in relevant Member States; and
- provide recommendations on specific issues identified by the partners in the areas of highest concern for attention and action, and future directions, in One Health (10).

In 2022, the Quadripartite developed the *Strategic Framework for collaboration on antimicrobial resistance* (11), reflecting their joint work to advance a One Health response to AMR at the global, regional and country levels. The framework broadly supports implementation of the five objectives of the *Global action plan on antimicrobial resistance*, as well as strengthening global AMR governance.

Quadripartite Joint Secretariat on AMR

The Quadripartite Joint Secretariat on AMR consolidates cooperation between FAO, UNEP, WHO and WOAHA to coordinate the global One Health response to AMR, drawing on the core mandates and comparative advantages of each organization.

It also provides secretariat support to the Global Leaders Group on Antimicrobial Resistance (12), which brings together world leaders and experts from across sectors to accelerate political action on AMR. The Global Leaders Group performs an independent global advisory and advocacy role, working to sustain urgency, public support and political momentum in relation to the AMR challenge, and maintain its visibility on the global health and development agenda.

The Quadripartite Joint Secretariat has the following functions:

- global promotion, advocacy and political engagement;
- support for global governance structures on AMR;
- coordination of interagency engagement and partnership;
- coordination and monitoring of Quadripartite workplans on AMR;
- mapping of gaps and opportunities;
- support for the functioning of the AMR Multi-partner Trust Fund (13);
- secretariat support for the Global Leaders Group on AMR.

AMR Multi-partner Trust Fund

The AMR Multi-partner Trust Fund has a timeframe extending to 2030 and is aimed at scaling up efforts to support countries to counter the immediate threat of AMR, as well as promoting increased One Health coordination to tackle AMR. The United Nations Secretary-General has recognized the AMR Multi-partner Trust Fund as a mechanism to secure consistent and coordinated development financing to support One Health national action plans and Quadripartite workplans.

Ad Hoc Codex Intergovernmental Task Force on AMR

Codex Alimentarius is a collection of standards, guidelines and codes of practice adopted by the Codex Alimentarius Commission. Codex texts are developed with the aim of protecting health and facilitating fair trade in food. This includes science-based guidance on how to assess and manage the risks to human health associated with antimicrobial-resistant microorganisms in food

and feed, as well as guidance to enable the coherent management of AMR along the food chain. Codex also develops texts on veterinary drugs and their residues. WHO supports Member States in actively participating in Codex work and adopting Codex texts into national legislation, policies and guidelines (14).

In recognition of the growing issue of AMR, its increasing threat to human, animal and plant health, and the need for a One Health approach to address this issue, the Codex Alimentarius Commission agreed, at its 39th session in 2016, that it was important for the food safety community to play its part, re-establishing the Ad Hoc Codex Intergovernmental Task Force on AMR. The objectives of the Task Force were to revise the Codex Code of Practice to Minimize and Contain Antimicrobial Resistance (CAC/RCP 61-2005) (15) and develop new guidance on surveillance programmes relevant to foodborne AMR, as well as guidelines for the risk analysis of foodborne AMR (16, 17).

Global AMR and use surveillance system

To support global surveillance and research in order to strengthen the evidence base on AMR, inform decision-making and drive national, regional and global actions, WHO launched the Global Antimicrobial Resistance and Use Surveillance System (GLASS) in October 2015. GLASS was developed to support the Global action plan on antimicrobial resistance and promote a standardized approach to the collection, analysis and sharing of AMR and antimicrobial medicines consumption (AMC) data at a global level by encouraging and facilitating the establishment of national AMR and AMC surveillance systems capable of monitoring trends and producing reliable and comparable data. The objectives of GLASS are to:

- foster national surveillance systems and harmonize global standards;
- estimate the extent and burden of AMR globally by monitoring selected indicators;
- analyse and report global data on AMR and AMC on a regular basis;
- detect emerging resistance and its international spread;
- inform implementation of targeted prevention and control programmes;
- assess the impact of interventions (18, 19).

Currently, GLASS collects and reports data on AMR rates and AMC aggregated at the national level. The system enables comparable and validated data on AMR to be collected, analysed and shared with countries and partners to inform decision-making; drive local, national and regional action; and provide evidence for interventions and advocacy. GLASS also collects data on the implementation status of national surveillance systems (20).

Global tricycle surveillance

In 2021, a GLASS One Health module was launched. This module is a WHO global, integrated, multisectoral, surveillance protocol based on the extended-spectrum beta-lactamase (ESBL)-*Escherichia coli* project. The project, Tricycle, is named after its three-wheeled namesake (see Fig. 2) to demonstrate the idea that it will simultaneously address three aspects of bacterial resistance – human health, food chain (animals) and the environment – as part of a One Health approach, in a simple and feasible manner designed to provide robust and valid, statistically-based surveillance outcomes using minimal resources (21).

Fig. 2. Tricycle: WHO integrated global surveillance on ESBL-producing *E. coli* using a One Health approach



Source: (21)

Integrated surveillance of AMR in foodborne bacteria

Guidance on the integrated surveillance of AMR in foodborne bacteria (22) was developed in 2017 with the support of the WHO Advisory Group on Integrated Surveillance of Antimicrobial Resistance. It aims to assist Member States and other stakeholders in the establishment and development of programmes for the integrated surveillance of AMR in foodborne bacteria – through a One Health approach. The guidance includes recommended standardized and validated antimicrobial susceptibility testing methods; harmonized, interpretive criteria, and approaches to the collection and reporting of AMC and use data.

Research and development

There have been significant advances in research and development on the detection, diagnosis, investigation and response to AMR-related public health incidents.

In 2016, WHO and the Drugs for Neglected Diseases initiative (DNDi), which is a not-for-profit product development partnership working to research and develop new and improved treatments for neglected disease, established the Global Antibiotic Research and Development Partnership. This partnership aims at developing new treatments for drug-resistant infections that pose the greatest threat to health.

In 2017, WHO published a list of bacteria for which new antibiotics are urgently needed. The WHO priority pathogens list for the research and development of new antibiotics was developed to guide and promote the research and development of new antibiotics, categorized according to urgency of need: critical, high and medium priority.

Since 2017, WHO has published an annual analysis of antibacterial agents in clinical development, and since 2019 in preclinical development, targeting the pathogens on the priority list.

In 2018, a landscape paper on whole genome sequencing for foodborne disease surveillance was published by WHO. The paper summarizes the benefits and challenges inherent in the implementation of whole genome sequencing and describes some of the issues developing countries may face.

In 2019, the *Landscape of diagnostics against antibacterial resistance, gaps and priorities* was developed by WHO, together with target product profiles for AMR diagnostics.

In 2020, target product profiles were developed by WHO for needed antibacterial agents for enteric fever, gonorrhoea, neonatal sepsis and urinary tract infections.

Improved awareness and understanding of AMR through effective communication, education and training

Awareness of AMR has increased among the general public and policy-makers, putting pressure on governments, businesses, international agencies and civil society to coordinate and scale up action in a timely manner. Nevertheless, there is still potential to further strengthen awareness and understanding of AMR in Member States (23). WHO is scaling up its advocacy efforts, taking every opportunity to spotlight the issue and demonstrate how everyone can make a difference.

To this end, it has developed a competency framework for health workers' education and training on AMR, which can be used to shape training curricula. The competency framework sets out the minimum level of information about AMR that every professional training course, for any cadre of health worker, should include. It also covers general principles on how antimicrobials should be used, examines new and existing guidelines on infection prevention and control measures, and provides new training materials and tools to cover existing gaps (24). Additionally, WHO has strengthened awareness of AMR and its relation to food safety among the general public, health workers and policy-makers, encouraging best practice to avoid the further emergence and spread of drug-resistant infections through the *Five keys to safer food manual* (25). Further efforts to mainstream food safety in the public agenda and reduce the burden of foodborne diseases globally include promotion of World Food Safety Day (see Box 1) (26) and World Antimicrobial Awareness Week (see Box 2) (27). WHO also contributes its experience and knowledge to global and regional forums, such as the World One Health Congress (28).

Box 1. World Food Safety Day

World Food Safety Day on 7 June (see Fig. 3) aims to raise awareness and inspire action to help prevent, detect and manage foodborne risks, thereby contributing to improvements in food security, human health, economic prosperity, agriculture, market access, tourism and sustainable development. The 2022 theme, "Safer food, better health", stresses that safe food is essential to human health and well-being. Indeed, recognizing the systemic connections between the health of people, animals, plants, the environment and the economy will help us meet the needs of the future.

Acknowledging the global burden of foodborne diseases, which affect individuals of all ages, in particular children under the age of five and people living in low-income countries, the UN General Assembly proclaimed in 2018 that World Food Safety Day would be celebrated annually on 7 June. In 2020, the World Health Assembly further adopted a decision on strengthening efforts on food safety to reduce the burden of foodborne disease. WHO and FAO jointly facilitate the observance of World Food Safety Day, in collaboration with Member States and other relevant organizations.

Food safety is a shared responsibility between governments, producers and consumers. Everyone has a role to play from farm to table to ensure that the food we consume is safe and healthy. Through World Food Safety Day, WHO works to mainstream food safety in the public agenda and reduce the burden of foodborne diseases globally. Food safety is everyone's business.

Calls to action:

1. Ensure it's safe – Government must ensure safe and nutritious food for all
2. Grow it safe – Agriculture and food producers need to adopt good practices
3. Keep it safe – Business operators must make sure food is safe
4. Know what's safe – Consumers need to learn about safe and healthy food
5. Team up for food safety – Work together for safe food and good health

Fig. 3. World Food Safety Day 2022 poster



Source: (29)

Box 2. World Antimicrobial Awareness Week

Antimicrobials: Handle with care

Every year, World Antimicrobial Awareness Week (see Fig. 4) aims to increase awareness of global AMR and encourage best practices among the general public, health workers and policy-makers to stop the further emergence and spread of drug-resistant infections.

Following a stakeholder's consultation meeting in May 2020 organized by the tripartite organizations (FAO, WOA and WHO), the scope of World Antimicrobial Awareness Week was expanded, changing its focus from 'antibiotics' to the more encompassing and inclusive term 'antimicrobials'. Expanding the scope of the campaign to all antimicrobials will facilitate a more inclusive global response to AMR and support a multisectoral One Health approach with increased stakeholder engagement. The Tripartite Executive Committee also decided to fix the campaign dates from 18 to 24 November every year starting from 2020. The 2020 slogan was "Antimicrobials: Handle with care" across all sectors, while the theme for the human health sector was "United to preserve antimicrobials".

Fig. 4. World Antimicrobial Awareness Week 2020

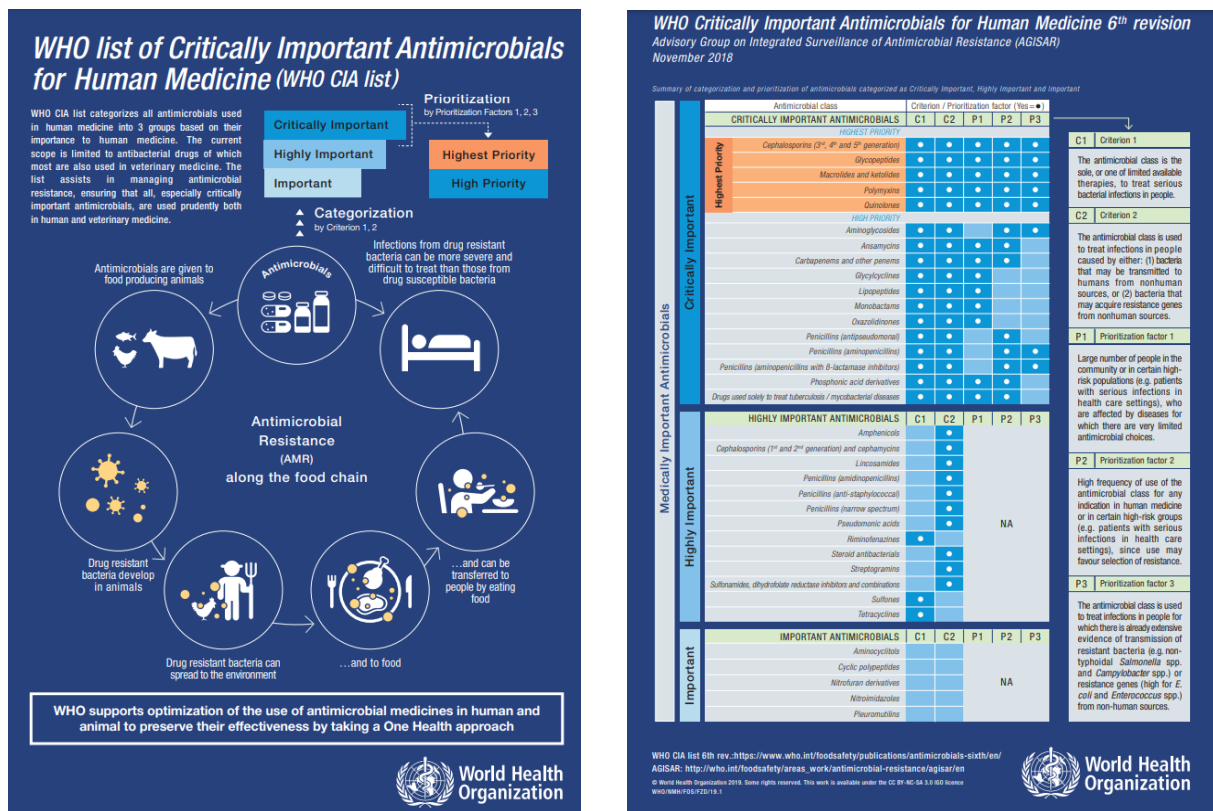


Source: (27)

Promotional material to optimize the use of antimicrobial medicines in humans and animals

WHO has launched new guidelines and infographics (see Fig. 5) on the use of medically important antimicrobials in food-producing animals, recommending that farmers and the food industry stop using antimicrobials routinely to promote growth and prevent disease in healthy animals. These guidelines aim to help preserve the effectiveness of antimicrobials that are important for human medicine by reducing their use in animals (32).

Fig. 5. Infographic on critically important antimicrobials for human medicine



Source: (32)

Additionally, WHO regularly publishes a list of critically important antimicrobials for human medicine (33), as well as model lists of essential medicines, which are intended as a guide for countries or regional authorities to adopt or adapt in accordance with local priorities and treatment guidelines for the development and updating of national essential medicines lists (34). With the purpose of optimizing the use of antimicrobials in the human health sector, the WHO Access, Watch, Reserve (AWaRe) classification categorizes antibiotics into three groups based on the potential to induce and propagate resistance, and identifies antibiotics that are priorities for monitoring and surveillance of use (35). For the animal sector, WOA produces lists of antimicrobial agents of veterinary importance (36), while for EU Member States, the European Medicines Agency (EMA) also classifies antimicrobials for human and veterinary medicine (37).

The way forward

The multifaceted, multisectoral and multistakeholder nature of the AMR challenge means that any approach to address AMR on the global stage must be carefully considered. Indeed, while there is much to be learned from existing global governance mechanisms, a bespoke approach may be the best way forward. With this in mind, a small cross-sectoral group of senior experts from across the world met in April 2018 under the auspices of the Interagency Coordination Group on Antimicrobial Resistance (IACG) to deliberate on the future global governance arrangements for AMR. As an output of this meeting, the IACG discussion paper entitled Future Global Governance for Antimicrobial Resistance (38) provided an overview of governance needs arising from the animal, environmental and human health sectors of the One Health agenda, showing which areas were well-aligned and which sectors required more specific support to develop a practical future

global governance model for AMR. For the animal, agriculture and food sectors, the following specific needs were identified:

- global standards/regulations to provide equal opportunities for all, including more strict veterinarian responsibilities and the restriction of access to black market antimicrobials;
- support (research, funding, technical support and infrastructure) to adapt processes in low-resource settings;
- development of affordable alternatives to antimicrobials across all species and settings;
- a consistent strategic approach supportive of trade and sector business models; and
- a precautionary but pragmatic approach.

Bringing these discussions together, a set of minimum requirements for an effective AMR governance mechanism emerged. While other additional qualities were raised, it was agreed that any new and existing AMR governance system must:

- have a clear mandate to elevate global action on AMR across human and animal health, agriculture, food and the environment, supporting the translation of this action to the national level;
- engage stakeholders from across the AMR system to ensure both a global and true One Health approach, focused on delivery which recognizes resource/context needs;
- provide sufficient flexibility to be inclusive of different nations and sectors, recognizing that, while we all have the same goals, we will start from different points, are driven by different incentives, and need different approaches to get there;
- secure binding global commitment for action, with accountability clearly assigned at every level;
- integrate with the wider global development agenda to better align on and mobilize actions that create common good;
- build on current structures wherever possible so as to avoid reinventing the wheel, and offer simplicity and sustainability while respecting the complexity of the AMR challenge;
- generate evidence-based targets and aligned tasks, supported by transparent multidimensional metrics and indicators, to identify a clearer way forward;
- be a credible and respected voice, synthesizing evidence and adding weight to global negotiations; and
- harness communication to present a more compelling case for action, recognizing the needs of different audiences from public to policy (38).

Regional level

Roadmap on antimicrobial resistance for the WHO European Region 2023–2030

Building on the Global action plan on antimicrobial resistance (8) and the progress achieved by the European strategic action plan on antibiotic resistance (for the period 2011–2020) (4), the overall purpose of the roadmap on antimicrobial resistance for the WHO European Region 2023–2030 is to support countries to identify, prioritize, implement and monitor high-impact interventions to tackle AMR.

The roadmap is organized around an AMR Compass that identifies five action areas and six enablers based on a combination of the best available evidence and expert opinion, for countries to adapt to their own national contexts. Each action area and enabler has a set of high-impact interventions and is intended as a practical and adaptable tool for countries to convene all relevant national AMR stakeholders, reach consensus on their priorities and inform the investment cases for action on AMR.

Improved Quadripartite coordination in Europe and central Asia

In 2021, the regional organizations of the FAO, WOA, UNEP and WHO Quadripartite for Europe and central Asia joined forces to strengthen the optimal use of available resources, foster synergies and avoid duplication of efforts in the fight against health risks at the animal-human-environment interface, including AMR, in support of their Member States.

This work is done through the Regional One Health Coordination Mechanism, comprising the One Health Executive Group, which sets the strategic direction and aligns the regional work with global One Health work, and the One Health Technical Group, which acts as the secretariat, delivering organization, facilitation and coordination services at the technical and operational levels. The Regional One Health Partner Platform for Europe then convenes multiple partners and stakeholders from various sectors and backgrounds for the mutual exchange of information on work in the area, and advice and input into the work of the Quadripartite to maximize country impact, foster synergies and avoid duplication.

The scope of the Regional One Health Coordination Mechanism includes issues arising from AMR and zoonotic diseases, such as foodborne diseases, rabies and influenza, as well as other existing or emerging One Health issues at the interface of human, animal and plant health and the wider environment that could pose a threat to humans within the WHO European Region (39).

Surveillance systems

WHO European Region

To contain and tackle AMR, it is crucial to strengthen the surveillance of AMR and AMC in human and veterinary medicine. In the Region, the main AMR surveillance mechanisms that gather and present combined country data are the European Antimicrobial Resistance Surveillance Network (EARS-Net) (40) and the Central Asian and European Surveillance of Antimicrobial Resistance (CAESAR) network (41). EARS-Net collects data from 29 European Union and European Economic Area (EU/EEA) countries, while the CAESAR network includes 19 countries, primarily in eastern Europe and central Asia, most of which provide data on an annual basis. CAESAR supports its network members in setting up and strengthening AMR surveillance, focusing on antimicrobial susceptibility testing data of isolates from blood and cerebrospinal fluid for nine bacterial pathogens of public health and clinical importance: *Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella* species (spp.), *Pseudomonas aeruginosa*, *Acinetobacter* spp., *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Enterococcus faecalis* and *Enterococcus faecium*. In addition, the European Centre for Disease Prevention and Control (ECDC) coordinates and develops AMR surveillance of human *Salmonella* and *Campylobacter* infections in EU/EEA countries, and produces a joint annual report with the European Food Safety Authority (EFSA) on AMR in zoonotic and indicator bacteria from humans, animals and food, thereby supporting implementation of the European One Health Action Plan against Antimicrobial Resistance (AMR) (42, 43).

For the surveillance of AMC in humans, the main surveillance mechanisms in the Region are the European Surveillance of Antimicrobial Consumption Network (ESAC-Net) (44), which collects data from 29 EU/EEA countries, and the WHO Regional Office for Europe AMC Network, which collects data from 19 countries plus Kosovo¹. Together, these two networks provide surveillance data for almost all of the 53 Member States in the Region.

The European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) project was launched to collect sales data on veterinary antimicrobials. Thirty-one European countries participate in the ESVAC network on a voluntary basis, providing information on how antimicrobial medicines are used in animals across the EU (45). From 2022, when Regulation (EU) 2019/6 on veterinary medicinal products came into force (46), the collection of data on the sale and use of antimicrobials in animals become mandatory throughout the EU.

In addition to various surveillance systems, WHO promotes the prudent use of antimicrobials by providing guidelines for the treatment of different pathogens (47–49), as well as by offering a multi-day online course on antimicrobial stewardship with the aim of equipping clinicians who frequently prescribe antimicrobials with knowledge and tools to improve their use of these essential medications in daily clinical practice (50).

WOAH

The WOAHP Terrestrial Animal Health Code (51) and Aquatic Animal Health Code (52) highlight the importance of:

- harmonizing national AMR surveillance and monitoring programmes;
- monitoring the quantities and usage patterns of antimicrobial agents used in food-producing animals;
- ensuring the responsible and prudent use of antimicrobial agents in veterinary medicine; and
- performing risk analysis for AMR arising from the use of antimicrobials in animals.

WOAH has further developed a list of antimicrobial agents of veterinary importance in parallel with the WHO list for human medicine (36), as well as standards and guidelines regarding laboratory methodologies for bacterial antimicrobial susceptibility testing (53), and a comprehensive book on WOAHP standards, guidelines and resolutions on AMR and the use of antimicrobial agents (54).

European Food Safety Authority (EFSA), European Centre for Disease Prevention and Control (ECDC) and EMA

EFSA independently monitors and analyses the situation regarding AMR in animals and food across Europe. At the EU level, EFSA is responsible for collecting and analysing data on AMR gathered by EU Member States on the occurrence of antimicrobial-resistant bacteria in food-producing animals and derived food. On a yearly basis, EFSA produces, in close collaboration with ECDC, the *European Union Summary Report on Antimicrobial Resistance*, which includes data on the occurrence of AMR and multidrug resistance in zoonotic and indicator bacteria from food-producing animals and food, as well as in *Salmonella* spp. and *Campylobacter* spp. isolates from

1. All references to Kosovo should be understood to be in the context of the United Nations Security Council resolution 1244 (1999).

human cases of foodborne infections (43). With the regular publication of technical and scientific reports, as well as risk assessments on different topics related to AMR, EFSA contributes to the strengthening of knowledge through the monitoring of AMR in zoonotic and indicator bacteria from food-producing animals and food (55).

ECDC is an EU agency aimed at strengthening Europe's defences against infectious diseases. AMR and Health Care-associated Infections is one of the disease programmes covered by ECDC. EMA is a decentralized agency of the EU responsible for the scientific evaluation, supervision and safety monitoring of medicines. In 2017, ECDC, EMA and EFSA published the Joint Scientific Opinion on a list of outcome indicators as regards surveillance of AMR and AMC in humans and food-producing animals (56). This was followed, in 2021, by the *Third joint inter-agency report on integrated analysis of antimicrobial consumption (AMC) and the occurrence of antimicrobial resistance (AMR) in bacteria from humans and food-producing animals (JIACR)* (57).

Other EU initiatives to improve collaboration on the addressing health risks in the animal–human–environment interface include joint meetings of the ECDC Food- and Waterborne Diseases and Zoonoses Network, the EFSA AMR Monitoring Network and the EU Reference Laboratory for Antimicrobial Resistance (EURL-AR).

As part of a staged approach to promote innovative and collaborative research and development efforts to bring new antimicrobials to patients, as well as efforts to analyse the need for new antimicrobials in veterinary medicine, the European Commission has suggested a range of activities. These include supporting research into the epidemiology of AMR, in particular the pathways of transmission between animals and humans, as well as the development of new tools for early, real-time detection of resistant pathogens in humans and animals. It will also continue to:

- support research into the development of new, effective, preventive vaccines for humans and animals;
- support the increase of the knowledge base concerning the barriers that influence the wider use of vaccination in medical and veterinary practice;
- support research into the development of new diagnostic tools, in particular on-site tests in humans and animals;
- encourage the uptake of diagnostics in medical and veterinary practice; and
- support research into knowledge gaps on the release of resistant microorganisms and antimicrobials into the environment and their spread.

Other proposed areas of research include the development of:

- new tools for monitoring antimicrobials and microorganisms resistant to antimicrobials in the environment;
- risk assessment methodologies to evaluate the risks to human and animal health from the presence of antimicrobials in the environment; and
- the development of technologies that enable the efficient and rapid degradation of antimicrobials in wastewater and the environment and reduce the spread of AMR (58).

Improved awareness and understanding of AMR through effective communication, education and training

Improving communication, education, awareness and understanding through targeted communication and advocacy materials in the veterinary field is one of the main objectives of the *OIE Strategy on Antimicrobial Resistance and the Prudent Use of Antimicrobials* (30).

The annual European Antibiotic Awareness Day and World Antimicrobial Awareness Week have also contributed to strengthening awareness and understanding of AMR in the WHO European Region. The 2022 slogan for World Antimicrobial Awareness Week, "Preventing Antimicrobial Resistance Together", highlights the importance of all sectors to encourage the prudent use of antimicrobials and to strengthen preventive measures addressing AMR, working together collaboratively through a One Health approach. European Antibiotic Awareness Day is a European health initiative coordinated by ECDC. It provides a platform and support for national campaigns on the prudent use of antibiotics in the EU/EEA and takes place each year on 18 November.

Reduced incidence of infection through effective sanitation, hygiene and infection prevention measures

Strengthening infection prevention and control is a vital measure in limiting the spread of AMR, but more awareness and understanding is needed about the particular role that poor hygiene practices play in spreading multidrug-resistant pathogens. Sound infection prevention and control practices can prevent resistant microbes from being transferred from one patient to another in hospitals and community health centres. More generally, limiting the number of infections reduces reliance on antimicrobials. Infection prevention and control is also relevant in the context of animals and has been taken into account in legislation, for example in Regulation (EU) 2016/429 on transmissible animal diseases, and in amending and repealing certain acts in the area of animal health (59).

EU legislation to optimize the use of antimicrobial medicine in humans and animals

Recent years have seen an extension of the regulatory framework on veterinary medicines and on medicated feed. The Veterinary Medicinal Products Regulation (EU) 2019/6 (46) harmonizes and enhances the internal market for veterinary medicinal products, reduces the administrative burden, stimulates innovation, provides for incentives to increase the availability of veterinary medicinal products and strengthens EU action against AMR. More importantly, the Regulation:

- bans the use of antimicrobials for promoting growth and increasing yield, thereby supplementing the 2006 prohibition on using antibiotics as growth promoters;
- restricts the preventive use of antimicrobial medicinal products to exceptional cases and to the administration to an individual animal or restricted number of animals when the risk for infection is very high or its consequences are likely to be severe – when the antimicrobial is an antibiotic, it can only be used in an individual animal in exceptional cases;
- restricts the metaphylactic use of antimicrobials to cases where the risk of spread of an infection or of an infectious disease in a group of animals is high and where no appropriate alternatives are available;
- allows for reserving certain antimicrobials for use in human medicine only, thereby banning their use in veterinary medicine;
- makes it mandatory for Member States to collect data on the volume of sales and on the use of antimicrobials per animal species; and

- requires non-EU countries to respect the ban on the use of antimicrobials for promoting growth or increasing yield and the ban on the use of antimicrobials designated by the EU as reserved for use in human medicine for animals and products of animal origin they intend to import into the EU.

Regulation (EU) 2019/4 on the use of medicated feed (60) bans the use of antimicrobials in medicated feed for prophylaxis and growth promotion, restricts veterinary prescriptions with antimicrobials, establishes harmonized limits for antimicrobials in ordinary feed, sets EU harmonized standards for manufacturing safe medicated feed, and creates a legal framework for the safe manufacturing and distribution of medicated feed for pets (61). The continuous adoption and implementation of European Commission regulations regarding maximum residue limits of pharmacologically active substances administered to food-producing animals are also critical for consumer protection (62–65).

Legislation to combat bacterial spread along the food chain

The spread of resistant or non-resistant bacteria along the food chain is influenced by measures implemented to ensure the hygienic production of animal products. This is covered by substantial legislation in most EU countries (see also Chapter 5.1.1).

National level

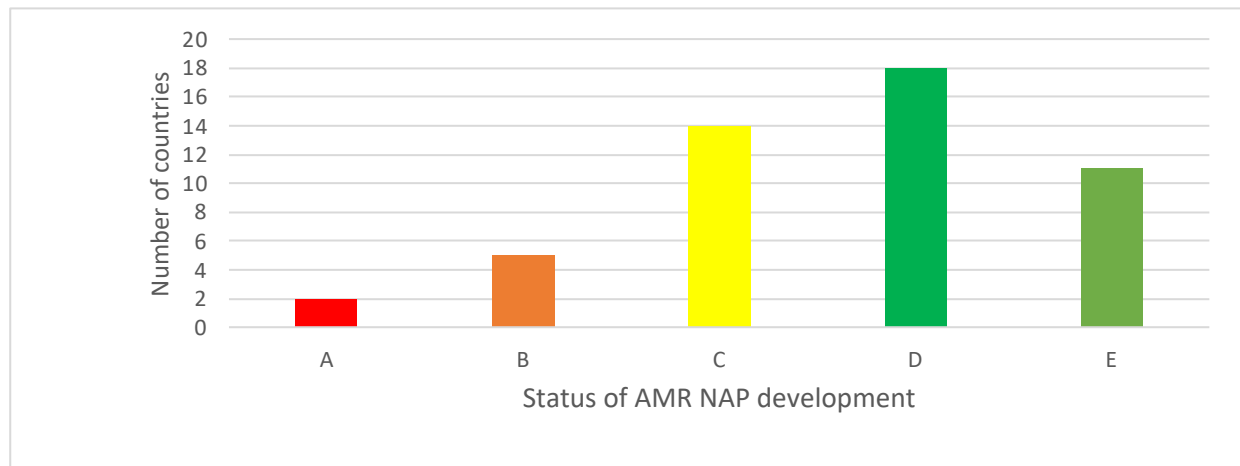
Strengthened national commitment to combating AMR – National action plans

Since the adoption of the *European strategic action plan on antibiotic resistance*, there has been intense activity in countries across the Region, and many of the strategies, policies and systems that are driving forward implementation of national action plans (NAPs) are now in place.

According to the Global Database for the Tripartite Antimicrobial Resistance Country Self-assessment Survey, 45 out of the 53 Member States in the Region have developed a national AMR action plan (as of 2020/2021). Eight NAPs have identified funding sources, are being implemented and have relevant sectors involved, with a defined monitoring and evaluation process in place, while almost half of Member States have NAPs approved by government that reflect the global action plan objectives, with a budgeted operational plan and monitoring arrangements (see Fig. 6) (66). In some NAPs, the responsibilities of the food safety authorities in combating AMR along the food chain are specifically mentioned (see Annex 1 for an example from Finland), as is the importance of taking a One Health approach, especially in relation to surveillance of AMR, communication on AMC, and resistance data and research (67–70). For most countries, the focus now is on implementation: converting these plans into sustained action and putting in place the policies and ways of working that will prevent resistance from spreading and gradually change the way in which antimicrobials are used. In this context, WHO, FAO and WOAHA are providing direct support to countries as part of cross-sectoral coordination and advising governments on priority-setting, particularly where resources are scarce. Tools and guidance are also being developed that can be adapted to each country's specific context. As countries move forward with implementation, they are encouraged to share their experiences and ideas through communities of practice, with a view to building an evidence base of tried and tested interventions. Another

important task of the Quadripartite collaboration is to continually monitor progress through a comprehensive framework based on a One Health approach, with defined measures of impact and outcome, and a clear set of agreed indicators.

Fig. 6. Country progress with development of a national action plan on AMR



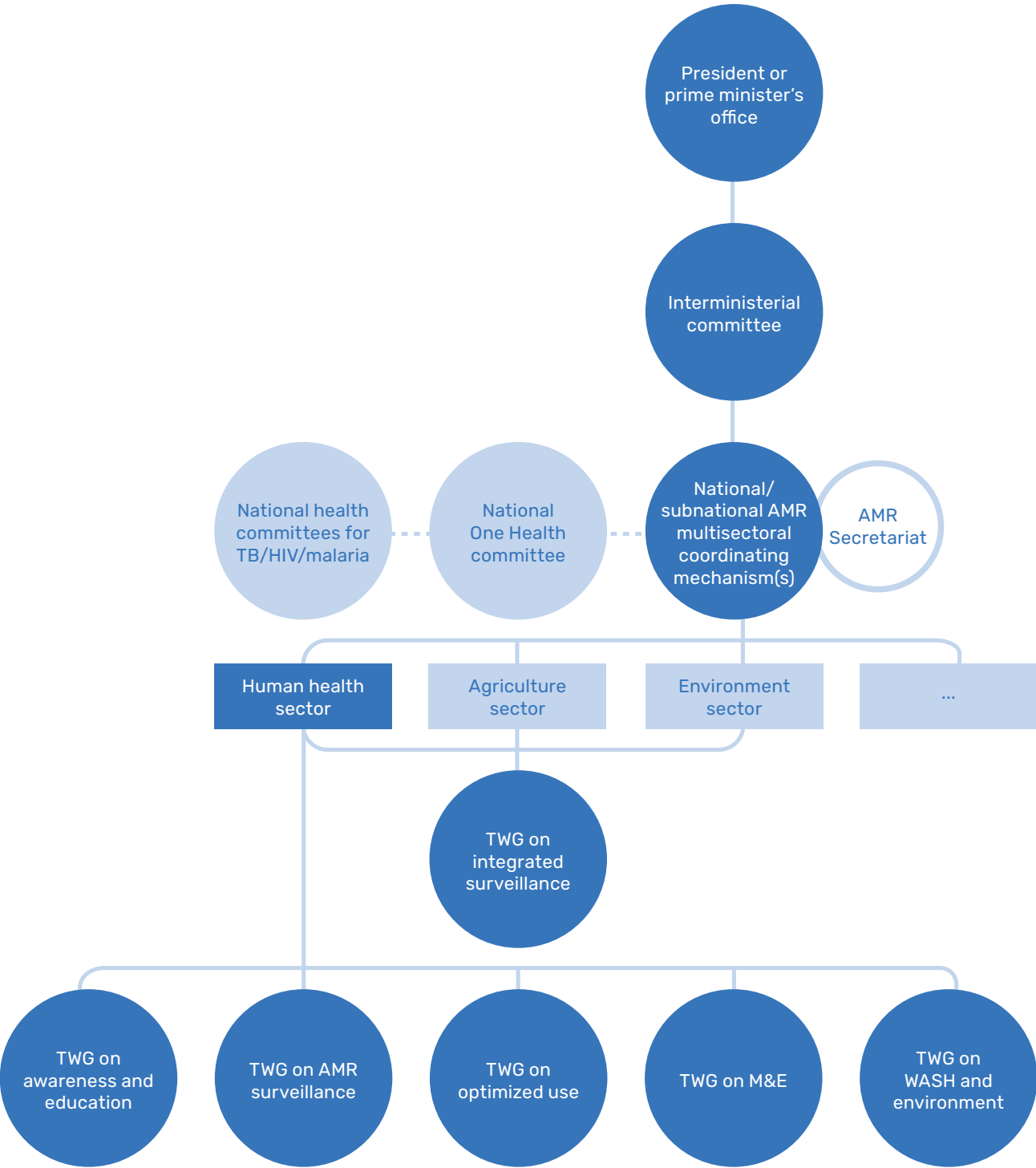
- A** No national AMR action plan.
- B** National AMR action plan under development.
- C** National AMR action plan developed.
- D** National AMR action plan approved by government that reflects global action plan objectives, with a budgeted operational plan and monitoring arrangements.
- E** National AMR action plan has identified funding sources, is being implemented and has relevant sectors involved with a defined monitoring and evaluation process in place.

Source: (66)

National AMR coordination committees

Many Member States in the Region that have developed their own NAP to tackle AMR have established coordination committees or equivalent bodies to deliver them. However, implementing NAPs at scale is proving a difficult task, especially in the resource-constrained settings of low- and middle-income countries. AMR coordination committees must play an enabling role, but they cannot be expected to carry out each and every activity listed in the NAP. Rather, they must develop and execute a strong implementation plan that embeds NAP activities in the national development agenda and sectoral strategies and budgets. This implementation plan should promote a collaborative approach to delivering the NAP across sectors and stakeholders (see Fig. 7) and must be both realistic and comprehensive, identifying and building on the strengths and activities of existing initiatives while simultaneously securing interest and investment for new activities as and where they are needed. To fulfil this task, the coordination committee needs a clearly defined role and remit, coupled with strong political backing and a thorough understanding of which AMR activities – both new and existing – to focus on, which development and sector plans and budgets to target, and which stakeholders are or should be involved. Focal points from food safety authorities should always be involved in the coordination committee.

Fig. 7. Generic template for a national AMR governance structure



Source: (71)

AMR: antimicrobial resistance, HIV: Human Immunodeficiency Virus, M&E: Monitoring and Evaluation, TB: Tuberculosis
TWG: Technical Working Group, WASH: Water, Sanitation and Hygiene

Armed with this authority and knowledge, the coordination committee can then develop a compelling narrative and build a strong case for investment that secures the political will and resources required at all levels, across all sectors, to deliver the implementation plan. In this context, six strategies for success were set out in *Turning plans into action for antimicrobial resistance (AMR), Working Paper 2.0: Implementation and coordination* (72):

- establish AMR coordination committee roles and responsibilities;
- prioritize AMR activities;
- get AMR into plans;
- engage stakeholders;
- make the case for investment;
- tailor the message.

National surveillance

Collecting data on antibiotic sales and consumption, as well as on the spread of AMR in human and veterinary medicine, is of growing importance at the national level, with various Member States in the WHO European Region having launched national surveillance and monitoring programmes in recent years (73, 74).

Harmonized Monitoring

EU Member States and several EU candidate countries have adopted EFSA's recommendations and EU legislation on harmonized monitoring at the national level (75).

Experiences in multisectoral collaboration to address AMR

Tackling antimicrobial resistance (AMR) together, Working Paper 1.0: Multisectoral coordination (76), published by WHO in 2018, summarizes the lessons learned from focal country experience on the tools and tactics needed to establish and sustain multisectoral collaboration for AMR action (see Table 1).

Table 1. Lessons learned from focal country experience on the tools and tactics needed to establish and sustain multisectoral collaboration for AMR action

Tools and tactics	Lessons learned from focal country experience
Political commitment	<ul style="list-style-type: none"> • Political commitment and leadership are critical to drive the AMR agenda, mobilize resources, and achieve action; • Progress will not happen without someone in government at the right level, with the right decision-making authority, to drive action on AMR; • AMR data, champions and events can serve to raise AMR's profile and keep it on the political agenda; • Legal instruments, including presidential orders and international agreements, can be leveraged to give AMR political visibility.

Tools and tactics	Lessons learned from focal country experience
Resources	<ul style="list-style-type: none"> • It takes time, money, technical assistance and dedicated human resources to coordinate across sectors and secure mutual trust, ownership and collaboration; • Development partners have proven a strong source of support, especially in getting early AMR efforts off the ground; • In the long term, governments must take the lead in resourcing NAPs and funding activities to combat AMR; • In many countries, those responsible for AMR may require training and support to coordinate all relevant stakeholders effectively.
Governance mechanisms	<ul style="list-style-type: none"> • Because AMR is a multisectoral issue, a NAP will necessarily be a plan of plans; that is, a plan linked to many existing plans and programmes; • There is no one-size-fits-all approach to AMR governance: countries must establish structures and mechanisms to suit their own situations; • To be effective in tackling AMR, governance structures should enable both vertical and horizontal multisectoral collaboration; • Whatever approach countries take to coordinating AMR, good communication and consultation is essential for successfully cascading action from governing bodies to implementing units.
Practical management	<ul style="list-style-type: none"> • Clear institutional mandates, roles and deliverables strengthen the transparency and accountability of NAP implementation efforts; • Coordination can be smoothed by anticipating potential problems and developing practical solutions in advance; • Regular progress updates or technical briefings help keep politicians and collaborators informed, interested and engaged; • AMR initiatives can build on existing programmes and activities by using existing structures, such as One Health committees, for coordination; and linking to broader plans and concepts, such as universal health coverage, to leverage AMR action; • A simple monitoring framework and feedback mechanism can help track progress and keep collaborators on course.

Source: (76)

The role of food safety authorities in reducing AMR

Food safety authorities play a crucial role in tackling and combating AMR. That role includes strengthening the policy and legal framework, establishing a nationally coordinated approach to contribute to the AMR-related work of Codex Alimentarius, strengthening One Health governance structures and coordination across sectors, performing risk analysis of foodborne AMR, and monitoring AMR in priority foodborne pathogens in the food chain. They also promote risk communication and education, including by advocating for high-level attention to AMR in the food chain, always taking into account the need for a holistic, intersectoral and multifaceted approach to these tasks.

What should food safety authorities do to tackle and combat AMR in the food chain?

Strengthen the policy and legal framework

To strike the appropriate balance between the benefits and risks of using antimicrobials, a strong regulatory environment is needed at the national and international levels. A comprehensive regulatory framework – supported by standards, guidelines and recommendations – is needed to define and control antibiotic use in animals. Regulatory authorities' responsibilities are described in guidelines issued by international bodies, such as the Codex Alimentarius Commission, WOAHA and the Eurasian Economic Commission, and authorities in the European Region, such as the EU.

WHO and FAO have highlighted the importance of legislation and the formation of an international legal framework to address AMR at the national and international levels in different publications (77–79), with FAO also pointing out the advantages of having legislation in place to regulate AMR, and the disadvantages of its absence (see Table 2):

Table 2. Advantages and disadvantages of the presence and absence of legislation regulating AMR

What can legislation do for AMR?	What could happen in the absence of adequate and appropriate legislation?
Prevent the introduction of counterfeit medicines and monitor the quality of veterinary drugs	Flooding the market with counterfeit and/or poor-quality veterinary medicines
Ensure antimicrobials are labelled with the necessary warnings and instructions	Inadvertent use of medicated feed without realizing the antimicrobial contents
Serve to differentiate antimicrobials from other so-called feed additives	Prolific overuse and misuse of antimicrobials for non-therapeutic purposes
Limit the non-therapeutic uses of antimicrobials	Waste contaminated with antimicrobials discharged close to water sources
Foster alternative options to the use of antimicrobials through appropriate regulation	Food, feed, water and soil contamination with antimicrobials resulting in contaminated products entering into the food chain
Control waste potentially contaminated with antimicrobials	
Control residues of antimicrobials in food, feed, water and soil	

Source: (80)

In this context, legal frameworks should address veterinary medicines, medicated feed, the use of antimicrobials in crop production, and the environment, including water, soil and waste, as well as surveillance (78–81). The importance of contemporary policy and legal frameworks is also highlighted in the *WHO implementation handbook for national action plans on antimicrobial resistance: guidance for the human health sector* (71). A country example on legislation regulating AMR is provided in Box 3.

Several pillars need to be considered when strengthening the policy and legal framework for tackling AMR in the food chain (see Table 3) (3).

With regard to the food-producing animal sector, EMA and EFSA have also made recommendations regarding the prudent use of antimicrobials and the need to reduce, replace and rethink the use of antimicrobials in animals (82, 83).

Key message

To tackle AMR in the food chain, food safety authorities need to strengthen the policy and legal framework by regulating marketing authorization of antimicrobials, studying the risk of antibiotic resistance, setting maximum residue limits and generating preclinical data; defining the conditions of use of antimicrobials; and promoting the rational prescription of antimicrobials; as well as regulating the off-label use of antimicrobials and the surveillance of pharmacovigilance of veterinary medicinal products.

Box 3. Legal framework in Switzerland

Antimicrobials should only be prescribed for specific cases and if medically indicated. To maintain the effectiveness of antimicrobials in the future, legal frameworks have to be optimized and the prudent use of antimicrobials promoted, including by improving the availability of first-line antimicrobials. Critically important antimicrobials to treat infectious diseases in humans should be used as rarely as possible.

The Swiss Federal Food Safety and Veterinary Office supports the strengthening of the cantonal (regional) authorities and the harmonization of their legal activities, and promotes improved availability of first-line antimicrobials. The cantonal veterinary authorities perform farm and veterinary practice controls on a regular basis, including in relation to the prudent use of antimicrobials. Meanwhile, the availability of antimicrobials is improved by streamlining drug approval and importation processes, and addressing recurrent supply shortfalls (84). Specific legislation has also been adopted at a national level to ensure the prudent and responsible prescription, dispensing and use of antimicrobials in veterinary medicine (85), while a regulation on the collection of antibiotic prescription data for animals was adopted in 2018 (86).

Table 3. Pillars that need to be considered when strengthening the policy and legal framework for tackling AMR in the food chain

Pillar	Description	Guidelines, regulations and standards
Marketing authorization of antimicrobials	<p>Studying risk of AMR The risk of transfer of resistant bacteria or resistance genes from foodstuffs of animal origin to people must be studied for all antibiotic veterinary medicinal products intended for use in food animals.</p> <p>Setting maximum residue limits When setting acceptable daily intakes and maximum residue limits for veterinary antimicrobials, the safety evaluation is carried out in accordance with international guidelines and should include the determination of microbiological effects, as well as toxicological and pharmacological effects. Withdrawal periods should be established for each veterinary antibiotic.</p> <p>Generating preclinical data Preclinical data should be generated to establish an appropriate dosage regimen, including duration of the usage necessary to ensure the efficacy of the veterinary antibiotic and limit the development of antibiotic resistance.</p>	<p>CX-804, CX-AMR (14); 2001/82 EC (88); 2004/28 EC (89); 726/2004 EC (41); 2019/6 EU (46); VICH GL27 (91); Codex Veterinary Drug Residue in Food Online Database (87); EMA/CVMP/EW-P/133/1999-Rev.1 (40); EMA/CVMP/849775/2017 (44); MA/CVMP/627/2001-Rev.1 (92)</p>
Definition of condition of use of antimicrobials	The marketing authorization issued allows the use of the product according to the approved conditions defined in the summary of product characteristics. This summary should contain the information necessary to enable the product to be used effectively and safely while minimizing the risk of developing antibiotic resistance.	2015/C 299/04 (112); 2019/6 EU (46)
Rational prescription of antimicrobials	The relevant authorities should make sure that all veterinary antimicrobials used in food animals are prescribed by a veterinarian. In addition, antimicrobials should be administered to the animals by a veterinarian or under the supervision of a veterinarian or other suitably authorized person.	Terrestrial Animal Health Code (51); Aquatic Animal Health Code (52); 2015/C 299/04 (112); 2019/6 EU (46)

Pillar	Description	Guidelines, regulations and standards
Off-label use of antimicrobials	This involves using a product in any manner not specified on the label. This includes use in different species, for a different indication or at a dosage different from that on the label. In the EU, the exceptional off-label use of authorized medicines is allowed under specified conditions.	2001/82 EC (83); 2019/6 EU (46); 2004/28 EC (89); 470/2009 EC (33)
Pharmacovigilance of veterinary medicinal products	The surveillance of veterinary medicinal products under the EU pharmacovigilance system collects suspected adverse reactions in animals and people that relate to the use of veterinary medicinal products under normal conditions. It also takes account of any available information related to the lack of expected efficacy and off-label use. Investigations of the validity of the withdrawal period and of potential environmental problems that arise from the use of the product, which may have an adverse effect on the product's risk-benefit balance, are also considered. In addition, post-marketing authorization commitments could be requested on a case-by-case basis, especially for new classes of drugs that have never been authorized for veterinary use. Such drugs include substances with new mechanisms of action or those belonging to existing classes of antimicrobials, but with an extended or altered spectrum of activity.	2019/6 EU (46); EMA Volume 9B Pharmacovigilance for Medicinal Products for Veterinary Use (94); 726/2004 EC (95)

Source: (3)

Monitor AMR in priority foodborne pathogens in the food chain

Information on the level of AMR in common foodborne pathogens and levels of antimicrobial residues in food of animal origin is extremely important for guiding risk management and policy action. It is a key priority for the Region to establish and strengthen systems for surveillance of AMR and antimicrobial residues in the food supply, as well as to integrate AMR testing in existing systems for foodborne disease surveillance and response (87).

The surveillance of antibiotic resistance in zoonotic and commensal bacteria in different food animal reservoirs and meat products derived from these animals is a prerequisite for understanding the development and dissemination of antibiotic resistance, providing relevant risk assessment data, and implementing and evaluating targeted interventions. This surveillance entails specific and continuous data collection, analysis and reporting that quantitatively monitor temporal trends in the occurrence and distribution of resistance to antimicrobials; it also allows for the identification of emerging or specific patterns (3).

Over the past decade, many areas of monitoring and surveillance of AMR in priority foodborne pathogens in the food chain have been implemented by EFSA/EU Member States, and other countries in the Region are following suit.

Integrate monitoring and surveillance of foodborne AMR

Food safety authorities are responsible for the monitoring and surveillance of resistance in foodborne pathogens by taking samples of food throughout the food chain. According to the Ad Hoc Codex Intergovernmental Task Force on AMR proposed draft guidelines on integrating monitoring and surveillance of foodborne AMR, there are nine principles that need to be taken into account regarding integrated monitoring and surveillance programmes (see Table 4) (14):

Table 4. Principles 1–9 from the Ad Hoc Codex Intergovernmental Task Force on AMR proposed draft guidelines on integrated monitoring and surveillance of foodborne AMR

Principle	Description
1	A One Health approach should be applied whenever possible and applicable when establishing monitoring and surveillance programmes for foodborne AMR, contributing to the food safety component of such an approach.
2	Monitoring and surveillance programme(s) are an important part of national strategy(ies) to minimize and contain the risk of foodborne AMR.
3	Risk analysis should guide the design, implementation and evaluation of monitoring and surveillance programme(s).
4	Monitoring and surveillance programme(s) should be designed to generate data on AMR and AMU, in relevant sectors to inform risk analysis.

Principle	Description
5	Monitoring and surveillance programme(s) should be tailored to national priorities and should be designed and implemented to allow continuous improvement as resources permit.
6	Priority for the implementation of monitoring and surveillance programme(s) should be given to the most relevant foodborne AMR and/or AMR food safety issues (which are the defined combinations of the food commodity, the AMR microorganism and determinants and the antimicrobial agent(s) to which resistance is expressed as described in the Guidelines for Risk Analysis of Foodborne AMR – CXG 77 – 2011) from a public health perspective, taking into account national priorities.
7	Monitoring and surveillance programme(s) should incorporate, to the extent practicable, the identification of new and emerging foodborne AMR or trends and should be designed to inform epidemiological investigation.
8	Laboratories involved in monitoring and surveillance should have effective quality assurance/management systems in place.
9	Monitoring and surveillance programme(s) should aim to harmonize laboratory methodology, data collection, analysis and reporting across sectors according to national priorities and resources as part of an integrated approach. Use of internationally recognized, standardized and validated methods and harmonized interpretative criteria, where available, contributes to the comparability of data, facilitates the multisectoral exchange and analysis of data, and enhances an integrated approach to data management, analysis and interpretation.

Source: (14)

The concept of continuous improvement facilitates the design and implementation of integrated monitoring and surveillance programmes and allows countries to carry out activities to progress according to country-specific objectives, priorities, infrastructure, technical capability, resources and new scientific knowledge. An example of a programme for integrated AMR monitoring and surveillance is provided in Box 4. Preliminary activities, initiating monitoring and surveillance activities, evaluation and review are part of the framework for monitoring and surveillance programmes (14).

WHO has published several AMR surveillance guidelines and reports (88–91) and has links to EARS-Net (40) and ESAC-Net (44). EFSA also published technical specifications on the harmonized monitoring of AMR in zoonotic and indicator bacteria from food-producing animals and food in 2019 (92).

Key message

Food safety authorities should consider:

- establishing a food monitoring system for antibiotic resistance in selected priority foodborne bacteria to monitor current and emerging resistance patterns and enable timely corrective action to protect human health;
- contributing to joint analysis and reporting – in publicly available annual reports – of data on antibiotic resistance and usage, from the public health and the veterinary and/or food sectors; and
- participating in multidisciplinary task forces that involve public health, veterinary and food authorities, using surveillance data to identify trends, assess risks and ensure timely implementation of focused interventions.

Box 4. The Danish Integrated Antimicrobial Resistance Monitoring and Research Programme

The Danish Integrated Antimicrobial Resistance Monitoring and Research Programme (DANMAP) (93) was established by the Danish Ministry of Food, Agriculture and Fisheries and the Danish Ministry of Health in 1995.

The objectives of the programme are to: monitor the consumption of antimicrobial agents for food animals and humans; monitor the occurrence of AMR in bacteria isolated from food animals, food of animal origin and humans; study associations between AMC and AMR; and identify routes of transmission and areas for further research studies.

The monitoring of AMR is based on three categories of bacteria: human and animal pathogens, zoonotic bacteria and indicator bacteria. Human and animal pathogens are included because they cause infections and primarily reflect resistance caused by use of antimicrobial agents in the respective reservoirs. Zoonotic bacteria are included because they can develop resistance in the animal reservoir, which may subsequently compromise the treatment effect when causing infection in humans.

Indicator bacteria are included due to their ubiquitous nature in animals and humans, and as contaminants in food and their ability to readily develop AMR in response to selective pressure in both reservoirs.

Promote prudent use of antimicrobials in primary production

To increase the longevity of antimicrobials, clinical, pharmacy and veterinary practices must eliminate unnecessary dispensing. Evidence-based prescribing using effective, rapid, low-cost diagnostic tools is needed to optimize the use of antimicrobials for humans, animals and plants. In addition to better prescribing practices, the global community must address the inappropriate and unregulated use of antimicrobial agents by patients and the agricultural industry. Stronger compliance with antibiotic treatment regimes, quality assurance measures to prevent the consumption of substandard medications, and the restriction of non-therapeutic uses of antimicrobials within agriculture will provide a foundation for antimicrobial stewardship. Regulations regarding antibiotic distribution, quality and use preserve the effectiveness of antimicrobials as a public good.

The prudent use of antimicrobials in agriculture and aquaculture is critical to reduce the risk of AMR in common foodborne pathogens. WHO supports food safety authorities in strengthening the legal framework governing antimicrobial residues and microbial contaminant limits in food, as well as the use of antimicrobials in food-producing animals. This is done in line with the *WHO list of critically important antimicrobials for human medicine* and the *WHO guidelines on the use of medically important antimicrobials in food-producing animals* (14, 32, 33).

A strong national policy for prudent antibiotic use is a necessary first step to minimize the misuse of antimicrobials in food animals and plants and reduce problems related to the occurrence of AMR in the food chain. Such a national policy should not only require the monitoring of AMR in the food chain, but the surveillance of antibiotic use as well. It should also form part of a national public health policy, while associated guidelines and regulations for compliance should be instituted to protect public health. Indeed, specific antibiotic use guidelines need to be established for each major type of food animal, with indications for first-, second- and last-resort choices of antimicrobial for treating different bacterial infections. An example of a programme to promote prudent use of antimicrobials in primary production is provided in Box 5.

International interaction is important as well: all parties must recognize that resistance caused by AMU practices in food animals and plants in one country can travel very quickly to other countries through food exports due to travel and trade.

Attention should not only be given to the promotion of the prudent use of antimicrobials in primary production, but also to the continuous implementation of appropriate measures for disease prevention, including implementation of good agricultural practices. In many countries, this is under the responsibility of veterinary services or the ministry of agriculture; only in countries with a single food safety authority would its responsibilities include biosecurity and AMU in animals and plants.

To minimize infection in food animal production and decrease the volume of antimicrobials used, efforts should focus on improving animal and plant health, thereby eliminating or reducing the need for antimicrobials for treatment or prophylaxis. This can be achieved by improving hygiene, biosecurity and health management on farms, and preventing disease through the use of vaccines and other measures, such as probiotics (beneficial bacteria found in various foods), prebiotics

(non-digestible foods that help probiotic bacteria grow and flourish) or competitive exclusion products (intestinal bacterial flora that limit the colonization of some bacterial pathogens) (see also the recommendations of EMA and EFSA (82, 83)).

Box 5. Yellow card initiative on antimicrobials in Denmark

In order to reverse the trend of constantly increasing antibiotic consumption in pig production and the risk posed by increasing AMR, the Danish Veterinary and Food Administration (DVFA) established the yellow card initiative in 2010 (94, 95).

The initiative operates on three levels: yellow card, increased supervision and red card.

For herds of pigs and cattle, thresholds for use of antimicrobials were formulated. The threshold is given in animal daily dose per 100 animals per day. When the consumption of antimicrobials in a herd exceeds the threshold, the number of annual advisory inspections by a veterinary practitioner increases. When the consumption of antimicrobials in a pig herd exceeds the threshold, the farmer gets a warning – namely, a yellow card.

If the antibiotic consumption in the holding has not been reduced below the maximum limits after the expiry of the nine-month period, the DVFA may issue another injunction compelling the owner of the holding to seek supplementary expert advice from an impartial veterinarian with a view to reducing the antibiotic consumption in the holding below the maximum limits within nine months of the issuance of the second injunction. The expert advice must include a plan of action with concrete suggestions for interventions to reduce the consumption of antibiotics in the holding. The DVFA may carry out one or more unannounced inspection visits to the holding during the five-month period while the injunction is in effect – known as increased supervision.

If the antibiotic consumption in the holding has not been reduced below the maximum limits after the expiry of a five-month period following the second injunction, the DVFA may issue another injunction compelling the owner of the holding to implement one or more initiatives mentioned in the above mentioned plan of action or, as a last resort, issue an injunction compelling the owner of the holding to reduce the stocking density with a suitable percentage to ensure that the consumption is reduced to a level below the threshold levels – known as a red card.

Key message

Food safety authorities should – in collaboration with the private sector – promote preventive veterinary medicine and the prudent use of antimicrobials in primary production with all relevant stakeholders (particularly veterinary practitioners and farmers) by:

- reducing the need for antimicrobials in animal husbandry by improving animal health through biosecurity measures, disease prevention (including the introduction of effective vaccines), and good hygiene and management practices;
- implementing international guidelines on the prudent use of antimicrobials in food animals at the national level, adapted to national circumstances;
- establishing guidelines on the prudent and appropriate use of antimicrobials for different classes of food animals, including indications of first-, second- and last-resort choices for treating various bacterial infections, in collaboration with veterinary societies; and
- eliminating economic incentives that facilitate the inappropriate prescription of antimicrobials.

Advocate for high-level attention to AMR in the food chain

The accuracy and effectiveness of messages to the public could be improved by engaging with the media to ensure responsible and accurate reporting.

Advocacy could be carried out by providing evidence about the scope of the problem through the communication of food monitoring data, and by engaging in joint communication about the multisectoral aspects of AMR.

Food safety authorities should consider:

- developing and implementing educational strategies that emphasize the importance and benefits of prudent use principles, in order to provide relevant information on antibiotic resistance to producers, stakeholders and the public;
- developing guidelines on the prudent use of antimicrobials in food animals through multidisciplinary involvement, taking into consideration antimicrobials categorized as critically important for human medicine and those of veterinary importance;
- providing training or collaborating with ministries of agriculture to deliver training for both veterinarians and farmers on the application of guidelines on prudent use, and using auditing and feedback to veterinarians and farmers to improve compliance; and
- strengthening capacity-building activities and addressing antibiotic resistance from a food safety perspective.

A country example of an information and education initiative is provided in Box 6.

Key message

Food safety authorities should engage in advocacy and communication activities that raise awareness of the food safety perspective of antibiotic resistance and how to prevent the development and spread of antibiotic resistance in the food chain by:

- emphasizing a participatory approach, involving decision-makers, professionals, producers, the media and the general public, in formulating key messages and setting up events, in order

to strengthen collaboration between the different stakeholders in generating more attention for AMR in the food chain;

- raising awareness of the food safety perspective of AMR and highlighting the prudent use of quality antimicrobials; and
- promoting the careful and targeted use of media to improve the effectiveness of messages on antibiotic resistance to the public at large.

Box 6. Information and education in Switzerland

Apprenticeship and in-service training of specialists

Thanks to lectures and presentations on antibiotic resistance in Switzerland and the current implementation of the national strategy on antibiotic resistance, the number of specialists on the subject is steadily increasing. This is achieved through multiplier events, whereby veterinarians and agricultural advisers are given comprehensive information and equipped with training materials in order to pass on their knowledge to a wider audience, such as cantons, organizations or schools. In June 2016, the Swiss Veterinary Society also published a special edition of the journal *Swiss Archive for Veterinary Science* on the subject of antibiotic resistance.

Additional training has also been created for veterinarians, giving them the title of veterinarians with technical responsibility. This allows veterinarians to prescribe veterinary medicinal products for farm animals in advance, on an exceptional basis and subject to certain conditions (see Article 10a of the order on veterinary medicines (85)). The additional training also covers the associated rights and obligations, and permits these veterinarians to prescribe medicated feed and medication premixes for entire groups of animals.

Information for the general public

In the fight against resistance, the public is not ignored. Antibiotic resistance is everyone's business! It is important that people who are not confronted with antimicrobials and resistance on a daily basis also know about the problem of resistance. In order to raise awareness among the general public, information is provided in an easily understandable manner. Everyone who endeavours to use antimicrobials responsibly is helping ensure that antimicrobials will continue to work in the future (96).

Fill knowledge gaps and support research needs

It is suggested that national authorities, in collaboration with the private sector, support studies that help provide comparable data on AMR and usage for risk assessment and risk management. Support is needed to strengthen research on the development and spread of resistance, and the development of new antimicrobials and alternative approaches to antibiotic therapy, including

less stressful and disease-provoking animal husbandry systems. Implementation research is also needed to overcome current bottlenecks in the implementation of NAPs on AMR.

As stated in the 2018 IACG discussion paper entitled *Antimicrobial resistance: Invest in innovation and research, and boost R&D and access* (97), a successful response to AMR will address not only antimicrobials but also diagnostics, vaccines and alternatives to antimicrobials for human and animal health, including gene editing to produce better multivalent vaccines and design disease-resistant animals and plant-based animal feed with animal health properties. However, there are multiple challenges in research and development and in accessing AMR-related health technologies, as well as gaps to be addressed in the current response. Funding should be increased in priority research and development areas that are currently underfunded, while research efforts should be coordinated to ensure appropriate priority-setting and funding allocations and avoid the duplication of activities. For example, there are no global access initiatives on AMR beyond those related to HIV, tuberculosis and malaria, which do require greater coordination, and gaps in access in animal, plant and environmental health receive little attention. Additionally, further guidance should be given to funders on investing in AMR in order to maximize the impact of their investments in meeting the challenges of research and development and access. Lastly, more work is also required to operationalize the One Health approach in AMR research and development and access.

An example of an initiative to fill the knowledge gap and support research needs is provided in Box 7.

Key message

Food safety authorities, alongside education and research institutions and the private sector, should consider:

- securing comparable national data on the occurrence of antibiotic resistance in relevant bacteria from food animals, food products and people, and on the use of various types of antimicrobials in different categories of food animals;
- actively using surveillance data in epidemiological research and risk assessments, including the evaluation of interventions;
- promoting research that can further improve the understanding of mechanisms of resistance development and transfer; and
- strengthening research on the development of new antimicrobials and alternative approaches to antimicrobial therapy.

Box 7. Joint Programming Initiative on Antimicrobial Resistance

The Joint Programming Initiative on Antimicrobial Resistance (JPIAMR) is an international collaborative platform engaging 28 nations and the European Commission in the fight against AMR (98). The JPIAMR coordinates national research funding and supports collaborative action for filling knowledge gaps on AMR within a One Health perspective. The joint Strategic Research and Innovation Agenda outlines the key areas to be addressed and provides guidance for countries to align their AMR research agendas nationally and internationally.

Strategic Research and Innovation Agenda

The Strategic Research and Innovation Agenda on Antimicrobial Resistance presents an overview of recent developments and future needs for AMR research, outlining six key priority topics: therapeutics, diagnostics, surveillance, transmission, environment and interventions. Each priority topic includes a set of research objectives.

Strategy and implementation

The JPIAMR coordinates activities in scientific, strategic and policy areas that are identified and addressed through its Strategic Framework and Implementation Plan, which highlights the JPIAMR's mission and key objectives.

Support from the European Commission

The JPIAMR and European Commission work together in the alignment of activities between member countries and the European Commission Framework programme on AMR research and funding.

How can food safety authorities contribute to tackling and combating foodborne AMR?

National coordination and collaboration

Food safety authorities play an important role in implementing NAPs on AMR, particularly in coordinating efforts to address AMR in foodborne pathogens. Depending on the institutional setup in countries, this typically includes collaboration and coordination with relevant departments in the ministries responsible for health, agriculture and the environment, and veterinary and laboratory services.

Food safety authorities also need to play an active role in the work of multisectoral coordination mechanisms and coordinating efforts with partners. This may include contribution to the identification of common priorities for addressing AMR, resource mobilization, the implementation of joint activities or the sharing of relevant data with partners for joint risk assessment and decision-making.

A country example on multisectoral coordination to address AMR is provided in Box 8.

Key message

Food safety authorities need to promote and support the implementation of NAPs on AMR through a coordinated multisectoral approach.

Box 8. Tackling antimicrobial use and resistance in pig production – lessons learned in Denmark

The report entitled *Tackling antimicrobial use and resistance in pig production – lessons learned in Denmark* (99) provides an example of one country's experience in addressing AMR in the pig-producing sector. It is a testimony to the collaboration between the regulatory sector within the Ministry of Environment and Food (and its agriculture-focused precursors), private veterinary practitioners and pig producers (large and small) to tackle the unsustainable overuse of antimicrobials in the industry. The report is a retrospective tribute to all those who had the foresight to make significant changes to ensure consumer protection – improving hygiene at primary sites of pig production, developing options for intervention through a system of surveillance and the collation of data from feed mills to veterinary practitioner prescriptions, identifying sites for intervention, setting targets, restructuring the relationship between the veterinary services and farmers, and implementing changes in behaviour for the greatest impact.

Lessons learned

Change takes time. Most of the initiatives have been implemented gradually, giving farmers and veterinarians time to adjust and devise smart solutions. Infections in pigs have remained treatable despite a reduction in the overall use of antimicrobials and strong limitations on certain antimicrobials of critical importance in human medicine. The co-creation of incentives through the collaborative efforts of the public and private sectors to meet the political targets and ultimately drive changes in mitigating the AMR threat has been hugely successful in Denmark. The well-organized Danish agricultural industry has been an important factor in achieving this success. Denmark has strong private and public structures to aid the implementation of the above-mentioned initiatives. The proposed solutions may not be directly transferable to other countries, as they may have different incentives to drive change at all levels of society. However, this short report aims to provide inspiration for reducing AMU in a collaborative way, and thereby contribute to the global battle against AMR.

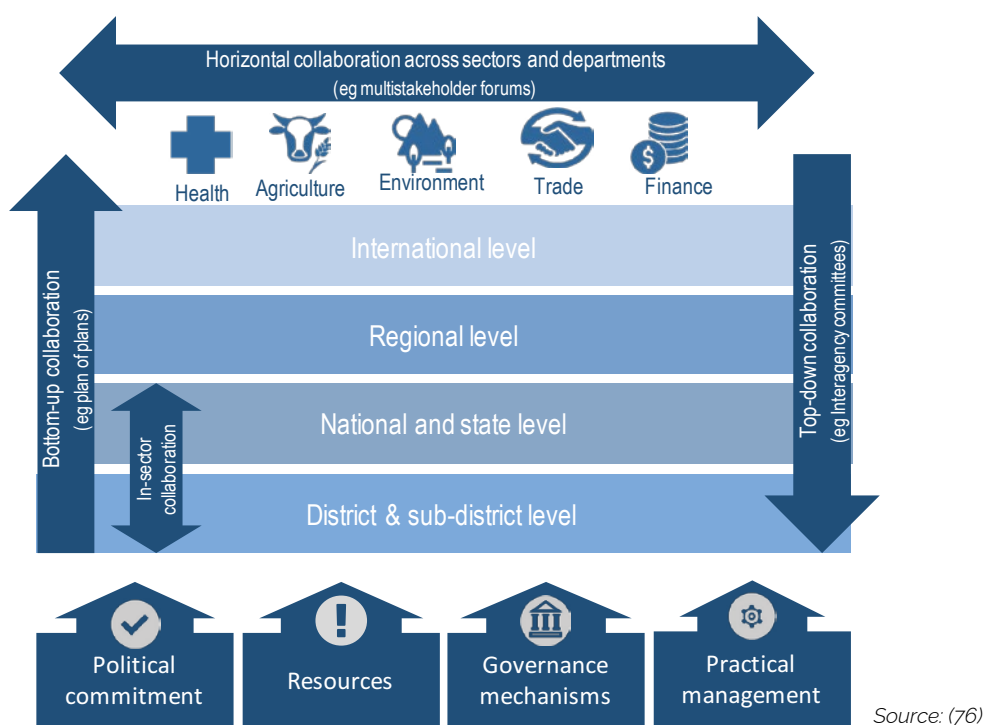
Strengthening One Health governance structures and coordination across sectors

Containing and controlling AMR demands coordinated, international action across a broad range of sectors. Within individual countries, governments will need to work with multiple stakeholders across diverse sectors and disciplines to tackle AMR. At the very minimum, that means multisectoral collaboration across health and agriculture. More often, it means coordinating action with departments of trade, finance and the environment, among others. Deliberate coordination

and collaboration between key stakeholder groups – such as government, civil society and the private sector – is needed. This is true even within individual sectors: for example, within health, curative services and public health or primary health care services must work together to address AMR. A country example on operationalizing the One Health approach to address AMR is provided in Box 9.

Multisectoral collaboration is the deliberate coordination of different stakeholder groups – such as government, civil society and the private sector – and sectors – such as health, agriculture, trade, education and the environment – to jointly achieve a goal. In the context of addressing AMR, multisectoral collaboration refers to the way in which a country organizes its systems and processes to achieve coordinated, effective action on AMR (see Fig. 8) (76). The environmental dimension of AMR is described in the UNEP publication entitled *Environmental Dimensions of Antimicrobial Resistance: Summary for Policymakers* (100), while the role of the environment in One Health – including the way in which the environment acts as a reservoir for antimicrobial-resistant genes – is covered in the WHO publication entitled *A health perspective on the role of the environment in One Health* (101), which focuses on the WHO European Region in particular.

Fig. 8. Multisectoral collaboration can be both horizontal across sectors as well as vertical across levels, and is enhanced by four groups of tools and tactics



Key message

In the fight against AMR, food safety authorities play an important role in strengthening One Health governance structures at the national and district levels, fostering bottom-up and top-down collaboration between levels and promoting coordination across the health, agriculture, environment, trade and finance sectors by taking action with regard to political commitment, resources, governance mechanisms and practical management. Food safety authorities should also contribute to the work of national governments to establish formal mechanisms for interaction between the food safety ministry and other relevant ministries and authorities to address the issue of antibiotic resistance in the food chain (1, 76).

Box 9. Ireland's first One Health Report on Antimicrobial Use and Antimicrobial Resistance

As part of Ireland's National Action Plan on Antimicrobial Resistance 2017–2020, Ireland committed to develop and produce an annual One Health surveillance report on AMU and AMR. In 2019, the first cross-sectoral report was published (102), aiming to promote increased awareness and understanding of the issues of AMU and AMR in both the animal health/food safety and human health sectors, and of the One Health collaborative approach to addressing these issues, by:

- presenting AMU surveillance information in both sectors;
- presenting AMR surveillance information in both sectors;
- highlighting some relevant initiatives in both sectors;
- highlighting AMU and AMR surveillance gaps in both sectors; and
- sharing the report with a wide target audience and seeking feedback to guide its future development.

The intended target audience includes: undergraduate, postgraduate and qualified professionals working in the health care, veterinary, farming, food production, environmental health and health protection sectors; the scientific, diagnostic, research and education community that underpins continuous development and excellence in these sectors; patients and their families; keepers of animals; other members of the general public; and policy-makers.

Risk analysis of foodborne AMR and its effect on AMU

In 2011, Codex Alimentarius published its *Guidelines for risk analysis of foodborne antimicrobial resistance* (17), which describe the general principles as well as the framework for foodborne AMR risk analysis. Risk analysis is a systematic, disciplined approach to making food safety decisions and has three major components: risk management, risk assessment and risk communication. It is a powerful tool for carrying out science-based analysis and for reaching sound, consistent solutions to food safety problems. The use of risk analysis can promote ongoing improvements in public health and provide a basis for expanding international trade in foods (103).

WOAH's terrestrial (51) and aquatic (52) animal health codes give recommendations on analysing the risks to animal and human health from antimicrobial-resistant microorganisms of animal and aquatic animal origin, focusing on:

- definition of the risk;
- hazard identification;
- release assessment;
- exposure assessment;
- consequence assessment;
- risk estimation;
- risk management components;
- risk communication.

Risk Assessment

Risk assessors may want to consider the risk profile, the information documented during commissioning of the risk assessment, and the risk assessment policy. In addition, risk assessors may require a preliminary investigation phase to define and map the work to be undertaken within the framework of the AMR risk assessment. Risk assessment is composed of hazard identification, exposure assessment, hazard characterization and risk characterization (17).

At the EU level, EFSA has published reports on the risk assessment of AMR along the food chain through culture-independent methods (104–107), while in 2014, EMA provided some considerations for the current and future assessment of veterinary medicinal products in its reflection paper on AMR in the environment (108).

Risk Management

Risk managers may want to consider both non-regulatory measures and regulatory controls. Risk management decisions should be proportionate to the level of risk, whether an intervention is a single risk management option or a combination of risk management options.

Once a decision has been made to take action, the risk management options should be identified, evaluated, selected, implemented, monitored and reviewed, with adjustments made as necessary. It is implicit in the recommended approach to AMR risk management that good agricultural practices, good veterinary practices and good hygiene practices should be in place along the food production to consumption continuum, and that the relevant Codex codes of practice should be implemented as fully as possible (17), including:

- Code of Practice to Minimize and Contain Foodborne AMR (CXC 61-2005);
- Guidelines for the Design and Implementation of National Regulatory Food Safety Assurance Programmes Associated with the Use of Veterinary Drugs in Food Producing Animals (CAC/GL 71-2009);
- Principles and Guidelines for the Conduct of Microbiological Risk Management (CAC/GL 63-2007);
- Code of Practice on Good Animal Feeding (CAC/RCP 54-2004);
- General Principles of Food Hygiene (CAC/RCP 1-1969);
- Code of Hygienic Practice for Meat (CAC/RCP 58-2005);
- Code of Hygienic Practice for Milk and Milk Products (CAC/RCP 57-2004);
- Code of Hygienic Practice for Eggs and Egg Products (CAC/RCP 15-1976);
- Code of Hygienic Practice for Fresh Fruits and Vegetables (CAC/RCP 53-2003);
- Principles for the Establishment and Application of Microbiological Criteria Related to Foods (CAC/GL 21-1997);
- Guidelines for Risk Analysis of Foodborne AMR (CXG 77-2011); and
- Guidelines on integrated monitoring and surveillance of foodborne AMR (CXG 94-2021).

Additionally, relevant sections of the WOAHP Terrestrial Animal Health Code (51), the *Aquaculture development 8. Recommendations for prudent and responsible use of veterinary medicines in aquaculture* (109) and the *WHO Global Principles for the Containment of Antimicrobial Resistance in Animals Intended for Food* (6) should be consulted.

Risk Communication

Communication with all interested parties should be promoted at the earliest opportunity and integrated into all phases of a risk analysis. This will provide all interested parties, including risk managers, with a better understanding of risks and risk management approaches. Risk communication should also be well-documented. Mechanisms may be established for routinely engaging interested parties in food safety decision-making at the national or regional levels. For foodborne AMR risk analysis, communication should bring together industry representatives – such as producers, food processors and pharmaceuticals – consumer representatives, government officials and other interested parties – such as public health experts and medical professionals – to discuss problems, priorities and strategies (17). An example of joint communication on AMR is provided in Box 10.

WHO makes continuous efforts to raise awareness regarding safe food and the possible occurrence of AMR in the food chain. It does this through various information campaigns and the promotion of the basic principles that everyone should know in order to prevent foodborne disease, known as the five keys to safer food: keep clean; separate raw and cooked food; cook thoroughly; keep food at safe temperatures; and use safe water and raw materials. Following basic good food hygiene practices is an effective way to prevent common foodborne illnesses, including those caused by resistant bacteria (25).

Key message

Food safety authorities should play the following role regarding risk assessment.

- Regarding exposure assessment, they should promote improved identification of the types and sources of antimicrobial-resistant bacteria and their AMR genes in food of animal origin, the potential transmission of those antimicrobial-resistant bacteria and their AMR genes through the food chain, and the pathways for human exposure, such as ingestion of contaminated food products, that can potentially lead to infection and adverse health effects, with a focus on known as well as emerging bacterial pathogens;
- Regarding health effects assessment, they should develop approaches to estimate health risks associated with exposure to antimicrobial-resistant bacteria and their AMR genes in food of animal origin through food contact and consumption. There is a need to encourage and support new research and demonstration projects to assess and estimate the human and animal health risks through field epidemiological-microbiological studies and quantitative microbial risk assessments.

Food safety authorities should play the following role regarding risk management.

- There is a need to identify possible solutions to the problems caused by the presence of antimicrobial agents, antimicrobial-resistant bacteria and their AMR genes in food of animal origin. These efforts should include the identification of approaches to the development of management systems and plans to overcome and combat the widespread and uncontrolled use, misuse and abuse of antimicrobials and other antimicrobial agents and the conditions that contribute to the production and dissemination of antimicrobial-resistant bacteria in people, animals and environmental media;

- There is a need to identify approaches to the development and implementation of systems for tracking and monitoring antimicrobials and other antimicrobial agents, their metabolites and antimicrobial-resistant bacteria in food media. These efforts should focus on sources, source mitigation and minimization, supported by the development of management strategies and systems to minimize use, and improve containment and treatment processes;
- There is a need to develop specific management objectives, policies, plans, procedures and practices to prevent and control the risks from exposure to antimicrobial agents, antimicrobial-resistant bacteria and their mobile and functional genes within animals and food of animal origin, as presented in existing and new, revised and better harmonized WHO guidelines.

Food safety authorities should play the following role regarding risk communication:

- ensure that all interested parties are included in the process of risk analysis; and
- promote the continuous communication of the general principles of food safety and related risks regarding AMR in the food chain.

Box 10. RaDAR: Risk and Disease burden of Antimicrobial Resistance

The RaDAR project (111) aims to generate consensus estimates for sources attribution, risks of exposure and the disease burden of AMR by integrating available data from various sources.

Resistance mechanisms emerge and spread globally. Circulation of antibiotic-resistant bacteria in food and the environment, and the resulting exposure of human beings to these bacteria, may be significant. In general, information on the overall exposure to AMR from food and the environment is scarce. Therefore, efforts are needed to fill data gaps and systematically integrate data into consensus estimates for sources attribution, risks of exposure and the disease burden.

The RaDAR project aims to fill these gaps with a multidisciplinary and cross-Member-State approach by: addressing the relative and absolute contribution of animal and environmental sources to the public health burden of AMR; linking data on AMC and the effects of different kinds of AMU on AMR in animal husbandry; modelling the spread of resistance determinants in microbial communities, the environment and along the food chain; and quantifying human exposure and the disease burden.

The project develops generic risk and transmission models that may be adapted to various bacterial species and resistance determinants. It will generate consensus estimates for sources attribution, risks of exposure and the disease burden of AMR by integrating available data from various sources and will lead to a consolidation of international cooperation on AMR risk assessment.

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Annex. List of responsibilities of the Finnish Food Safety Authority Evira according to different actions described in the Finnish national action plan on antimicrobial resistance 2017–2021

Country: Finland

Food safety authority: Evira

Description of responsibilities of food safety authority

Training of professionals:

- Increase training of veterinarians and other operators on the prudent use of antimicrobials and their environmental impacts;
- Intensify provision of up-to-date information on antimicrobials to veterinarians.

Education of the general public:

- Propose more efficient use of European Antibiotic Awareness Day materials produced by ECDC for the education of the public. This applies particularly to the use of materials related to infections, vaccinations and use of antimicrobials;
- Intensify education on AMU, including the environmental impacts of antimicrobials, targeted at owners of companion animals and horses;
- Produce materials for consumers on the use of antimicrobials for the treatment of diseases in production and other animals, as well as on the resistance risks associated with goods.

Surveillance of AMR:

- Increase the efficiency of FINRES-Vet surveillance and use of materials.
- Promote the use of reliable and rapid laboratory diagnostics and susceptibility testing to support animal pharmacotherapies.
- Continue the surveillance of zoonotic, pathogenic and indicator bacteria resistance according to EU legislation and national decisions.

Surveillance of AMU:

- Construct an information system to collect user data on antimicrobials covering all animal species.

Country: Finland

Food safety authority: Evira

Description of responsibilities of food safety authority

Infection prevention:

- Intensify measures to ensure the availability of medicines on the Finnish market.

Combating of multidrug resistance:

- Produce guidelines on the prevention of infections caused by work-related resistant bacteria of animal origin and draft joint operational principles for health and environmental health professionals to investigate and control the occurrence of human diseases caused by resistant bacteria of animal origin;
- Enhance competence in infection control at animal health clinics and hospitals and provide them with information on good practices.

Guidelines on AMU for professionals:

- Set national objectives for the volume of AMU in animals;
- Update the recommendations on the use of animal antimicrobials at regular intervals and publish the recommendations in the form of a mobile application;
- Provide instructions to decrease use of antimicrobials and zinc oxide.

Source: List of responsibilities of the Finnish Food Safety Authority (Evira) according to the different actions described in the Finnish national action plan on antimicrobial resistance 2017–2021 (67)

The WHO Regional Office for Europe

The World Health Organization (WHO) is a specialized agency of the United Nations created in 1948 with the primary responsibility for international health matters and public health. The WHO Regional Office for Europe is one of six regional offices throughout the world, each with its own programme geared to the particular health conditions of the countries it serves.

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